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PREFACE

It is with great pleasure that we present the Proceedings of the Central European Conference on Information and Intelligent Systems.

These Proceedings contain full conference papers presented at the Central European Conference on Information and Intelligent Systems (CECIIS 2020), held in Varaždin, Croatia, October 7-9, 2020. Proceedings are published in print and digital edition.

CECIIS has been held for 31 years. Due to the pandemic and travel restrictions, and having in mind the health of the participants and organizers, this year the conference was held online. The main purpose of the conference was, in particular, to bring together people active in the area of computer science and related sciences and to present new research results.

The conference had international participants, as well as an international Program Committee, which has enabled CECIIS to become one of the most important conferences in the field of applied information science and informatics in Central Europe. It is our great pleasure that this year's international co-editor is professor William Steingartner from the Technical University of Košice, Slovakia.

Moreover, the conference and the accompanying events are certainly the most significant annual scientific event at the Faculty of Organization and Informatics, University of Zagreb (FOI). Together with the scientific journal JIOS, CECIIS is one of the pillars of scientific research activities at FOI and often the first arena of internationalization and networking for many young researchers.

The special topic of CECIIS 2020 Conference "Intelligent systems – Trends, Future, Society", was designed with the aim to provide our participants an opportunity to research and discuss the advantages and possibilities of contemporary digital technologies and their impact on society.

As in the past, we have been successful in bringing together specialists from a wide variety of fields. The Proceedings of CECIIS 2020 include 38 research papers, internationally peer-reviewed by two independent reviewers and approved by the international Program Committee within the following research tracks: Computer Games, Data and Knowledge Bases, Education and Learning Analytics, Emerging Trends in ICT, ICT Entrepreneurship and Innovation, Intelligent Information Systems, Quality of Software and Services, Software Engineering, Strategic Planning and Decision Making. All papers focus on actual problems and present both theoretical and practical results and applications thus exploiting the innovative approaches.

CECIIS 2020 reviewers conducted 85 reviews (38 from Croatia and 47 from abroad) of 38 accepted papers that were prepared by 82 (co)authors from 4 countries (Croatia - 56, Slovenia - 19, Serbia - 5 and Cyprus - 2) and presented online during three conference days.

The authors of eight accepted papers have also submitted the Croatian translations of their papers. The translated papers are published on the conference website:

http://archive.ceciis.foi.hr/app/index.php/ceciis/index/pages/view/ProceedingsArchiveHR.

On the first day of the conference, a meeting of the international Program Committee was held, during which it was elected the best research paper of the conference. Several interesting papers were presented at the conference, so the selection process was not easy. The winning paper (after the careful selection process) titled "Topic Modeling in Social Sciences: Case Study of Web of Science" was submitted by authors Maja Buhin Pandur, Jasminka Dobša and Luka Kronegger.

The paper was presented in the section "Intelligent Information Systems" and was officially declared the best conference paper during the closing session of the conference. The special value of this year's conference is featured by the outstanding invited lecturers, researchers who have left a deep mark in the scientific and professional areas of their interest.

Within the CECIIS 2020 the following two invited lectures were presented:

- Prof. Jan Mendling, Vienna University of Economics and Business Institute for Information Business, Austria: "The Convergence of Business Process Management and Digital Innovation" and
- Prof. Josep M. Duart, University of Oberta de Catalunya, Educational Sciences Department, Spain: "AI in Higher Education: Teaching and Learning Perspectives".

Within the Student Poster Section, 16 student research papers in interdisciplinary fields were presented by students from prominent American and European universities - University of Central Florida (FL, Orlando), University of Cincinnati (Ohio), Massachusetts Institute of Technology MIT (Cambridge, Massachusetts) and University of Pennsylvania (Philadelphia, PA, USA), the universities of Tirana and Shkodra (Albania) and FOI (Croatia).

The conference program also included two academic panels, in which more than 200 participants from Croatia and abroad actively participated. The panel discussion on "O_HAI 4 Games - Orchestration of Hybrid Artificial Intelligence Methods for Computer Games" was moderated by professor Markus Schatten (Faculty of Organization and Informatics) and was attended by foreign panellists: Vicente Julian Inglada (Valencia University of Technology, Spain), Carlos Carrascosa Casamayor (Universitat Politècnica de Valencia, Spain), Jaime Andres Rincon Arango (Universitat Politècnica de Valencia, Spain) and Glenn Smith (University of South Florida, USA).

The academic panel discussion titled "Universities of the Future" was moderated by professor Blaženka Divjak (Faculty of Organization and Informatics) and was attended by the distinguished panellists: Ivica Crnković (Chalmers University of Technology & University of Gothenburg, Sweden), Lourdes Guàrdia (Open University of Catalonia, Spain), Mladen Vouk (North Carolina State University, USA) and Enrique Mu (Carlow University, USA). The CECIIS 2020 conference was organized in cooperation with the EDEN network. During the conference, the "Eden PhD Symposium 2020" was held, which served as a great opportunity to encourage the exchange of experiences and knowledge among doctoral students engaged in research in the field of technologically enhanced online, digital, open and distance learning.

Another panel was held in the sponsorship section, with the participation of sponsors Oracle, Infodom and DignetSoftware. The biggest challenge for the organizers of the CECIIS 2020 conference was to hold the conference in a virtual format. In addition to the difficulties and disadvantages of such conference format, including the lack of face-to-face meetings, physical contact and networking, the online conference had some advantages, primarily the access from remote locations and greater attendance at scientific sections and other events.

Our thanks go first and foremost to the invited speakers and all authors who, by their presence and scientific contributions, made this conference such a success. We also like to express our appreciation to all reviewers for their valuable opinions and recommendations. Thanks to their expertise and experience, they have contributed to increasing the impact of the submitted articles. Furthermore, we would like to express our utmost gratitude to session chairs, attendees, organizers of parallel events, as well as Program and Organizing Committee members for their contributions. We acknowledge that the organizational and supporting assistance and hosting of the Faculty of Organization and Informatics was crucially important for the overall success of the Conference. We are very grateful to all our industrial partners and sponsors for their support. CECIIS 2020 was supported by sponsors - Infodom, Oracle, DignetSoftware, Varaždin County and the Ministry of Science and Education of the Republic of Croatia.

Finally, we hope that inside these covers you will find relevant and interesting papers in the field of information and intelligent systems.

We are looking forward to the following Central European Conference on Information and Intelligent Systems that will be held on October 13-15, 2021 at the same location.

October, 2020

On the behalf of the Program and Organizing Committees

Vjeran Strahonja, William Steingartner and Valentina Kirinić
Editors

Computer Games

Markus Schatten, Bogdan Okreša Đurić, Igor Tomičić
Orchestration Platforms for Hybrid Artificial Intelligence in Computer Games - A Conceptual Model

Markus Schatten, Igor Tomičić, Bogdan Okreša Đurić
Towards Application Programming Interfaces for Cloud Services Orchestration Platforms in Computer Games

Orchestration Platforms for Hybrid Artificial Intelligence in Computer Games - A Conceptual Model*

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Abstract. *It is argued that hybrid artificial intelligence methods provide us with the necessary toolset to develop complex computer games. Additionally, to deploy such complex games at scale (for example in form of massively multiplayer on-line games) an orchestration platform based on microservices and multi-agent systems seems to be an adequate architectural choice. Herein we provide a state-of-the art literature review on hybrid artificial intelligence methods, their possible applications to complex computer games as well as introduce a high-level conceptual model of such a system.*

Keywords. hybrid artificial intelligence, artificial intelligence, computer games, multi-agent systems, orchestration

1 Introduction

The application of hybrid artificial intelligence (HAI) which can be defined as the orchestration of heterogeneous artificial intelligence (AI) methods including both statistical and symbolic approaches in various domains is omnipresent in current scientific literature. It is largely overlapping with the term hybrid intelligence (HI) that has been defined as *"the combination of complementary heterogeneous intelligences (...) to create a socio-technological ensemble that is able to overcome the current limitations of (artificial) intelligence."* (Dellermann et al., 2019). HI lies at the intersection of human, collective and artificial intelligence, with the intent of taking the best of each.

There have been numerous studies recently addressing issues related to HAI and HI methods in a multitude of application domains including but not limited to land-slide prediction (Li et al., 2018), drug testing (Chen et al., 2018), forecasting crude oil prices (M. Wang et al., 2018), prediction of wildfire (Jaafari et al., 2019), evaluation of slope stability (Koopialipoor et al., 2018), modeling of hydro-power dam (Bui et al., 2018), wind energy resource analysis (Fu and C. Wang, 2018), industry 4.0 and production automation (Azizi, 2019), airblast prediction (Armaghani et al., 2018), heart disease diagnosis (Manogaran et al., 2018) and these are just a few references from 2018 until the time of writing this paper. Most of these and such studies report building HAI systems by combining various AI methods to acquire better and more precise results. However, when it comes to methodology of the actual orchestration of HAI methods the usual approach is ad-hoc and depends from project to project. The lack of methodology in orchestrating HAI shall be addressed in this paper.

Computer games have always been connected to the development of AI. From the earliest chess minmax algorithm by Claude Shannon in 1949 to the more recent AlphaGo™ in 2015, computer games provide an ideal testing environment for AI methods. Similarly, AI has always been an important part of computer games. Computer games have often been judged by the quality of their AI and praised if they used an innovative approach like for example the ghosts in Pacman™ which had individual personality traits (1980), Creatures™ which used neural networks for character development (1996), Black & White™ which used the belief-desire-intention (BDI) model (2000), F.E.A.R.™ which used automated planning algorithms (2005) and many others (see Yannakakis and Togelius, 2018, pp. 8–15 for a very detailed overview). Artificial intelligence in games is not only used for non-player character (NPC) or opponent implementation, but also for various other parts of games (Yannakakis and Togelius, 2018, pp. 151–203) including but not limited to **generating content** (graphics including levels and maps, sound, narratives, rules and mechanics or even whole games like the Angelina game-generating system (Cook et al., 2018)), **player behaviour and experience modeling** (Yannakakis and Togelius, 2018, pp. 203–259), as well as **bot development and automated game testing** (Yannakakis and Togelius, 2018, pp. 91–151). Due to their complex nature and endless possibilities of creative design, computer games present us with an excellent opportunity to study the orchestration of HAI in various scenarios – not only for fun and leisure but also for

* This paper is published and available in Croatian language at: http://ceciis.foi.hr

other domains in form of serious games and/or gamification.

In a previous project sponsored by the Croatian Science Foundation (Installation Project No. HRZZ-UIP-2013-11-8537 entitled Large-Scale Multi-Agent Modelling of Massively Multi-Player On-Line Playing Games - ModelMMORPG - see (Schatten, Okreša Đurić, et al., 2017) for details) a comprehensive methodology for modelling large-scale intelligent distributed systems has been developed that includes a graphical modelling tool and code generator (described in (Schatten, Okreša Đurić, Tomičić, and Ivkovič, 2017) and in more detail in (Okreša Đurić, 2018)). The implemented toolset allows for modelling complex multi-agent organizations and could be applied to numerous applications domains (Schatten, Ševa, et al., 2016; Schatten, Tomičić, et al., 2017). Herein, we would like to propose the application and incorporation of this methodology to the development of HAI orchestration platforms for computer games.

In the previously mentioned ModelMMORPG project, we have already used an open source massively multi-player on-line role-playing game (MMORPG) called The Mana World (TMW) for which we have implemented a high-level interface to test intelligent agents playing the game. Additionally a number of connected game quests have been developed for various scenarios which allowed us to build an automated game testing system (Schatten, Okreša Đurić, Tomičić, and Ivković, 2017). Herein we would like to use this interface to test orchestrated HAI methods, but also develop other testbeds for the planned platform.

Therefore, the main contribution of the current ongoing project (O_HAI (4) Games - Orchestration of Hybrid Artificial Intelligence Methods for Computer Games - HRZZ-IP-2019-04-5824) shall be: (1) a comprehensive framework for the orchestration of hybrid artificial intelligence methods for computer games allowing to define models of HAI for various purposes, (2) an open source distributed cloud platform that will allow to implement such models based on existing HAI methods and connect them directly from game development platforms, (3) a set of best practices in developing HAI ensemble models tested in at least four specific testbeds described bellow.

The rest of this paper is structured as follows: firstly in section 2 we provide an overview of the domain of HAI in computer games. Then, in section 3 we outline a high-level conceptual model of the planned cloud-based orchestration platform and describe the details of its architecture. In the end in section 5 we draw our conclusions and provide guidelines for future research.

2 Domain Overview

Whilst HAI methods have recently been applied to numerous application domains with various degrees of success, their use in computer games seems to be an exception. Computer games usually do use various heterogeneous AI methods including finite state machines (FSMs), behaviour trees or rule based planning systems to implement different parts of a game's AI system, but there seems to be a lack of methodology when it comes to orchestrating these methods into a coherent playable game. Most literature for AI implementation in games (see for example (Funge, 2004; Nareyek, 2004; Yannakakis and Togelius, 2018)) does not address the issue of orchestration. Some older papers (e.g. (Nareyek, 2004) from 2004) do state that standardized interfaces between AI systems are necessary to make their integration into games as easy as possible and also provide possibilities for reuse, but still no such interfaces were developed, or if they have, aren't fully applicable to contemporary techniques in AI. Games are specific in terms of requirements they pose on AI and consequently HAI methods, for example they have to work in real-time not to disturb gameplay, ensembles of methods have to be coordinated and timely to provide a consistent behaviour of the game or its characters, and they have to be believable to not become frivolous.

In (Liapis, 2015) the term of creativity facet orchestration is defined as the "*aims to combine generation across the multiple creative domains that comprise game design*". There are six core facets in computer games: (1) level design, (2) game design, (3) audio, (4) visuals, (5) narrative and (6) gameplay, all of which can benefit from HAI methods as mentioned earlier (see Yannakakis and Togelius, 2018). As already stated, the current project has the main objective to establish a sound methodology in orchestrating HAI methods to be useful for computer games (including serious games and gamification systems) in all above mentioned facets. Additionally, it shall provide a cloud-based platform for building orchestrated HAI systems for games that will address the needs for real-time, coordinated and believable ensembles. During the project the newly developed methodology and platform shall be tested in at least four gaming-related environments: (1) a MMORPG game, (2) a gamified platform possibly with virtual assistants, (3) serious game related to autonomous vehicles as well as (4) a to be developed holographic / volumetric (Ho/Vo) gaming platform.

In order to develop a framework for orchestrating HAI methods one has to have the heterogeneity of the methods that have to be orchestrated in mind: they can include everything from simple expert systems to deep learning neural network models, from swarm intelligence optimization to automated planning systems, from rule-based knowledge bases to complex natural language processing (NLP) agents. A platform allowing to organize such methods and make them work together has to be distributed, robust, and scalable similar to big data platforms since the amount of data and processing resources for some of those methods can become quite demanding. Such a platform has to pro-

vide standardized interfaces to allow for coordination between various used methods and allow continuous data-streams and messaging. Multi-agent systems provide a natural abstraction for building such systems (Wooldridge, 2009), and have already been shown to be valuable in developing large-scale systems (see (Schatten, Ševa, et al., 2016) for a detailed overview).

In the mentioned ModelMMORPG project we have developed a methodology for modelling large-scale multiagent systems (LSMASs) based on an ontology (e.g. (Schatten, 2014)) which was the input for creating a metamodel (Okreša Đurić, 2016) for a graphical modelling language (Okreša Đurić, 2017a; Okreša Đurić, 2017b). It was shown that this ontology can be integrated with other domain ontologies to provide additional semantics, for example for massively multiplayer on-line (MMO) games (Okreša Đurić and Konecki, 2015; Okreša Đurić and Schatten, 2016), for virtual intelligent environments (Okreša Đurić, Rincon, et al., 2018) or even smart cities (Tomičić et al., 2018). Thus, during the proposed project an additional ontology for HAI methods shall be developed as a basis for a LSMASs model of a distributed HAI orchestration platform.

3 Conceptual Model

In the following we will outline the basic architecture of the planned HAI orchestration platform in form of a conceptual model. The HAI orchestration platform can be modelled conceptually as shown in Fig. 1.

The conceptual model depicted in Fig. 1 is visually divided in several elements. The distributed orchestration platform provides a set of interfaces including application programming interfaces (APIs) for various game engines and an administration user interface (UI). The platform, which is to be implemented as a multi-agent system provides load balancing, service allocation, and orchestration through an orchestrations subsystem like Docker Swarm or Kubernetes to a set servers playing the role of holons (see (Horling and Lesser, 2005) for details on the concept of holarchy or holonic organisations where each element can consist of multiple elements, i.e. each holon can either be a single element (a holon) or an organised group of elements), which, in turn, enables new holons to be added dynamically, i.e. *on the fly*. A single holon, i.e. a single service instance may comprise multiple other service instances on an, arguably, lower level, although such services can be standalone holons.

Each service is to be implemented as a single agent in a multi-agent system. It will be located in the same environment as the other agents providing other implemented services. This shared environment does not negate the concept of a distributed system, though, as the agents can be physically distributed even though they are a part of the same intelligent virtual environment (IVE) of the same system. Each agent is containerised insomuch as it must be run in a secure environment that is not allowed to be influenced by any external effects other than the usual communication with other agents of the system.

The applicable services are to be modelled as filter applications that are capable of utilizing the standard input and output channels, with optional arguments for fine-tuning the service's processes. Naturally, services are to feature system-wide standardised inputs and outputs that can consist either of single values as provided data that should be processed by a holon, or a stream of data, thus providing the basis for implementing dynamic and real-time systems, such as are required for the domain of computer games, as described earlier in this paper.

Since individual services are containerised, an apt implementation concept is a container orchestration platform like Docker Swarm or Kubernetes. This idea is motivated by efficient load balancing features that allow for on-time service allocation and orchestration where needed. Considering the distributed orchestration platform provides more holon-based services than necessary at any given point in time, the docker swarm is deemed as a good solution for the general application domain of the part of the research described in this paper.

Furthermore, the distributed orchestration platform itself is to be implemented as a multi-agent management system, since agents can operate individually, cooperate when cooperation is needed, communicate and reach an agreement using any of the communication methods, including auctions and bargaining, and they can be instantiated dynamically, i.e. agents can be run depending on the existing load of the system or the extension and the amount of requests towards the platform.

4 Application Domains

As already mentioned previously, AI and consequently HAI methods can be used in computer games for a number of various tasks like (1) implementation of NPCs and opponents, (2) automated playing and testing, (3) generation of content as well as (4) game analytics. Herein we will outline four particular use-cases for each of these domains.

4.1 Intelligent opponents in MMO games

MMO games *per se* present a complex task for implementation especially from the perspective of performance when thousands or hundred of thousands of players interact in parallel. The usual approach in generating opponents is to use simple AI methods like finite automata or behaviour trees in order to keep computation low and allow for fluid gameplay. Using a hybrid orchestration platform with numerous redundant servers more advanced HAI methods could be used to

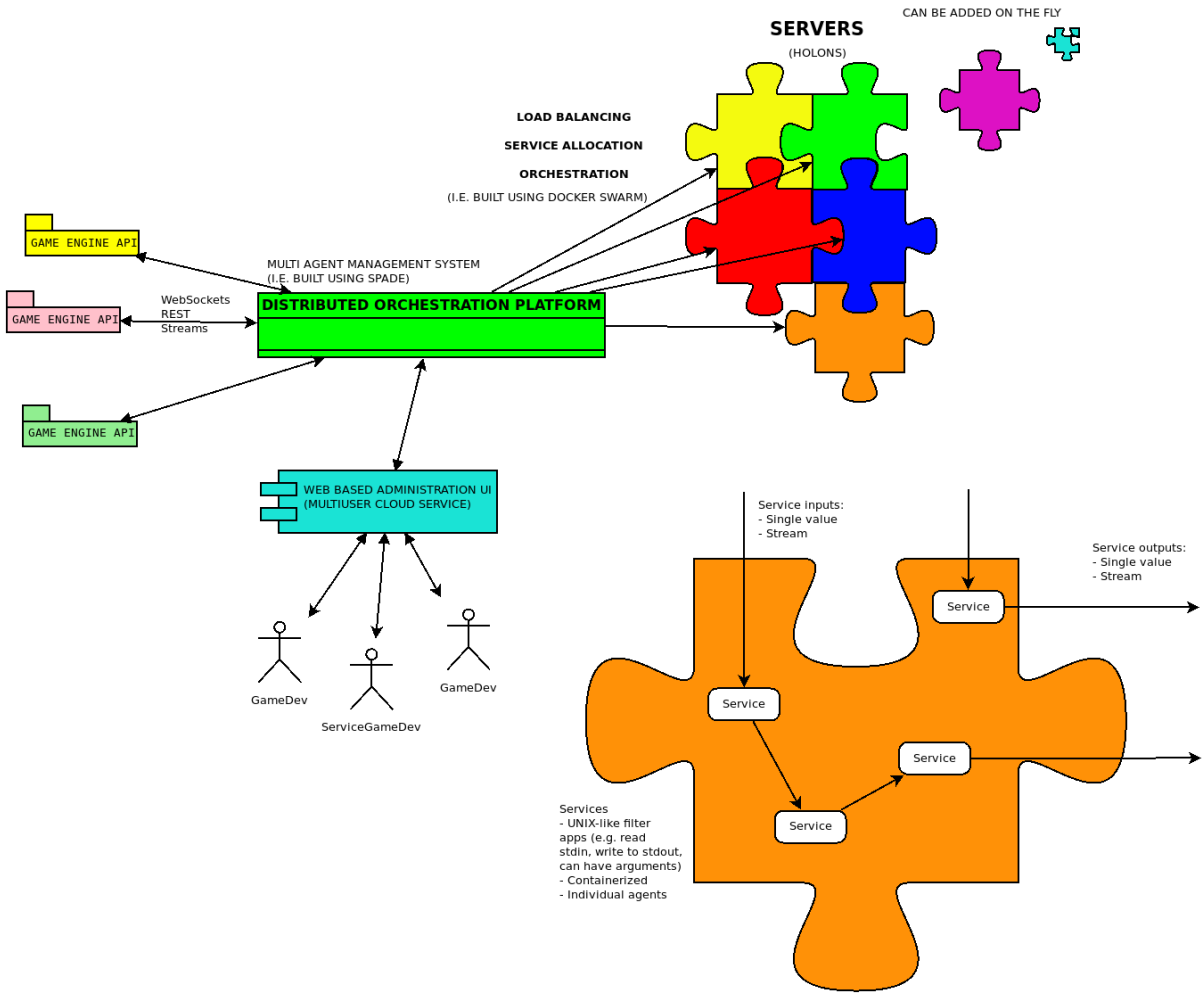


Figure 1: High-level Conceptual Model

implement much more *intelligent* and thus more interesting opponents. New opponents could be generated *on the fly* just by instancing new services (agents) on the orchestration platform. This would lead to individual opponents that do not enact easily predictable behaviour and could result in much more realistic games.

4.2 Large-scale automated testing

While performance testing in MMO games has been well implemented in numerous platforms, when it comes to gameplay testing (especially for example in MMORPGs), large-scale testing becomes a very complex task as outlined in (Schatten, Okreša Đurić, Tomičić, and Ivkovič, 2017). Not only do we need to test the various logic puzzles and tasks a player has to perform in order to advance in the game, but also the emerging interactions between players which might change the outcome of the game completely. By using a distributed orchestration platform automated players could be added to the game at will by instancing new agents. Additionally, test results could be reported and analyzed by adding additional reporting and/or analysis agents.

4.3 Heteregeneous content prediction in game streaming

Game streaming platforms like Google Stadia or NVidia's GeForce Now have just recently been gaining momentum. When put in a network multiplayer game or even MMO context, such platforms (but also networked multiplayer games in general) suffer from network lagging - e.g. the time from pressing a button on a game controller until the game's resulting actions on all players' screens is not zero due to network transmission and graphic and audio processing time. Some game engines have thus recently been experimenting with HAI methods for player prediction in which they try to predict the possible next moves of a player and generate all likely (visual and audio etc.) outcomes. When the actual action packet arrives, the generated outcome is automatically sent to all players' game clients. With a hybrid orchestration platform such a prediction system would be much easier to implement, since new possible outcomes for each player could be generated *on the fly* by just assigning new generating agents each time a new player joins the game.

4.4 Player analytics and game adaptation

Analysing the behaviour of players while playing and interacting with a particular game is of great interest to game studios. Not only do such behaviour logs provide insights into bugs or loopholes which need to be fixed, they also provide interesting insights into the actual interaction of the player with the game as well as feedback information: what does a player like, what doesn't she/he like, where does the player spend most of her/his time, etc. Such data can be used to improve the game and recent advancement in AI and data science allow us even to automate some of this improvements, i.e. some parts of the game (which a player likes more for example) could be made longer by generating additional content. By using a distributed orchestration platform analytics and improvement agents could be established for each player and allow for a individualized experience of the game.

5 Conclusion

Although there is a significant body of research dealing with the application of hybrid artificial intelligence, we argue that there is a lack of methodology in orchestrating HAI methods, which we are addressing within this paper.

As well as presenting the state-of-the-art literature review on hybrid artificial intelligence methods and their application domains, with focus on complex computer games, we have introduced a high-level conceptual model of the framework for orchestrating HAI methods, that would be able to deal with a significant level of the methods' heterogeneity, real-time requirements, distributed nature, robustness and scalability requirements. We have chosen multi-agent systems as a natural abstraction for building such a large-scale system as it was already proven to be a feasible choice.

We have graphically presented a tentative representation of the to-be-developed system, generally composed of distributed orchestration platform, APIs, UI, load balancing, service allocation, as well as orchestration services, and a proposed structure of a single holon/multi-layer service instance, which is to be implemented as a single agent in a multi-agent system.

We have also presented numerous application domains of such a distributed orchestration platform by providing four particular use-cases in which such a platform could solve major problems in game implementation and provide creative, new and unseen possibilities for games.

Our future research will be focused on the implementation of the basic architecture of such a system in order to test various types of HAI methods in various types of games including but not limited to serious games and gamification.

Acknowledgement

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Towards Application Programming Interfaces for Cloud Services Orchestration Platforms in Computer Games

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Abstract. *Services orchestration platforms which allow for the implementation of scalable, distributed and containerized multi-agent systems are gaining momentum. Lots of contemporary computer games, especially massively multi-player on-line (MMO) games and game streaming platforms are such systems and can have major benefits in using orchestration platforms. In order for a game to use such a platform its game engine has to have the necessary prerequisites including an application programming interface (API) which we analyze in this paper. Additionally, we provide four proof-of-concept implementations of such APIs in four different game development platforms (namely Godot, RPG Maker, Ren'Py and Blender Game Engine).*

Keywords. services orchestration, computer games, multi-agent systems, game engine, application programming interface

1 Introduction

The challenge of building scalable, robust, large applications that can be incrementally upgraded, yielded a need for a concept called microservices (Fowler and Lewis, 2014). Within such concept, the core functionality of an application is decomposed into many smaller units, usually packed as containers, that are in some way able to communicate within themselves.

As (Khan, 2017) notes, such applications can be "composed of clusters of hundreds of instances of containerized services", and the cluster of containers must be "fault tolerant, available, and potentially geographically dispersed". Because of the sheer complexity of such systems, the notion of orchestration platforms became highly significant within the domain – such platforms can simplify container management and are generally used for integrating and managing containers at scale. Some of the general container orchestration platforms in use at the time of this writing are Kubernetes, Amazon Elastic Container Service, Docker Swarm, Mesosphere Marathon, RancherOS, etc.

Blanchet et al. (Blanchet et al., 2005) introduce an intelligent-agent framework where web services are wrapped in a conversation layer and service orchestration is presented as a conversation among intelligent agents, each of which is responsible for delivering services. Their effort was to avoid inflexible composition evolution where all parties must be updated concurrently in order to avoid interaction problems.

Hahn and Fischer (Hahn and Fischer, 2007) present a model-driven approach to design interoperable holonic multiagent systems in Service-oriented Architectures, illustrating how a choreography model can be easily conceptually implemented through holons.

On the other hand, computer games as applications are usually monolithic with a thick client handling most of the computations. Network based games including massively multi-player on-line (MMO) and streamed games only recently shifted their attention to microservices, and there are not many reports on using orchestration platforms for game servers and game system architectures. For example (Yahyavi and Kemme, 2013) note only three types of system architectures for MMO games: (1) client-server; (2) distributed multi-server and (3) peer to peer. The distributed multi-server architecture is most closely related to the concept of microservices, but not equivalent. According to (Yahyavi and Kemme, 2013) there are two types of such an architecture: (a) shards - each server contains an own copy of the game world and (b) one world - each server contains only one part of the game world. An industry expert (Walker, 2020) mentions even six types of game server architecture patterns:

Monolithic Architecture resembles a server on which the entire game is implemented in a single process on a single computer. First-person-shooters like *Quake 2*, *Unreal Tournament*, *Counter Strike* and *Call of Duty* use such a pattern.

Distributed Network Connections pattern usually implements a server which accepts and manages client connections in order to multiplex client

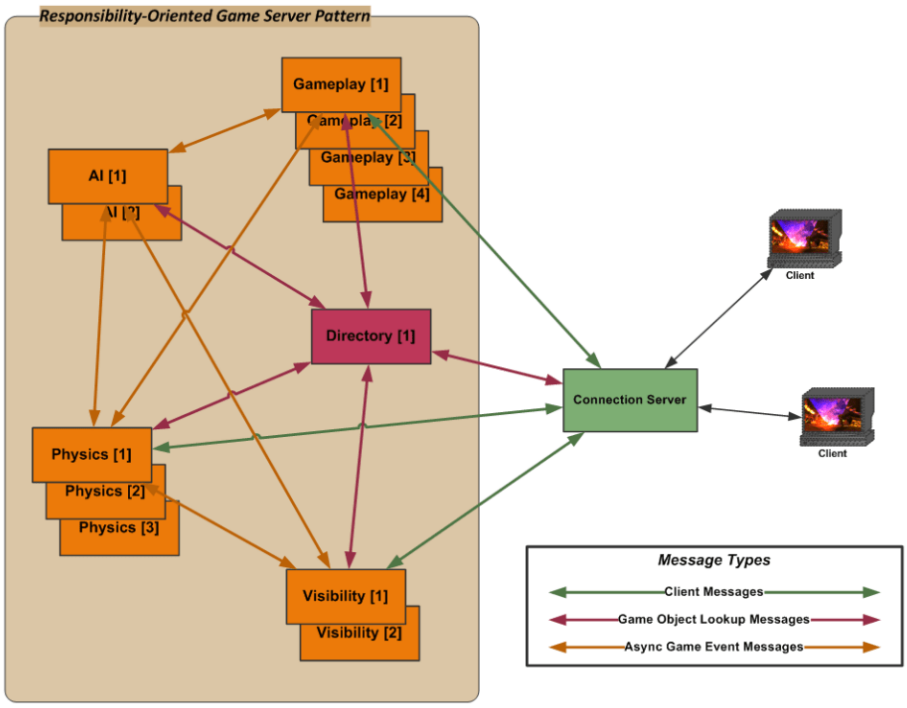


Figure 1: Responsibility-Oriented Game Server (Walker, 2020)

network traffic to several game servers (other names for such a server are connection server, user server, gateway server, front-end server or player server). Most commercial MMO games use this kind of pattern.

Client Side Load Balancing is an implementation pattern in which the game client contains a mechanism to randomly choose between a number of available connection servers described above. Some large-scale MMO game solutions use this kind of pattern.

Map-Centric Game Server (Walker, 2020) describes this pattern as follows: "*Develop a map-centric game server strategy that concentrates core game play activity with the maps in which it occurs. Do this by creating two server types, area server and world server. The game's server cluster contains many area server processes connected to a single central world server process. One or more connection servers generally manage client network connections, but are not part of this pattern.*". From our perspective these area and world server types could be viewed as service types in an orchestrated architecture. Such an implementation pattern is used by *Richard Garriott's Tabula Rasa*, *Hero Engine* (an MMO server framework) and *Face of Mankind*.

Seamless World Game Server is a variant of the previous pattern in which the world map is divided into smaller region maps distributed across a uniform server grid. Such a pattern is used by games like *Ultima Online*, *Ultima Online 2* (cancelled), the mentioned *Hero Engine* and *Star Wars Galaxies*.

Responsibility-Oriented Game Server is a pattern in which server types responsible for specific subsets of game play functionality (like gameplay, artificial intelligence (AI), visibility, physics, game state directory etc.) are defined. Such a pattern is used by *Rift (Trion Worlds)* and *Lineage*. This type of architecture closely resembles the idea of a microservices architecture as shown on figure 1.

In the following we will argue that orchestration platforms, especially when modeled and implemented as holonic and organization centered multiagent systems (MASs) can profoundly benefit the implementation of game server architectures by introducing various *out-of-the-box* features which are usually manually implemented in MMO game servers.

The rest of this paper is organized as follows: firstly in section 2 we provide an overview of requirements for both orchestration platforms and game engines to make a large-scale system work. In section 3 we provide four proof-of-concept game implementations that allow using existing microservices on any given orchestration platform. In the end in section 4 we draw our conclusions and provide guidelines for future research.

2 Requirements Definition

As already outlined in the introduction, a microservices orchestration platform allows for building scalable, robust, large applications that can be incrementally upgraded (Fowler and Lewis, 2014). In order to implement a computer game that make use of such an architecture, there are a number of requirements that have to be adhered and a number of features the actual game engine has to offer.

In the following we will describe a cloud service orchestration platform as a holonic multi-agent organisation or holarchy (see Horling and Lesser, 2005; Rodriguez et al., 2011). The latter idea, describing services as holons (agent that can be comprised of other agents), provides for the mechanism of nesting services, i.e. making it possible for the platform to run services either as individual services (agents) or complex organizations of agents. In this way it is possible to define multiple levels of holonic organization (see Schatten, 2014 and Schatten, 2013 for details on this approach).

The platform that contains several redundant agents is therefore the back-end of the platform described in this paper. Such agents consist of a chosen process, an input, and an output and can be instanced on demand – usually when load on a given agent becomes to high for it to process it adequately. Holons are, therefore, the structure of the back-end module of the cloud services orchestration platform - they take care of instancing agents when there is need, provide communication and coordination facilities and load balancing. Usually orchestration platforms are *invisible* to the client – the client communicates with a service (an agent in our case) which might be just one such service in an ensemble of agents in the background. Thus, any service that could be offered through the network can be orchestrated in this way, and this includes various aspects of gameplay. Thus, for a game engine in order to communicate with a microservice orchestration platform it needs to feature a simple application programming interfaces (APIs) that is able to communicate with a service needed by the game engine. Most prominent possible APIs are representational state transfer (REST), Web Socket or NetCat (simple TCP or UDP connections) that will enable developers to implement connections between their game and the cloud services orchestration platform. Therefore, in most game development engines all necessary prerequisites are already established since most engines allow for various types of network connections.

On the other hand, in order to make a game that puts an orchestration platform to good use, there are a number of requirements on the actual game architecture. The most important one is modularity – possibly implemented to an actor model (which is basicaly an agent model just in terms of game development usual terminology) in which each actor connects to some kind of service (agent) in order to act upon the game world and react to certain game events. Thus, an agent based approach to implementing both games and their necessary server architecture allows us to handle fairly complex terminology in terms of agents communicating. coordinating, competing etc.

Networked game server architectures including MMO and game streaming services can have major benefits from using a containerized microservices orchestration platform. Khan, 2017 outline that there are seven key capabilities of a container orchestration platform:(1) cluster state management and scheduling, (2) providing high availability and fault tolerance, (3) ensuring security, (4) simplifying networking, (5) enabling service discovery, (6) making continuous deployment possible, (7) providing monitoring and governance – all of which would have to be implemented manually when implementing a game server architecture from scratch. Thus, orchestration services provide game backend developers and administrators with a higher-level of abstraction in implementing their desired architecture.

3 Proof-of-concept Examples

In the following we will present four proof-of-concept APIs which were made in four different game engines for a number of games which have been developed or are in development. As already stated most general game engines already have the necessary prerequisites for communicating with services. Herein we will show how such communication can be established with four game engines: Godot, RPG Maker, Ren'Py and Blender Game Engine.

3.1 Godot

Godot is a cross-platform, free and open-source game engine that allows for the implementation of both 2D and 3D games (Wikipedia contributors, 2020b). Figure 2 shows the main graphical user interface (GUI) of Godot when a game project is loaded.

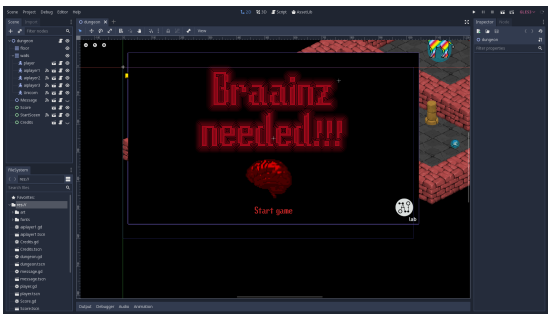


Figure 2: Godot – main user interface

As an example we have created a simple role-playing game (RPG) like game in which each non-player character (NPC) interacts with the player and gives her/him

simple tasks to solve. Figure 3 shows the main screen of the game.[1].

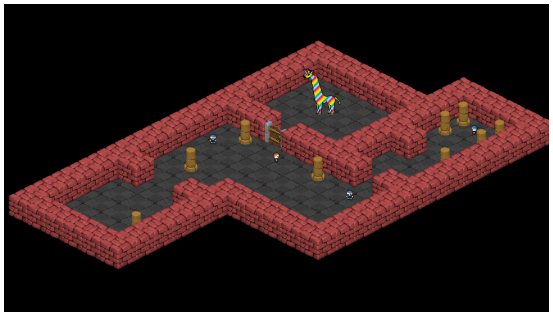


Figure 3: Godot – proof-of-concept game *Braainz needed!!!*

Godot can use a number of progamming languages to implement the actual game, but the default language is GDScript. Listing 1 shows how communication to a server can be implemented by using the built-in `HTTPRequest` object.

Listing 1: Excerpt from game code related to server connection

```
func get_message():
 var data = RQ_RESULT.result
 if data:
  data[ 0 ][ "msg" ] = data[ 0 ][ "msg"
      ↪ ].replace( '\\n', '\n' )
  if data[ 0 ][ "cmd" ] == "giveItem":
   emit_signal("give_item",NAME)
   DONE = true
  return data[ 0 ]
 return { "msg":"Zombies ate my brain!!!\
     ↪ nCan you program me a new one?\
     ↪ nPretty please ...?", "btns":"
     ↪ Exit", "cmd":"null"}

func send_request( caller ):
 CALLER = caller
 $HTTPRequest.request("http://localhost
     ↪ :2709/query/" + NAME.
     ↪ percent_encode() + "/" +
     ↪ LAST_COMMAND)

func _on_HTTPRequest_request_completed(
    ↪ result, response_code, headers,
    ↪ body):
 RQ_RESULT = JSON.parse(body.
     ↪ get_string_from_utf8())
 CALLER.show_message( self )
```

3.2 RPG Maker

RPG Maker is a tool for creating 2D RPG games (Wikipedia contributors, 2020d). Figure 4 shows the main interface of RPG Maker MV.

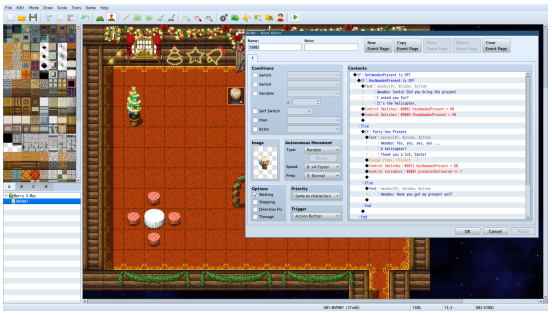


Figure 4: RPG Maker – main user interface

In its current version (RPG Maker MV) the scripting language of choice is JavaScript which makes communication to various types of services fairly easy. For this proof-of-concept game we have implemented a simple greeting card game for Christmas shown on figure 5.[2]



Figure 5: RPG Maker – proof-of-concept game *Marry X-Mas*

In order to communicate to a REST service, one can use the built-in `XMLHttpRequest` and `JSON` objects to communicate and parse results respectively, as shown in listing 2.

Listing 2: Excerpt from game code related to server connection

```
$gameMessage.setFaceImage('Actor1',0);
$gameMessage.setBackground(1);
$gameMessage.setPositionType(2);
let xhr = new XMLHttpRequest();
xhr.open('GET', 'http://localhost:5000/
    ↪ query/ivek', false);
xhr.send();
var ans = JSON.parse( xhr.response )
$gameMessage.add( ans[ 'msg' ] )
```

3.3 Ren'Py

Ren'Py is an open source visual novel engine written in Python (Wikipedia contributors, 2020c). The main

[1]The game uses art by Deesiv @ Deviantart, and is based on an example game by Filipe Mice.

[2]The game contains a number of game resources avaliable online, namely Deep male burp sound by Mike Koenig, Jingle Bells by Kevin MacLeod, Christmas sprites by PandaMaru, Santa face by Idril's Grove, Santa sprite by slimmmeiske2.

interface of Ren'Py is shown on figure 6.

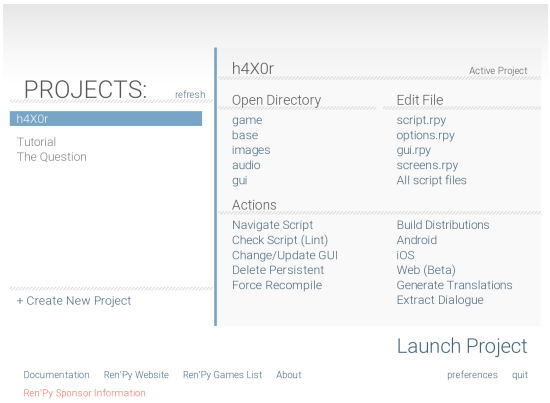


Figure 6: Ren'Py – main user interface

As a proof-of-concept game we have implemented a visual novel game (which is still work in progress) shown on figure 7.



Figure 7: Ren'Py – proof-of-concept game *h4X0r*

Ren'Py uses its *Animation and Translation Language* and its *Screen Language* for game implementation, but it is possible to embed Python code into the script. Listing 3 shows an example of how Python code inside Ren'Py script can be used to access a REST service by using Python's `urllib` and `json` modules.

Listing 3: Excerpt from game code related to server connection

```
init python:
 import urllib.request, json
 def get_request( req ):
  with urllib.request.urlopen( "http://
      ↪ localhost:8001/q=%s" % req ) as
      ↪ url:
   data = json.loads( url.read().decode()
       ↪ )
   return data

 config.grequest = get_request
```

3.4 Blender Game Engine / UPBGE

Blender Game Engine (BGE) component of Blender, a free and open-source 3D production suite, used for making real-time interactive 3D and 2D games (Wikipedia contributors, 2020a). Since BGE was discontinued, UPBGE (Uchronia Project Blender Game Engine) which is a fork of Blender has been developing the engine further. The main user interface (UI) of UPBGE is shown on figure 8.

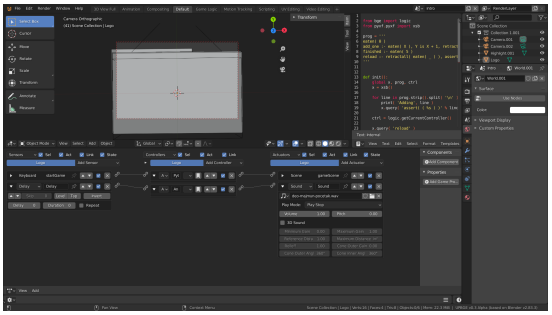


Figure 8: Blender Game Engine – main user interface

We have created a small proof-of-concept game in UPBGE shown on figure 9.[3]



Figure 9: Blender Game Engine – proof-of-concept game *Monkey Doghnut*

Since BGE and consequently UPBGE uses Python as its main implementation and scripting language, the implementation of a sensor communicationg with a service is straightforward and similar to the Ren'Py implementation (listing 4).

Listing 4: Excerpt from game code related to knowledge base connection

```
from bge import logic
import urllib.request, json

def query( req ):
 with urllib.request.urlopen( "http://
     ↪ localhost:8001/q=%s" % req ) as
     ↪ url:
  data = json.loads( url.read().decode()
      ↪ )
  return data
```

[3]The game uses the Public Domain image of a monkey by frankes.

```
def main():
 if ctrl.sensors[ 'eating' ].positive:
  act = ctrl.actuators[ 'njam' ]
  ctrl.activate( act )
  x.query( 'add_one' )
  result = x.query( 'finished' )
  if result:
   act = ctrl.actuators[ 'finish' ]
   ctrl.activate( act )
```

4 Conclusion

In this paper we have argued that containerized microservices orchestration platforms can benefit game server architectures on a number of ways by allowing to use already established services provided by the orchestration platform. We have shown that both the backend server-side as well as the actual game engine can (and should) be modeled and implemented as a (holonic) multi-agent system. In this way the same simplified and much more human understandable abstraction is used in both sides of the development.

We have also argued that most general game engines already provide the necessary prerequisites for implementing game infrastructures as orchestrated systems, namely: (1) support for actor model (i.e. agent model) and (2) network communication abilities.

In the end we have provided four proof-of-concept games implemented in four different game engines to show how simple it is to implement orchestration server communication from a game engine, since orchestration server behave as simple REST, WebSocket or even Netcat (TCP / UDP) services. Additionally, programming examples have been shown for the interested reader to try out.

Our future research will be focused on implementing valid APIs for a number of game engines to communicate with an orchestration platform focused on hybrid artificial intelligence (HAI) services that shall be implemented as part of the O_HAI (4) Games project sponsored by the Croatian Science Foundation.

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Data and Knowledge Bases

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Data Warehouse and Data Quality – An Overview

Vedran Juričić, Matea Radošević
Characteristics of Graph Database Benchmarks

Snježana Križanić, Kornelije Rabuzin
Process Mining and Data Warehousing – A Literature Review

Data Warehouse and Data Quality – An Overview

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Abstract. *Almost every company today is collecting and storing data for later analysis and business decision making in some kind of repository, usually a data warehouse. In order for decision to be timely and accurate (content-wise), it should be based on high quality data. Data quality policies and standards can be applied to every data warehouse. However, every data warehouse is unique and there is a need to consider a lot of criteria to achieve the best outcome. The goal of this paper is mostly to give an overview of data quality issues in a data warehouse, explain different criteria and categories for data quality and show some causes and consequences of saving low quality data in the data warehouse. The main contribution of this paper is, consequently, an overview of data quality issues in the context of data warehouses and an insight into some new and emerging research areas in the field of data warehouse quality.*

Keywords. data warehouse, data quality, database, ETL, data model

1 Introduction

Amount of data that business organizations and their business processes generate nowadays is bigger than ever. Additionally, every person on this planet generates some data on a daily basis. A need to store (and later process) all that data in an efficient and useful way becomes a necessity.

A data warehouse (DW) is a subject-oriented, integrated, time-variant and non-volatile collection of data in support of management's decision-making process (Inmon, 2002) and it is one of the approaches to store this integrated and processed data in one place, for a later business analysis.

However, this data needs to be of a high quality in order to serve as a good basis for business decision making. This is the motivation behind this paper – the authors wanted to get an overview of data quality (DQ) approaches and issues, in the context of data warehouses. It is also the main focus of this paper.

Low-quality data represents incorrect, untimely or inconsistent data – however, data that is correct, complete, readable and available can also be a candidate for a low-quality data (Vuk et al., 2015). Bad data is the one with inadequate semantics; the one that can't be interpreted correctly. That data can still be processed and used but the user will receive limited or wrong information. With that in mind, data quality (its policies and standards) must be defined and maintained in every data warehouse.

The main research question of this paper is "What are the most common data quality issues in a data warehouse?". Related to the question, the goal of this paper is to give an overview of data quality issues in a DW and of some aspects which demand additional attention (like categories which might contain data of poor quality). The main contributions of this paper are, thusly, an overview of data quality issues in the context of data warehouses and additionally, an insight into some new and emerging research areas in the field of DW data quality.

The paper is organized as follows: in Section 2 the data quality problem is presented, in Section 3 criteria for defining data quality is explained, in Section 4 most common problems that every DW faces are described, in Section 5 most common requirements for data quality are mentioned, in Section 6 some phases in building a DW where the mistakes can happen and thus produce low quality data are mentioned, in Section 7 different aspects and user roles in data quality are shown, in Section 8 some consequences of bad quality data are discussed, in Section 9 some recent research approaches in the field are shown and finally in Section 10 are some conclusions.

2 The Data Quality Problem

Before the appearance of a data warehouse (DW) as an integrated system for business analysis, data was stored in databases (DB). Even now, databases are used on a daily basis for storing all kinds of data.

The goal of a data warehouse is to integrate all those databases that store daily operational data and to serve as a comprehensive, historical and central repository for further analysis. Because of that, most of the data quality approaches in the context of a DW can be related to previously researched data quality problem in the context of a DB (broadened with some DW-specific issues). The most popular and widely used database underlying model was relational model – it is so even nowadays, for operational everyday tasks. One of the biggest problems in databases is redundancy, because of which the same value is being stored into multiple rows (Chen et al., 2011). To avoid data redundancy tables are normalized, that is, specific rules are followed to store data from one table in multiple (related) tables (Chen et al., 2011). Multiple categories of the normal forms are representing one step forward to better data structure in order to remove redundancy in a database. If, for any reason, relationships between the tables need to be changed and re-defined in a database, it needs to be understood how that change will affect data model and if new tables need to be created and normalized.

Changing a data model is putting at risk data integrity and increases the risk of creating data redundancy in the tables (Chen et al., 2011). Changing the database model after it's already in use is not easy and it requires a lot of planning and testing before the change is implemented. DW is much more prone to changes in its environment – changes in the data model of its data sources, changes in the users' requirements, technology changes and system upgrades – it all affects the DW. Redundancy is still one of the biggest data issues but more effective methods exist to find the errors in data and their manipulation after they are already saved and used in a DW. Three approaches to data quality in a DW can be seen in literature: intuitive, theoretical and empirical (Wang et al., 1996). Intuitive approach is based on a previous experience and intuition of the researcher. It is based on accuracy and reliability of the data in a DW. With this method it's easier to make decisions about which criteria is the most important for data quality and quality of the data system. Theoretical approach is based on researching the process which, gradually, turns good data into bad. Empirical approach is more concentrated on data as a product that transforms, loads and is being processed.

However, these three approaches could be seen through a much wider view of the complete system for which data quality is being measured. In this context, four categories of data quality can be distinguished (Wixom et al., 2001):

1. Internal quality,
2. Quality of availability,
3. Contextual quality,
4. Representational data quality.

Internal quality is observing accuracy, objectivity, credibility and privacy of the data source.

Quality of availability is making sure of data availability. It is being implemented by introducing security measures into online services and applications where the data is being originally inserted.

Contextual quality is referring to events that data consumers are performing. Data must match context the consumer is currently in, and data must bring the consumer information he needs. It includes following criteria: data relevancy, added value, timeliness, complexity and data quantity.

Representational data quality means that consumers must easily understand the data in front of them. Data must be consistent, interpretative and presented in an intuitive way.

Table 1 contains an overview of these categories and key criteria related to each category.

Table 1. Data quality categories

Internal quality	**Quality of availability**	**Contextual quality**	**Representational data quality**
Accuracy	Availability	Relevancy	Consistency
Objectivity	Security measures	Timeliness	Interpretability
Credibility		Complexity	Intuitive representation
Privacy		Data quantity	

There can be four additional categories, when observing data from information system point of view with the goal to own data whose quality is controllable, that is, making sure that with bigger volume of data in a DW its quality doesn't decrease. These categories are: timeliness, data quality, expense and worth.

Each data has its lifecycle, it becomes inaccurate and inconsistent with time. It is important to serve the right information at the right time to the user.

Data quality is a result of invested human resources, money and time. If the person who is managing the data knows the process and its advantages and disadvantages, extracting necessary information will be cost-effective and faster. Expenses can be referred to consequences of supporting low quality data over time – re-entry and re-control of data, making wrong business decisions and how those decisions affect company business and expenses for improving data quality. That contains cost of investing in employee experience, applying standards of data quality, cost of analysis and repair costs.

The user is determining value that every data is bringing to him. Since the data has previously been through a series of transformations, its value should be as high as possible.

Table 2. Data quality criteria

Data Completeness	Consistency	Value	Conformity	Accuracy	Integrity
Available at any time	Data format from different sources	Data accuracy	Consistent data keeping	Real world data	Table connections
Data usability	Saving the same fact throughout whole data warehouse	Data reasonableness	Ease of reading information	Actual events	Loosing memory space
Incomplete data					Loosing speed of work

3 Measuring Data Quality in a Data Warehouse

Data quality is being measured according to three criteria (Calero et al., 2010): DBMS quality, data quality and data model quality.

DBMS (Database Management System) quality – to achieve the higher quality of DBMS, it is best to use international standards.

Data quality consists of three parts, quality of data definition (does the data represent real business image), quality of data values (values that are saved to the tables must represent real world, they have to be accurate and must contribute to business requirements based on which they were saved to the data warehouse) and quality of data presentation (format in which the data is being saved must be clear and intuitive to the user).

Data model quality – DW designer must choose tables, processes and data partitions so they represent logical structure of a data warehouse and that they serve its purpose.

4 Bad Data Indicators

Many business systems have multiple data sources. To coordinate all that data and save it to a unified schema, ETL[1] processes are being used to transform and insert data into a data warehouse. This step is critical since it is necessary to detect in advance all the possible irregularities in the source and find a way to diminish or remove these irregularities. Problems that are most often encountered are:

- Inability to compensate source records that are incomplete,
- NULL values,
- Process of manual inserting data is not being controlled on the user's side,
- Rules of data structure are not being followed,
- Errors when transferring data from one system to another (exporting data from one database to another even in the same format leads to errors in data values),
- Additional integration of the data from external systems that have different data structure.

[1] ETL (Extract, Transformation, Load) is everything that connects source records and data warehouse, that is, representational layer of a warehouse (Kimball et al., 2013).

5 Data Quality Requirements

Every data warehouse is specific and contains different issues that can be improved, that is how it can be contributed to data quality. To improve data quality, the problems must be previously known in order to handle them properly. Possible consequences that bad data will make to the business processes must also be known in advance - so that it could be measured if the problem is resolved or not.

Six different criteria can be distinguished according to which it can be decided if the data in a DW is of high quality: completeness, consistency, value, conformity, accuracy and integrity (Singh et al., 2010). An overview of the criteria is shown in Table 2, together with key factors for every criterion.

Data completeness: is referred to data availability at any time, if the data is usable, if any data is incomplete or missing. Example: let's take customer data and products that every customer bought. It contains description of every bought product and its price but is missing quantity of products bought for some customers. That data is not complete and will be discarded for every customer that is missing quantity.

Consistency: ideally, data from every source should be in the same format and if that is not possible then the data must be transformed in order to save it to a unified data warehouse and the same data item should be stored the same way, no matter the source format. Example: tracking if a user is currently an active customer - it can be marked with numbers 0 and 1, or with character string 'Active' or 'Inactive'.

It is important to define one format of every information that will be saved in a data warehouse.

Value: is referred to value of every fact that is saved to a data warehouse, its accuracy and reasonableness. Example: being careful when inserting records that describe specific product since it is easy make a typing mistake. Wrong information that is saved to a data warehouse won't be clear to the user.

Conformity: every fact that is saved to multiple places must be in the same format in every table. Multiple formats can be specified for saving specific data type and it is important to be consistent with the defined formats. Example: saving data of type DATE throughout data warehouse.

Type DATE has a lot of predefined formats and one format must be chosen that will be used in a DW, so later a faster and easier search on the necessary data can be done and more time won't be lost to transform existing data to a unified format. Accuracy: data must represent events from a real world, that is, data saved to a DW must have happened or must exist in the real world. Example: address of every user is an existing address. Data that is incorrect must be removed from a data warehouse since it can lead to bad business decisions.

Integrity: Data is saved throughout many tables and there must exist a way to mutually connect the tables to have complete image of the saved data. If it's not possible to connect necessary tables, data will be duplicated in all tables that can't be connected - with that memory capacity and velocity of retrieving and processing the data will be lost.

Example: there are two tables that hold data about customers and products and a DW is used for different reports. There is a need to change products table because for one of the products there are new values that need to be saved in a DW. The existing table cannot be changed since it is already in use, but instead of that, a new instance of the same table with a few changes in the attributes can be created.

When creating a data warehouse, all the criteria from above must be considered. If one of them is skipped, there will be data losses in a DW and the information the user is receiving won't be consistent which will result with the user being unsatisfied with the results.

6 Classification of Losing Data Quality

Except having to consider all the criteria for data quality loss, it must be clear where exactly bad data is located so specific processes can be improved to increase data quality in the data warehouse.

Data quality can be compromised in different phases of a DW development cycle and in different layers of a DW architecture: in the data sources, in data integration, ETL processing or data model.

6.1 Source Data

Most of the data warehouses today are collecting data from multiple (and heterogeneous) data sources. Some of that sources are included into a DW design from the beginning and some of them are being added as new business requirements are changing or progressing. Data in the data sources are often typed or selected by the users with a help of different applications and information systems or they are generated from some devices. Each of that device or application has its own way of saving the data. A security level must be ensured and embedded into the applications and devices so not everyone can generate data that is later processed. If the data generator is not known and under control, data becomes unreliable and that is affecting data quality directly. Some of the issues that affect low quality in data in this phase are: bad choice of source data, different time of loading the data from different sources, lack of checking and limiting data in the source applications/devices, using different formats in the source systems, bypassing defined standards, possibility of inserting empty values, additionally adding columns to the tables or input fields in the applications, using special signs inconsistently, using default values for missing data, incomplete metadata.

6.2 Data Integration

This is a phase of loading data from multiple data sources and checking its type and format to ensure that data that is being inserted to a data warehouse is consistent. After it has been decided which data sources will be used, a data profile for every source needs to be defined in order to decide which data is necessary or not, and to define a format of all data types that will be saved to a DW. These steps are often skipped or developers don't have enough time to define all details, since in the beginning of the project it is more important to have a stable system that will send the data, process it and have a stable infrastructure for a data warehouse. If the data is not profiled right away, later during maintenance process data will have to be filtered and transformed more often to have more accurate and meaningful information that represents real business events. Issues that affect data quality in the integration phase are: selecting inappropriate profiling tool, insufficient analysis of the source data, not limiting input boxes to a specific character length, insufficient analysis of total records that are being inserted, inaccurate data parsing and applying standards, not knowing the data model and relationships between the tables.

6.3 ETL

In this phase data is imported from the sources to a data warehouse. Different transformations are being applied to data in order to adjust it to a DW model and standards and then store them there. This is one of the most important phases of handling the data warehouse. Here, data is saved and is not being checked unless an anomaly is noticed and must be corrected. It is important to plan all problems in the source data, make specific actions to standardize that data and import to the data warehouse only the data that is necessary for business analysis. In an ETL process, every record from the source data is being checked and data model must be well known by now (its formats and standards) in order to create a quality ETL process that will fix or discard all the data not suitable for the DW. Before this phase, a source to target analysis must be made, the data must be integrated and data model known so it can properly map all the data to appropriate tables. Process of data refresh is a process which is applying changes from a data source to a data warehouse. This process is being executed through different cleaning phases, integration and filtering phases (Vassiliadis et al., 2000). These functions can be sorted consecutively with many different combinations and they need to be carefully applied so none of the necessary data is lost. Every system is unique, the order that transformations are applied, helps owning a higher quality data warehouse. In an ETL process, data quality depends of three factors (Vassiliadis et al., 2000):

- Data coherence – maintaining data in the same metrics system leads to data of higher quality.
- Data Completeness – percent of data found in a data warehouse, compared to amount of data that is necessary. Also referred to having all the necessary data in the moment it is being needed, not having missing or incomplete data.
- Data age – for older data in the data warehouse, it is possible that it’s no longer accurate. This is referring to the data that has an end date and new records are inserted with new and valid values.

Major problems that produce low quality data in ETL phase are: different business rules in the source data, inability to define one schedule to refresh data, bad detecting of only new or changed data to save to a warehouse, not knowing ETL standards to manipulate data, wrong selection of data that will be saved to slowly changing dimensions, wrong source to target mapping, incorrectly manipulating with NULL values, lack of data documentation, wrong handling insert or update dates, incorrect usage of insert, update and delete functions, inconsistent naming of the ETL processes (sessions, transformations, flows, jobs) losing records that don't meet specific criteria, inability to restart an ETL job from specific checkpoint without losing data (Singh et al., 2010), (Golfarelli et al., 2017).

6.4 Data Model

Schema of the data model must be designed and prepared to save the data for specific business of the company. This is one of the first steps when building a data warehouse and it's important to dedicate enough time and watch all details of the business requirements. There are possible problems with data quality that are affected by data model: failure to satisfy project criteria, delay in source data, wrong data granularity in the tables, inability to follow standards caused by wrong or incomplete tables definitions or relationships between them (Singh et al., 2010), (Golfarelli et al., 2017).

7 Different Aspects of Data Quality

Data quality can be observed through different criteria, phases of data manipulation and category of users. The last approach depends on the user and his purpose in using the data. Based on that, the same data can have different level of quality to people with different roles and different purpose of work (Jarke et al., 2006).

Decisions maker is a person that is using different data analysis tools to extract the information he needs. He is also taking care of quality of the data that is already saved to a warehouse, time the data is inserted there, last time it was refreshed and ease of writing a query over necessary tables.

Data warehouse administrator's job is to define methods to detect data anomalies, find out what is the cause of every anomaly and what consequence that anomaly has made on existing data. Administrator is also taking care of data age, anomalies reports, functionality of tools that build the reports and last, metadata and its availability.

Data warehouse designer is in charge of metrics saved to a data warehouse, complete warehouse data model, changes that occur in the model and how are they applied in practice. To a designer, metadata is important since it is describing which table is storing which data and how are the tables mutually connected. DW designer also needs to take care of tools for DW maintenance - they need to be tested to make sure they meet all the conditions for a specific business data warehouse.

Data warehouse programmers develop tools and programs for data warehousing and they need to know what kind of data will be kept in the DW in order to build specific function to manipulate the data and its tables. Also, they need to know standards for managing and implementing a data warehouse so they can integrate those standards within the tool.

8 Consequences of Bad Quality Data

A person that is using a data warehouse daily will best describe the problems he or she encounters, omissions in the data and if he or she eventually sees the cause of the problems. With that information the mistakes can be analyzed and removed and new standards implemented in order to have a higher quality data in a data warehouse.

Except taking improving guidance from people that are working on a DW on a daily basis, bad data can be detected with cost analysis, that is, if expenses of maintaining the DW have risen and the amount of data didn't increase, quality issues exist.

If the data is used as support to making business decisions, and if some of the decisions ended badly, it's possible that data that affected that decisions is incomplete or incorrect. Decisions made based on faulty data can reflect employee dissatisfaction.

Customer dissatisfaction is also one of the indicators of bad data. This is happening while using online services and generating personalized messages based on customer interest and previous purchases. If the customer sees suggestions he or she doesn't like, he/she will use other services in the future.

9 Related Work

Data quality in a DW is a widespread issue, influenced by a lot of events and business processes and can be managed in a lot of ways. Many authors dedicated their time to investigate causes of the data quality problems, and some widely known research was already mentioned in the paper.

Wixom and Watson (Wixom et al., 2001) conducted a research about implementation success factors of a data warehouse. They concluded that strong connection between system quality and data quality, good management and organized resources with high quality skills are associated with higher quality data.

Calero, Piattini, Pascual and Serrano (Calero et al., 2010) researched metric that is affecting data quality: table metrics, star metrics and schema metrics. They described metrics that anyone can use to measure data quality by separate categories.

Vuk, Cirikovic and Suk (Vuk et al., 2015) explored different approaches to data quality and factors defining data quality. Their main research question was how can multiple data sources affect data quality with time, life expectancy of specific data stored in the warehouse, and when it becomes inconsistent.

Vassiliadis, Bouzeghoub, Jarke and Quix (Vassiliadis et al., 2000), (Quix, 1999) and (Jarke et al., 2006) pointed out importance of metadata and how it affects overall content quality.

They presented quality factors such as new source integration and how they affect other dependent tables and metrics, and of course, importance of good data warehouse maintenance.

R. Singh and Dr. K. Singh (Singh et al., 2010) introduced stages of data warehousing that can affect data quality and they classified problems in each stage. The summary of most common problems was: lack of standards, varied data sources, missing and inconsistent data and inadequate data quality testing. Additionally, some newer research and emerging trends in a field of DW data quality will be mentioned here. It can be seen that some new data quality issues appeared in the context of data stream management systems, data lakes, big data, view maintenance quality in a DW and in general data quality related to different DW design methodologies. In (Jarke et al., 2017) the authors researched the role of conceptual models, their formalization and implementation as knowledge bases, and the related metadata and metamodel management. They traced this evolution from traditional database design, to data warehouse integration, to the recent data lake architectures.

In (Berti-Equille et al., 2016) the authors discussed data quality problems in the context of Big Data applications and the challenges to data quality regarding the unprecedented volume, large variety, and high velocity of data.

In (Geisler et al., 2016) the authors researched data quality in Data Stream Management Systems (DSMS). DSMS provide real-time data processing in an effective way, but there is always a tradeoff between data quality and performance. They proposed an ontology-based data quality framework for relational DSMS that included data quality measurement and monitoring in a transparent, modular, and flexible way.

In (Gosain et al., 2019) the authors focused on view maintenance models' quality in the context of a DW data quality. In this context they mentioned problems such as definition of views, composition of views and maintenance of views but focused their research on the problem of the judicious use of materialized views so as to achieve the best combination of good query performance and low view maintenance in terms of cost efficiency.

In (Di Tria et al., 2017) the authors provide metrics for evaluating the quality of multidimensional schema in reference to the effort spent in the design process and the automation degree of the data warehousing methodology. They theirour evaluation to the major emerging hybrid methodologies for data warehouse schema design, as a case study.

In (Gautam, 2018) the author argued that the formal representation of metadata can enhance the quality of information required for decision making. The author introduced three formal models to properly manage metadata with different types of operation and to provide qualitative information to user.

In (Golfarelli et al., 2017) the authors show a very good overview of more than 20 years of research on data warehouse systems, from their early relational implementations (still widely adopted in corporate environments), to the new architectures solicited by Business Intelligence 2.0 scenarios, and up to the new challenges of integration with big data settings.

In (Homayouni,2019) the authors propose ADQuaTe, an automated data quality test approach that uses an unsupervised machine learning technique to discover constraints in the DW that may have been missed by experts.

In (Heine, 2019) the authors describe a prototype of an automated data quality monitoring system. The focus is on the aspect of expressing advanced data quality rules such as checking whether data conforms to a certain time series or whether data deviates significantly in any of the dimensions within a data cube.

In (Mann, 2020) the authors summarized various metrics proposed for conceptual model of Data Warehouse and their formal and empirical validation to prove their correctness and practical utility. It is a good state of the art paper on this topic.

10 Conclusion

Data quality is an important issue, nowadays more than ever. In order to make a good business decision, the companies need to have timely, accurate and realistic data.

Data quality in a data warehouse (DW) always needs to be in focus since it has direct consequences to the business and the customers. Processes can always be modified and adjusted to the new standards, but it's important to invest enough time, money and educated employees to build a good and quality data warehouse. If data quality control is skipped in the data warehouse building phase, additional analysis and process implementation will cost much more - it will demand more people and eventually cause down time in the moment when the changes are being implemented.

Business model is changing as the market demands change, in order to serve best possible product and make the best profit. Changing business rules means changing the data warehouse model. Every model holds its advantages and disadvantages and it is important that disadvantages are well known from the beginning and that people are working on reducing or removing them, that standards are being applied and data quality is being tested constantly. The data warehouse structure is constantly being replaced with a newer, better models, but developers and DW architects must not forget to check the data quality from different perspectives, many categories and various criteria, in order to have a high-quality data in a data warehouse.

The main research question of this paper was "What are the most common data quality issues in a data warehouse?" and the goal of the paper was to give an overview of data quality issues in a data warehouse. The main contributions of this paper are: a) an overview of data quality issues in the context of data warehouses and b) an insight into some new and emerging research areas in the field of DW data quality.

It can be noted that the research based on a traditional DW methodologies and architectures is very comprehensive and very well defined – there is a little need to further research this area. However, some new and emerging trends in data influenced further (and future) research in a data quality filed in some new contexts and perspectives. Some of these are definitely fields of data stream management systems, data lakes, big data, view maintenance quality in a DW and in general data quality related to different DW design architectures and methodologies.

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Characteristics of Graph Database Benchmarks

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Abstract. *Many graph database management systems have been designed over the past years because of their suitability in special usage scenarios and their performance of read and write operations. To successfully implement them into an existing system or an application, users must often compare various graph database systems and their effectiveness. Because of their specific characteristics and data model, it is challenging to create a benchmark that is adequate for graph databases in required use cases and scenarios. This paper describes the common queries and operations in graph database systems and enumerates their important features. Also, it defines the desired characteristics of graph database benchmarks and describes the most popular benchmarks for different database management systems.*

Keywords. Graph data, graph database, benchmarking, benchmark characteristics

1 Introduction

Organizing data in graphs has become a common way to help analyzing data like social network data, computer network data, travelling data etc. The amount of data that are stored in graphs is huge and algorithms used for analyzing those graphs and data are pretty complex in most cases. For example, two of the most popular social networks, Facebook and Twitter, have about 400 billion and 60 billion edges, respectively (Ching et al., 2015). Graph Database Management Systems are of great help when it comes to working with data structures which are shown in the shape of graphs or some generalization of graphs.

Graphs in general are found to be difficult to work with, especially when it comes to working with enormous number of data and data connections stored in large graphs. Both researchers and the ones who are dealing with graphs and graph databases are working on many Graph Database Management Systems whose main purpose is to make working with data stored in graphs less complex and demanding.

Ching et al. (2015) made scalability improvements to use it on graphs up to one trillion edges. They also introduced processing techniques for graphs, that allowed them to make graph databases applicable in new industries, and works on more efficient graph partitioning algorithms. Hong et al. (2015) designed indexes for graph data and signatures for vertices on basis of which a new strategy that uses the specific features of weighted set family and graph topology is created. In addition to this, they introduced an efficient subgraph matching algorithm to improve query performance. As one of the properties of graph databases are frequent changes that are made, Bok et al. (2017) made up with a dynamic partitioning scheme of Resource Description Framework (RDF) graph. The scheme creates clusters and subclusters that achieve load balancing, which are based on the average frequency of queries for observed server. Also, they minimized the number of edges to reduce the costs of transmission between servers.

The main purpose of this paper is to review Graph Database Management Systems benchmarking and to characterize forms which should be thought-about when benchmarking.

In this paper, important features od graph databases are explained and features that are found in large graphs. Applications of graph data and graph databases are also described as it is important to understand where graph databases are actually used and in which domains they are especially useful. In the next chapter, popular benchmarks for relational, object oriented, Extensible Markup Language (XML) and graph databases, and RDF, are presented. Next, the elements that should be considered when designing benchmark are defined. In the end, conclusions will be made regarding review of previously made researches.

2 Graph Databases

To understand the importance of adequate benchmark, this chapter gives a brief description of the way data is stored in graphs and explains the most important features of graph databases.

2.1 Important Features of Graph Databases

In graph databases, entities are stored as nodes. There are relations between entities and they are represented with edges. Not all graph databases are the same since the complexity of data that is stored effects on the complexity of graphs. However, features that are required by most popular applications are attributes, direction, node and edge labelling, multigraphs and hypergraphs (Dominguez-Sat et al., 2011).

Attributes contain additional information linked to nodes and edges, commonly string or numerical values. When taking observing relation between nodes, it can be symmetric or asymmetric. Symmetric relation means that the edge may be passed through from any of node to opposite one and if it is not symmetric, edges have both beginning and the end, so called the head and the tail. There are also undirected graphs, where undirected edge is shown as two directed edges.

Different types of nodes and edges are also common in some applications. Node and edge labelling identifies distinct kinds of relations.

Multigraphs and hypergraphs are special kinds of graphs. In multigraphs, two nodes are possibly connected by multiple edges, and in hypergraphs, edges are replaced with hyperedges (which are composed of unreasonable number of nodes).

2.2 Common Features Found in Huge Graphs

Data represented in graph in real life is much different than standard graphs by definition. Mostly, it is because datasets are huge and number of edges is bigger than anyone could imagine. However, characteristics that are frequently found in large graphs are that they contain more edged than it is expected to be the maximum number of edges in a graph and there is a power law distribution which means that some nodes have more connections then there are expected to occur.

Also, in huge graphs there is a small diameter which reassures a short path to most other nodes in small world property. There is a large connected component found in great fraction of nodes and nodes are grouped in clusters with big density of edges between them (Chakrabarti & Faloutsos, 2006).

2.3 Applications of Graph Data and Graph Databases

With the technology growth and increase in amount of information in general, the need for storing large amount of data has occurred. Both scientists and people who work in those industries find graphs and networks suitable for organizing and representing large amount of data where nodes stand for entities and edges represent relationships between those entities.

One on the most popular datasets that is considered to best fit in graphs are organizations and social groups, and with increase of usage of social media, social networks are also one of the most popular examples of graph data.

One of the most successful tools to examine the architecture of different kinds of social groups is Social Network Analysis. Social Network Analysis is focused on determining the pattern of people's interaction. It is done by following mathematical algorithms and systematic analysis of empirical data. However, it has applications in organizational behaviour, spread of contagious diseases, social support, mental health, diffusion of information and animal social organization, counter terrorism, viral marketing etc (SNA, 2020).

With the increasing use of social networks where people can interact with each other and share information, it has become important to have possibility to track all the relationships and also interactions. Interactions can also be found in library catalogues or scientific paper repositories.

World Wide web is also one of examples that can be viewed as a directed graph with its nodes and edges (Kumar et al., 2000). This graph has more than one billion nodes and is expected that the number of nodes and edges will grow exponentially with time. It is observed for many reasons, primarily mathematical, sociological and commercial.

In addition to World Wide Web, some other web pages that are organized like huge networks or graphs should be mentioned. Some of them are Wikipedia, Amazon, Google etc. which are the best example of nodes and connections between them, that can represent various of things, maybe in most researches they try to track interest of users by giving them additional information they could be interested in, followed by links where they can find those information.

Scientists dealing with new trends in data mining also find graph data and graph database features interesting (Chakrabarti & Faloutsos, 2006). They tend to analyze social roles and interactions, and graph databases help them manage data, but also graph generators create synthetic but enough realistic graphs which follow the patterns in real-world graphs.

Large studies of proteins and genetic interactions are presented with interaction networks where nodes represent proteins. An example of database which demonstrates the complexity of graph data is Protein Data Bank (PDB) and many researches on nodes and relationships between them but also roles in those protein networks can be made based on that kind of data (PDB, 2020).

Another real-life example is traffic and demonstration of cities or places people can visit. In that cases, nodes represent places, and edges show connections between them. The understanding of graphs could help users find the best or quickest or cheapest route to plan their journey.

3 Popular Benchmarks

During ages, relational databases were standard and as a result, the most of database benchmarks are meant to appraise relational database queries. Those benchmarks highlight queries with selections, joins and sorting operations. As the use of graph databases is starting to be more frequent and graph databases focus on different types of queries than relational databases, benchmarks made for rational databases are not appropriate for measuring their efficiency.

3.1 Relational Databases

When talking about relational database benchmark, one of the most popular benchmarks are TPC-C and TPC-H, both products of TPC (Transaction Processing Performance Council), an organisation whose main activities are creating benchmarks and creating processes for monitoring benchmarks they created (TPC, 2020). TPC-C benchmark describes the whole environment in which users perform activities. It represents only five most commonly used transactions (in wholesale supply system), but is not meant for any specific industry. Although it is mostly use to represent industries that sell or distribute a product. On the other hand, TPC-H simulates decision support system that works with large amount of complex data and it represents all kind of industries.

Benchmarking tools that are based of TPC-C simulate workload of more users with one machine and most of them are made for a single database management system. Therefore, benchmark logic should be adjusted to database management system's properties or should be even implemented in it (Lima et al., 1970).

3.2 Object Oriented Databases

Relational databases and graph databases have many differences, but object-oriented databases and graph databases have more in common. Data stored in object-oriented databases can be understood as a graph, but with objects and relationships between them instead of nodes and edges. One of the most common benchmarks for object-oriented databases is OO1 (Object Operation 1). The OO1 benchmark evaluation includes measures for inserting objects (adding a set of objects and relations between them to database), looking up objects (finding set of object for specific object identifier) and traversing connections between them (performing 7-hop operation that starts at any given node). It is designed so it can be applied to object-oriented, relational, network or hierarchical database systems and even some custom application-specific database systems (Cattell & Skeen, 1992). When working with object-oriented databases, OO1 determines dataset that consists of one type of object with firmed number of edges. Graphs that are made of those kinds of objects are mostly regular.

OO7 is also commonly used benchmark for object-oriented databases. The database consists of three different types of objects that form a tree whose depth is seven and all objects have firm number of relations between them. OO7 contain traversal queries and general queries. It is more complex and thorough then OO1, and it was designed to support multiuser operations (Carey et al., 1993). Even though object-oriented databases form graphs, those graphs are much different than typical data that is stored in graph databases. As mentioned before, graphs in graph databases are mostly irregular, as the number of nodes can vary a lot and they are also creating clusters with small diameters. When analyzing graph data, relationships are of great interest (shortest path, patterns etc.), and in object-oriented databases more attention is given to objects and their attributes.

3.3 XML Databases

XML databases are another type of databases which go after model that relate entities. In XML databases, data and attributes form a tree. XMark is a popular benchmark for XML databases that is designed by taking XML standards in consideration. The queries round up basics of XML processing in database management systems. Some of them are querying for NULL values, full-text search, sorted data, path expressions etc (Schmidt et al., 2002). XML databases and graph databases have some similarities, but XML forms trees which are only one subbranch of graphs.

3.4 Resource Description Framework

Web researchers, developers and scientists introduces a language to represent metadata on the Web, and it is known as Resource Description Framework (RDF). From database perspective, RDF is considered to be an extension of data models used in database management systems, mostly in graph database models, as a collection of conceptual tools that describe real-world entities (in most cases those entities are metadata on the Web) (Angles & Gutierrez, 2005). Together with RDF, knowledge community has come up with SPARQL, a query language that helps describe relationships between entities. There is a benchmark for SPARQL queries, called LUMB, which is actually a benchmark for OWL (Web Ontology Language) Knowledge Base Systems that is part of W3C's Semantic Web Technology stack and includes RDF, SPARQL, etc (Guo et al., 2005).

3.5 Graph databases

Since graph databases are much younger than for example relational databases, there are less benchmarks for graph database models.

The most popular benchmark meant for measuring efficiency of graph data is High Performance Computing (HPC) Scalable Graph Analysis Benchmark (Bader et al., 2009).

3.5.1 HPC Scalable Graph Analysis Benchmark

HPC Scalable Graph Analysis Benchmark was designed by scientists and researchers in collaboration with developers from several companies. They tried to gather the most commonly used and therefor the most representative operations, like graph loadings, graph traversals and short navigations (Dominguez-Sal et al., 2010).

This benchmark is made of different operations over graph data and it simulates a power law distribution. The operations are: insertion of a graph database, restoring edges whose weight is the greatest, performing k-hops and measuring the number of edges traversed per unit of time.

3.5.2 LinkBench

LinkBench is a new synthetic database benchmark based on the Facebook social graph. It is based on traces from making databases storing social graph data at Facebook and reflects real-world database workloads for social applications. It is known that data gathered from social networks is one of the typical data stored in graph databases.

LinkBench operates in two phases. First, it generates and bulk-loads a synthetic social graph. Then, it benchmarks the graph that is stored with generated workload of database queries and takes statistics about how efficient it is. All parts of process have many parameters that can be changed to examine the workloads that have other characteristics (Armstrong et al., 2013).

4 Graph Database Benchmark Evaluation

When creating a graph database benchmark, there are few elements that should be considered. Most important is the structure of graph database and graphs itself. Then, benchmark designer should also take care of fields of business that are most likely to use graph database and which queries are expected to be used in those cases. Graph structure and most frequently used graph types are presented in chapter 2, and in this chapter the other elements are described.

4.1 Types of Graph Operations

There are few types of operations used in fields that are most frequently expected to be organized as graphs. Those are operations that can useful in any framework. They let us get information from graph (node, value of an attribute, neighbour nodes) or they let us create, change or delete graph or part of the graph.

Operations that are mentioned need to be broaden in order to be adequate for use in examples from previous chapter. Operations can be grouped by types: traversals, connected components, communities, graph analysis, centrality measures, pattern matching and graph anonymization (Dominguez-Sal et al., 2011). One of the typical operations are traversals. These are operations that examine the neighbourhood of a node following recursive principal until assigned depth or node is hit (Ciglan et al., 2012). There is a difference in traversals in directed and undirected graph because in directed graphs the direction is set from tail to head. One of traversals is also finding shortest path or cheapest journey. k-hops are other common traversals, and by calculating k-hops is meant to find out which nodes are k nodes away from the root node. Connected components are subsets of nodes for which there is a connection between any of two nodes. Therefore, a single node can be part only of one connected component of the graph. In many examples, to determine connected components or bridges that are crucial for making components connects, is of great significance. Similar to connected components, communities are set of nodes that are closer to each other than to any of the nodes that are not part of the community. It is definitely often found in social networks. Subgroup could be communities that are made of clusters where hierarchy is of great importance. Leskovec et al. that the structure of large social and information networks follows the pattern of graphs but when adding more and more information, actually nodes and edges, the community properties start to fade and graph partitioning algorithms become unavoidable. Graph analysis gives more information about topology, complexity and objects that are found in graphs. It is done to find patterns in graphs and to get more information about role of objects, in this case nodes and edges. Part of graph analysis is measuring density, diameter, degree of transitivity etc.

Centrality measures as operation give information of how a single node is imbedded in entire network. Pattern matching is an operation that recognizes patterns and helps fine homomorphisms or isomorphisms. Graph anonymization gives a duplex graph that has much in common with the original graph. It is used when datasets are modified to hide personal information.

4.2 Different Query Categories

Dominguez-Sat et al. (2010) have built few categories to group different operation used in a specific database: transformation/analysis, cascaded access, scale, attributes and result. Transformations are operations that create new types of objects or change value of an attribute. The other queries are analysis. Queries do not change the graph but they serve as access to secondary storage that is necessary because memory is often not big enough for all the results that are generated in process of querying.

Cascaded pattern assume that a query performs neighbour operations and that the depth is at least two. On the other hand, noncascade operations do not request the neighbours of observed node. Scale gives two types of queries, global and neighbourhood ones. Attributes differentiate queries by the attribute set it accesses (edge, node, mixed or no attributes accessed).

Three types of results are found: graphs, aggregated results and set. Most common output is graph which is usually part of the original graph. Aggregates are frequently histograms, while sets are made of entities or some other sets that are not graphs.

In benchmarking, queries should serve as workload of the real surrounding and therefore should be tested on the observed application. There are different graph operations and queries, but they mostly follow the same pattern. Most operations approach edges and information that are stored in them which are actually the most important information the graph has. Graph database should have ability to save different type of results in objects that are temporary to help operations proceed to the end. Some of the result should be stored in graph in order to help analyzing graphs.

Since some operations are extremely complex, it could be impossible to calculate them, so it should be taken in consideration that sometimes the approximate values could also be useful and satisfying.

4.3 Experiments

Dominguez-Sat et al. (2011) also claim that experimental setup and measurement make the most important parts of benchmark. It should be well defined to grant legitimate testing of solutions in different environments. As benchmarks have become more sophisticated and databases more complex, it is not enough for benchmarks to focus on response time of queries but also pricing, answer completeness etc.

New benchmarks let the sizes of datasets to be scaled so the comparison is fair. One example of scaling is algorithm presented by Leskovec et al. (2010). It calculates one specific measure on the basis of which synthetic graph that imitates the features of desired graph is created. Also, data partition, indexing, redundancy and data reorganization should be clearly defined. As it is common when working with databases, ACID (atomicity, consistency, isolation, durability) features should be respected. Experimental process is expected to minimize side-effects of other events that could affect the experiment results. It is done in three phases: computer warm-up, query generation (to define order of queries) and observational sampling procedure (sets the number of executions for queries and how they are compiled). Phases can and should be modified depending on goals and applications.

The most common measures in graph benchmark are load time, which give the time needed for loading the dataset, size of the graph. Also, query response time, that represents the time passed until the query gives the results, and throughput, which stands for ratio of number of queries that are completed and time that was required for those queries to be completes. In the end, there are price and power consumption. Price includes the costs of hardware, software, license and other costs that occur, while power consumption evaluates demands regarding the use of energy.

There are some special metrics, for example, HPC Scalable Graph Analysis Benchmark came up with measure that gives the number of traversals per second. On the other hand, Duan et al. (2011) gave another measure and called it a macroscopic metric or coherence. They worked with RDF benchmarks and their measure combines more different primitive metrics and measures the structuredness of different datasets (Songyun et al., 2011). Measures that can be determined in benchmarking are various, but which measures are about to be selected depends on benchmark and the goals. It is to be expected that benchmarks that are done inside industry would pay more attention on price (actually, cost of queries) and throughput. On the other hand, benchmarks that are done in research purposes will more likely expect to give answers on how efficient observed operations are in different environments.

Table 1. Benchmarks and supported features

	LDBC	HPC	McColl	XGDBench	WGB	Sotirios
Bulk operations			ID			ID
Single operations	All			ID	All	ID
Shortest path			x			x
BFS / DFS		x	x			
Multiple node types	x					
Centrality	x	x		x	x	x
K-hop					x	
Transaction			x			
Scalable	x	x	x		x	
Synthesized	x	x	x		x	x
Directed	x	x				
Weighted		x				

Table 1. shows popular benchmarks and their supported characteristics or features, with emphasis on queries and data structure (Tang, 2016). The tested benchmarks include Linked Data Benchmark Council (LDBC) benchmark (Angles et al., 2014), HPC and McColl benchmark (McColl et al., 2014).

First two rows show their support for basic bulk and single operations, i.e. insert, select, delete and update. ID in cells stands for insert and delete operations.

It can be seen that the most benchmarks do not support shortest path operations, breath-first and depth-first searches. Also, they generally do not support k-hop operations. This is certainly a great disadvantage, because those operations are common in majority of graph database usages, but users are not able to measure their performance.

Centrality, a measure of node importance in a graph, is supported by all benchmarks except XGDBench, which, on the other hand, is the only one that supports transactions.

The last four characteristics refer to the type of supported data and potentials of generators of synthetic data. As it can be seen from the table, most of the observed benchmarks support generation of synthetic data and have the possibility to scale them according to the benchmark or user needs. Directed graphs are supported in two benchmarks and weighted graphs only in one benchmark.

5 Conclusion

In this paper, important characteristics of graphs and graph databases are presented. Also, it is shown that there exists a need for designing more specific graph database benchmark. One of the main reasons is because graphs and graph databases are used in many different industries which could gain profit out of it and improve their work.

When designing a benchmark, it should be taken in consideration that graph characteristics are important, that it is necessary to be informed about the application of database and to determine which properties are about to be measured.

Also, different existing benchmarks are presented. In future work, it is planned to examine the differences in synthetic and real-world workloads, and to compare their advantages and disadvantages, but also to give recommendations when creating synthetic workloads. When examining graphs and their structure, it is necessary to find the quickest way to determine patterns that occur more often so that communities and subgraphs can be found and maybe some insights can be made on representative subgraphs instead of the graph in whole.

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Process Mining and Data Warehousing – A Literature Review

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Abstract. *Process mining is a set of techniques which allow the automatic process analysis. Databases are places where all the data about process execution are stored. Data warehouses are databases of a special kind which collect and store data from different heterogeneous sources, including the data about processes. This article explores the existing literature about two related areas: process mining and data warehouses. The aim of this article is to research the methodologies used in previous researches, find out in which areas process mining combined with data warehousing is used, and what kind of tools researchers used to perform analysis.*

Keywords. process mining, process model, databases, data warehouses.

1 Introduction

In a time of changing work environment, possession of right information is important for business decision making. Information systems are used to support business processes in organizations, and business processes help to achieve the goals of the organizations. The flow and the success of business process execution need to be monitored and analysed with the aim of improvement.

Process mining is a set of techniques which allow the automatic process analysis. Process mining uses event logs which consist of events that are recorded during the process execution.

With the aim to produce useful information, huge amount of data needs to go through three stages:

1. transformation from a workflow log format into a format convenient for analysis,
2. loading into a data warehouse,
3. analysis (Koncilia, Pichler & Wrembel, 2015).

Data warehousing is an area which allows gathering business process information from different sources (González López de Murillas, Reijers & Van der Aalst, 2019). "A data warehouse is a subject-oriented, integrated, time-variant, and non-volatile collection of data in support of manager's decision making process" (Ghosh, Haider & Sen, 2015).

When we talk about process mining and data warehouses, there are two sides of a common model. The data side consists of next three elements: versions, objects and data models. The process side consists of: processes, instances and events (González López de Murillas, Reijers & Van der Aalst, 2019). Objects represent the appearance of an active actor in the process (Kassem & Turowski, 2018). A process model that is discovered from enhanced logs strives to become a generic model. That kind of generalization of the process model is usually popular to spaghetti-like models, or in situation when a business analyst wants to measure some key performance figures (Jareevongpiboon & Janecek, 2013). At the data level, e.g., different contexts by different content keywords, resources and people, involved in the events, can be distinguished (Štajner, Mladenić & Grobelnik, 2010).

It is expected that business analysts know about the features of how event data are stored, and that is an important challenge to overcome for every user (González López de Murillas, Reijers & Van der Aalst, 2019).

The motivation for writing this article stems from a curiosity to identify opportunities for possible contribution and improvement in future work in the domains of process mining and data warehousing.

The research aims are:

1. to identify the connection between process mining and data warehousing,
2. to identify the reasons for using data warehouses in the field of process mining,
3. determine the limitations of the data warehouse usage in process mining.

The purpose of this article is to detect a research idea for further work based on the results of this research.

Research questions that we are trying to answer in this article are:

1. Which methodologies are used in previous researches where the data warehousing terminology is used together with process mining?
2. What are the areas of research where the process mining is used as a technique for data warehousing?
3. Which tools are used or researched in previous researches that enable process mining in data warehouses?

This article is designed as follows: section 2 represents the literature review, where the basic ideas of process mining and data warehousing are presented. Section 3, Methodology, shows the methodology used in this article with the aim of gathering information about previous works. Then, there is a section 4 with results obtained from literature research. This article is also concluded with ideas about future research.

2 Literature Review

Information systems, which support business processes, generate a huge amount of information about events which occurred during system execution. This information can help in analysis of business operations and performance over time (Belo et al., 2017). The process related data, which are arranged over multiple tables in the company's database, are assembled and transformed to the format that can be used in the process mining technique (Jareevongpiboon & Janecek, 2013). The role of process mining stays in a function how the data plays, and it is one of the most popular and latest technology for data scientist process analysis. In order to better understand business processes and improve them, there are some techniques that process mining provides. These techniques are: process discovery, conformance checking, compliance checking, performance analysis, process monitoring, prediction, operational support etc. (González López de Murillas, Reijers & Van der Aalst, 2019). Discovery is a step of searching through event logs according to which process model can be designed. Conformance can consist of an associated process model with an event log record. The aim of the conformance is to discover if there exist any inconsistencies, and commonalities between the modelled performance, and the empirical comportment (Ahmed, Faizan & Burney, 2019). The data contained in event logs are usually quite complex and often have ad hoc structures, what can make the process mining difficult (Belo et al., 2017). Sometimes, process mining results are used to enable resource prediction based on the users point in the process (Štajner, Mladenić & Grobelnik, 2010). For these reasons, the importance of a structure called data warehouse arises. Data warehouse could help in decision making and improving the business. The data warehouse is "a database that is organized according to other design principles than those that are used for good database design". Once a data warehouse is implemented, reports used for decision making can be built within seconds (Rabuzin & Škvorc, 2016).

Workflow Management Systems record all steps of a business process execution in a file named log file. "A workflow log records which task in which business process has been performed by which actor, and what was its processing time" (Koncilia, Pichler & Wrembel, 2015).

There exist several ways in which events can be selected and grouped into traces. According to the perspective to which the data are taken, the event logs should be extracted differently (González López de Murillas, Reijers & Van der Aalst, 2019). One of the most popular method of data unification in process mining is clustering. It is possible to cluster similar process models, and select a representative for each cluster "assuming that big differences are more relevant to the analyst than minor differences between the models" (Vogelgesang & Appelrath, 2017). Usually, process models which reflect similar behaviour are clustered, and then one representative process model per cluster is selected (Vogelgesang & Appelrath, 2015). "The model has a perfect fit if all suggestions in the record can be repeated by the model from start to end" (Ahmed, Faizan & Burney, 2019).

Often mentioned term in the field of process mining is multidimensional process mining. Limitations and challenges of multidimensional process mining are, e.g., comparison of cells, high effort for data integration, performance optimizations, interactivity, and handling of concept drifts (Vogelgesang et al., 2016). Multidimensional event log (MEL), on the other hand, is a specific data warehouse that stores all the available event data in a cube-like data structure, and maps the structure of event logs to a data cube while organizes events and cases on different levels (Vogelgesang & Appelrath, 2017). In this case, the purpose of a data warehouse is to physically integrate data from different sources and provide a trusted place for important pieces of information (Rabuzin, 2014).

Data warehouse is the basis for the powerful data analysis. Data warehouse uses cubes structure to contain the data that are imported. Cubes are the main objects in online analytic processing (OLAP) (Kassem, Turowski, 2018). OLAP is an important part of business intelligence that deals with a huge amount of data (Ghosh, Haider & Sen, 2015). Cubes in OLAP "divide the data into sub-sets that are defined by dimensions and the dimension is the descriptive attribute of a measure" (Kassem, Turowski, 2018). The OLAP queries (like *roll-up* and *drill-down*) are based on a set of basic operators like aggregation and selection (Vogelgesang & Appelrath, 2017). With the aim of maintaining a huge amount of data for analytical processing, data warehouse is the most effective solution (Ghosh, Haider & Sen, 2015). Using OLAP tools, Process Warehouse (data warehouse built for business process analysis) can implement information aggregating, analysis, comparing, mining new process

model and it can improve the quality of an existing process model (Xia, Yao & Gao, 2013).

The event data are spread through multiple database tables, and it is necessary to join these tables with the aim to reconstruct the relationships between them. For that reason, the central tables (tables with facts, cases and events) are joined and the fact table and the event table need to be joined with the dimension tables in order to link the events with their respective dimension level values (Vogelgesang & Appelrath, 2017). The fundamental data warehouse structure that allows a user to conduct multidimensional data analysis is named snowflake schema (Sturm, 2012).

According to Vogelgesang & Appelrath (2017), events can have dimension attributes, which are stored in dimension tables similar to the case dimensions. Additionally, the event table is directly referenced to the dimension tables and dimension values can be different for events of the same case. Dimensional modelling technique is used to build different data marts by using one fact table, several dimension tables, and relationships between them. A fact table is used for storing numerical performance measurements of the business process, while dimension tables contain a description of the business process as its attributes describe it. The primary keys of the tables are used to construct the relationships (Sturm, 2012).

Some of the most important reasons for using enterprise data warehouse systems (DWH) are quick response time, ad-hoc queries and reduction the load on existing productive systems (Kassem & Turowski, 2018). Extract-Transform-Load (ETL) system is important because of the fact that "it is the component responsible for populating the data warehouse, ensuring the right way how data is collected, processed and stored conveniently to support decision-making processes" (Belo et al., 2017). ETL allows organization of analytical data in a multi-dimensional format. Additionally, ETL is also used to migrate data from one database to another, to form data marts and data warehouses, and, finally, to convert databases from one format to another (Ghosh, Haider & Sen, 2015).

3 Methodology

In this section, the methodology used for the research is described.

The research was conducted by examining the existing literature in the fields of process mining and data warehousing. Two scientific databases were used: Scopus and Web of Science (WoS). The queries applied for document search are represented in table 1.

Table 1 Strategies of research

Scopus strategy of research	**Number of articles**
ALL (("process mining" OR "process discovery") AND "data warehouses") AND PUBYEAR > 2009	229
WoS strategy of research	**Number of articles**
ALL FIELDS: (("process mining" OR "process discovery") AND "data warehouse") Timespan: 2010-2020. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.	11

As table 1 shows, almost same keywords were used in searching both databases. Timespan was from 2010 till 2020 year for both databases, as we wanted the newest articles. Search in Scopus resulted with 229 articles, while the search in WoS resulted with 11 articles. Results in Scopus were sorted by relevance. From the 229 results in Scopus, the first 40 articles were taken for "quick analysis", where the titles, keywords and abstracts of the articles were analysed. From 40 examined articles, 12 best matching articles for this research were taken for deeper analysis. All the 11 articles, resulted in WoS, were taken for "quick analysis" where, once again, titles, keywords and abstracts of the resulted articles were examined. Some resulted articles in WoS overlapped with articles in Scopus. Precisely, 7 of 11 articles in WoS appeared also in Scopus. From the rest of 4 articles in WoS, 2 of them were good matching with the needs of this work, and were selected for deeper analysis. Totally, there were 14 articles selected for the analysis in this work: 12 from Scopus and 2 from WoS.

4 Results

In this section, the results of the examined literature are presented. As follows, there are two tables representing the results of the analysed literature. We've tried to determine:

1. the aims and the methodologies of the analysed literature,
2. tools used or researched in previous works and,
3. research area, where process mining and data warehousing were applied.

4.1 Methodologies Used in Previous Works

Table 2 shows the aims and the methodologies of the analysed literature. Common in most literature is usage of OLAP tools to analyse data stemming and process variants. Multidimensional process mining and appliance of it is also often studied. Usually, to reach the data, relational databases and SQL are used. In process mining, one of the aims is to extract process execution data contained in logs in order to see the real state of process execution. This information can be used for further and deeper analysis. The most common methods for process mining are clustering and classification. Prediction of process models allows action discovery and process discovery based on real data.

Table 2 Aims and the methodologies of the analyzed literature

Article name	Aim and a methodology of the analysed literature
"A Generic Data Warehouse Architecture for Analyzing Workflow Logs"	Usage of Sequence Warehouse (SeWA) architecture and OLAP tools to analyse data stemming from workflow logs, including process variants. Usage of PHP scripts, which parse and import a XES file into several tables in the PostgreSQL database and generate sequences of events.
"A Relational Data Warehouse for Multidimensional Process Mining"	The underlying relational concepts of PMCube, a data warehouse based approach for multidimensional process mining; generic query patterns which map OLAP queries to SQL to push the operations to the database management system.
"Connecting databases with process mining: a meta model and toolset"	A meta model in order to integrate process and data perspectives, which are related, is proposed. Automatically obtaining events from database systems. The meta model structure and the data, inserted into it, are stored in a SQLite file, while the process of extracting, transforming and querying data has been implemented in RapidProM workflow.
"A Process Mining Approach for Discovering ETL Black Points"	Using process mining to identify and characterize ETL black points (ETL bottleneck situations). Working example of an ETL system designed and implemented in one course at a university.
"An Integrated Approach to Deploy Data Warehouse in Business Intelligence Environment"	The proposed architecture that integrates business intelligence in On-Line Analytical Processing (OLAP) environment, that incorporates Data Warehouse, Data Mining, Data Mart and Virtual Data Warehouse.
"*Eventifier*: Extracting Process Execution Logs from Operational Databases"	Identification and extraction of process execution events from databases for reconstructing ready-to-use event logs for process discovery.
"Exploring contexts and actions in knowledge process"	An approach about how to automatically discover the contexts on which a business analyst is working in, and the numerous actions a business analyst executes across contexts. Except context discovery, an action discovery is also evaluated using predictive power of process models. Real data were used to resolve a clustering problem.
"Matching of Business data in a generic Business Process Warehousing"	Mapping the business data and integrating them in a data warehouse process model, with the aim to calculate different granularity level of the business process. A mechanism that allows keeping business data as a "separated table outside the multidimensional model and match it to the abstract multidimensional model based on executed events" is proposed. Workflow Mining is used to build a meta business process multidimensional model considering business objects and their attribute values.
"Multidimensional Process Mining with PMCube Explorer"	PMCube Explorer, a novel tool for multidimensional process mining, that allows an analysis of a process from various views, is presented.
"Problems and Challenges When Implementing a Best Practice Approach for Process Mining in a Tourist Information System"	A data warehouse component, that stores process logs in the tourism information system OHA, is implemented. The customer journey process through the tourism platform OHA is analysed. Process logs were gathered, modified, and converted into o format which was convenient for statistical calculations or process mining.

"Research and Design of Process Data Warehouse for Business Process Assessment"	A case study, where a process assessment-oriented warehouse for storage and management of process instance data is presented. A matrix is used to express the relationships among facts and dimensions as well as dimensions and dimensions.
"Supporting business process analysis via data warehousing"	A method for constructing data warehouse schemata from business process specifications is proposed. Snowflake Maker is a prototype in which the rules encompassed within the proposed method were developed. The aims were to facilitate the off-line analysis of the business process execution, and to identify potential improvements by querying the business process performance. Off-line analysis of business processes is done through OLAP using data warehousing.
"A data-mining based method for the Gait pattern analysis"	The method that captures procedures, creates an organized repository (data warehouse), standardizes the data, and develops the steps for process mining, is proposed. The proposed method consists of data classification automation. With the aim to find footprint signature patterns, a graphical analysis is used.
"Ontological approach to enhance results of business process mining and analysis"	A methodology that combines domain and company-specific ontologies with databases, in order to obtain multiple levels of abstraction for analysis and process mining technique. A real case study was performed using a prototype system and techniques developed in ProM. Approach used in the research combines domain ontologies, company ontologies and a company's database to form a knowledge source for process mining.

4.2. Tools and Research Areas of Previous Works

Table 3 represents the tools and the research area of the analysed literature. As already noted by the methodologies of analysed literature, OLAP techniques are widely used by data warehousing and process mining. Relational database, SQL, and all its variations are also often used for data access and querying. In several works, the usage of RapidProM (RapidMiner), Disco and ProM is mentioned, so it can be supposed that these tools are some of the most popular for process mining. Further on, various tools for generating scripts and reports are also popular in the stage of business analysis (e.g., PHP). If there is a sign "-" (minus) in table 3, that means that no tool is mentioned in the work. Research areas, where the domains of process mining and data warehousing are usually applicable, are: health care, multidimensional process mining, and higher education. Reasons for wider application of these domains in these areas could be in good data availability, rapid fluctuation of event records, lower sensibility of data, and economic accessibility of data.

Table 3 Tools and the researched areas of the analyzed literature

Article name	Tools used or researched in analysis	Research area
"A Generic Data Warehouse Architecture for Analyzing Workflow Logs"	OLAP techniques, DM, DDL for Sequential SQL (S-SQL), XES importer, Sequence Cube (data structure).	Workflow Management Systems (WfMS), traditional data warehouses.
"A Relational Data Warehouse for Multidimensional Process Mining"	OLAP queries, SQL, ROLAP (Relational OLAP).	Multidimensional process mining, health care.
"Connecting databases with process mining: a meta model and toolset"	RapidProM, SQLite.	Obtaining, transforming, organizing, and deriving data and process information from databases. Source environments: database redo logs, in-table version storage (Dutch financial organization), SAP-style change tables.
"A Process Mining Approach for Discovering ETL Black Points"	Disco.	Higher education.

"An Integrated Approach to Deploy Data Warehouse in Business Intelligence Environment"	Global B. I. analyser.	Analytical processing in OLAP environment, business intelligence, knowledge & report generation.
"*Eventifier*: Extracting Process Execution Logs from Operational Databases"	*Eventifier* (an integrated platform that includes the components for *eventification*, correlation and process discovery).	Producing process execution events in a fundamentally different context (e.g., there is no access to the information system running the process).
"Exploring contexts and actions in knowledge process"	-	Context mining (collection of documents), Action mining.
"Matching of Business data in a generic Business Process Warehousing"	OLAP Engine, SAP BW (BEx Query Analyzer).	Generic solution evaluated by Business Process Warehousing.
"Multidimensional Process Mining with PMCube Explorer"	PMCube Explorer.	Health care domain.
"Problems and Challenges When Implementing a Best Practice Approach for Process Mining in a Tourist Information System"	Relational database, Java Web server, OHA platform.	Tourist Information System.
"Research and Design of Process Data Warehouse for Business Process Assessment"	XES.	Health care.
"Supporting business process analysis via data warehousing"	BPMN modelling language.	Business process management (BPM), Higher education.
"A data-mining based method for the Gait pattern analysis"	GaitRite system, RapidMiner.	Health care.
"Ontological approach to enhance results of business process mining and analysis"	Process Mining Framework (ProM).	Apparel domain.

4.3. Fundamental Aspects of Literature Analysis

During the research conducted in this article, there were some findings which were noticed and should be highlighted. The findings are consistent with the aims that this research sought to achieve. One of the reason for implementing a data warehouse is reducing the complexity of data contained in event logs which are used in process mining. Besides, the data can have variable structure which can make process mining difficult. The data warehouse is designed to store and prepare logs in order to apply further research techniques like process mining, with the aim of analysing the process and obtaining information for decision making. The data warehouse integrates information into data sources and that is a basis for data analysis. Other advantages of data warehouses are ad hoc queries and quick response time. According to the results from table 2 in this article, the importance of relational databases like PostgreSQL can be noticed, in the sense that those are still some of the most popular tools in data warehousing. The usage of relational databases for data storage facilitates modifying logs and data preparation. It is important to perform a data log analysis and determine the order between the tasks. Workflow log records which task in the business process was performed by which participant, the duration and the processing time of a task. The usage of process mining in data warehouses can increase the efficiency, correctness and performance of ETL systems. We can use multi-relational clustering algorithms, which can handle large data sets that contain information about differences in distributions between resources and events. What is often mentioned is the usage of semantics and semantic technologies in web services, which manage synonyms and different languages of such terms, and convert them into a normalized form to increase the quality of process mining performance. Standard data warehouses do not consider the sequential nature of data stemming from a workflow log. The place for improvement could be in

finding a suitable more advanced type of data warehouse that could consider the sequential nature of data contained in event logs. According to the results from table 3 in this article, most of the existing analytical tools are focused on process mining only or offer basic functionality analysis which is not enough for OLAP analysis. Limitations in data warehouse design may be the lack of guidelines for designing data warehouse schemes or the lack of appropriate analysis of a process perspective, which could be a place for improvement in the form of standardization of a design of a special type of data warehouse.

5 Conclusion and Future Work

In this paper, we examined the existing literature in order to find out which methodologies are used in previous works in domains of process mining and data warehousing. Besides, we thought it would be interesting to perceive the tools used for conducting the analysis in previous works, and to examine the research areas where the process mining is used as a technique together with data warehousing. After conducting the analysis, the importance of OLAP techniques in data warehousing was confirmed. Some of the most popular tools for process mining are RapidMiner, ProM and Disco. Research areas in which process mining and data warehousing are most commonly applied are, e.g., health care and higher education. Future work could be oriented on examination types of data warehouses and their popularity. The advantages and disadvantages of these data warehouses as so as the domains of their application could be explored. Based on selected data from data warehouse, various business process analysis can be performed, and the functionality, as so as the behavior of a process warehouse can be affirmed.

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A Case Study of Students' Usage of a Platform for Digital Competence Certification in Schools*

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Abstract. *In this paper, the authors examine the correlations of variables across constructs – system use, satisfaction, and net impacts from the DeLone and McLean model in the scope of a platform for digital competence acquisition, evaluation and certification. A cross-sectional survey method was implemented online and used to collect 1725 students' answers in six European countries. Descriptive and inferential statistics were used to report data analysis results. Findings indicated that it is possible to implement such platform within a formal curriculum in primary and secondary schools. Also, students' decision on whether they will use the system in the future greatly depends on how the platform contributes to the success of their learning processes. Results also suggest that teachers are inevitable part of such process and are mandatory to achieve the full potential of the platform.*

Keywords. User satisfaction, net impacts, system use, digital competence certification

1 Introduction

Today, a young person needs to acquire a set of digital skills most commonly represented as digital competence (DC) to be able to enter the labour market without the risk of exclusion. The literature review has shown that the best solution for students to acquire digital competences is to integrate them into the formal educational curriculum (Tudor, 2018; Varela et al., 2019). This is further supported by (Casillas Martín et al., 2019; Siddiq et al., 2016, 2017; Zabotkina et al., 2019) who suggest that education and assessment of DC should be started from the earliest age of students and promoted throughout the curriculum. That way, schools could timely identify the lack of a specific DC and intervene with a certain plan of development. However, very few studies have been reported to deal with the assessment of DC at any level of education, especially in primary and secondary education. A three-year longitudinal study (Lazonder et al., 2020) concluded that digital skills do not develop equally over the years of education, e.g. creating information skill has been developing most slowly.

With that respect, an EU funded research project CRISS has been established to develop a standard methodological framework and the online platform for digital competence acquisition, evaluation and certification for students of primary and secondary school (hereinafter referred as CRISS DC platform).

The main aim of this paper is to assess students' satisfaction and use of the CRISS DC platform and to identify and assess the impact such a system has on students' work.

2 Background

Although recent research findings (Cordero & Mory, 2019; Scherer et al., 2019) suggest that teachers are the main drivers for the incorporation of DC assessment and certification into curricula, the main target audience is a population of students who need to benefit from the process. On the other hand, educational systems face a significant challenge to provide its users with an effective learning experience. Outcomes of interaction are most visible after extensive time and effort invested in learning on behalf of students. Therefore, it is up to a system to provide students with an engaging experience to achieve sustainability goals.

Studies have found that students who are satisfied with the system will use it more frequently (Aparicio et al., 2017). Findings also showed that students that could successfully interact with each other and had various ways of learning assessments within the system were more satisfied (Cidral et al., 2018). Students' perception of content structure, functionalities and navigation will also impact their satisfaction and use. The success of the system will be a result of students perceived benefits and attitudes towards the system. With that respect we focus our research on students' perception and define the main research questions:

1. In what ways the CRISS DC platform in primary and secondary schools impacts students' work?
2. What is the relationship between students' use of CRISS DC platform and its impact on the work of students?
3. What is the relationship between students' use of CRISS DC platform and their satisfaction?

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Therefore, the research aims are:

1. To examine the relationship between variables of students' use and impacts of CRISS DC platform.
2. To examine the relationship between variables of students' use and satisfaction with the CRISS DC platform.
3. To propose recommendations for practitioners and future academic research to make advancement in the field of DC platform development.

3 Research Context

Our research context was based on the online CRISS platform for DC acquisition, evaluation and certification that was developed to pilot DC evaluation in primary and secondary schools in Europe. It is based on the CRISS Digital Competence framework (hereinafter referred to as CRISS DC Framework) (Guárdia et al., 2017) that decomposes digital competence into five areas and twelve sub-competences. Each sub-competence is composed of a set of performance criteria (PC) that translate the sub-competences into more specific elements of what a student should be able to demonstrate. Teachers are responsible to plan the learning, to provide feedback and to evaluate activities and tasks that relate to an individual sub-competence. The activities and tasks are retrieved by the CRISS repository and teachers can apply them with or without further adaptations. The students should conduct the activities by performing one or more tasks and generate products (the pieces of evidence) to prove the acquisition of a specific sub-competence.

The assessment of digital (sub-)competence is performed through the CRISS DC platform with two types of interventions: human and technological. Human interventions are carried out by teachers and students using tools like Rubrics, Check Lists, Scales, etc., that are automatically generated by the CRISS DC platform and customized by teachers. The technological intervention is executed by the platform automatically which is set to track the students while working in their assigned activities and to collect relevant information i.e. the indicators of the evaluation of the pieces of evidence. The CRISS platform has been piloted in six European countries (Spain, Sweden, Croatia, Greece, Romania and Italy) for several months with a targeted population of students aged between 9 and 16 years.

4 Method

The method covers the respondents of the conducted survey, a developed and used instrument, and procedure of data collection.

4.1 Participants

The total of 1725 students (47% of boys and 53% of girls) participated in the cross-sectional survey between May and September 2019. They represent the sample of eligible individuals, i.e. students who were actively using the CRISS DC platform for at least one month.

An online survey instrument was distributed to primary (29%) and secondary (71%) students aged between 9 and 20 (M=14.91; SD=1.83) in six countries – Croatia (41.6%), Greece (12.3%), Spain (26.7%), Italy (4.8%), Romania (6.7%) and Sweden (7.8%). Most students were between 14 and 17 years old (80.5%). Only 2% of students reported being older than that.

The survey aimed to examine students' satisfaction and use of the system and the impact it had on them during the acquisition and evaluation of digital competences.

4.2 Instrument

To assess and identify the most relevant factors of students' satisfaction, use and impacts of CRISS DC platform we used three constructs from the D&M Model revised in 2016 (DeLone & McLean, 2016). The first construct, User satisfaction measures users' level of satisfaction with reports, platform, and support services. The second construct, System use measures the feedback on using the capabilities of the CRISS DC platform. The third construct, Net impacts measures the extent to which the platform contributes to the success of users. User satisfaction, System use and Net impacts are measured with five, eight and twelve items, respectively.

The instrument development phase was conducted by following the recommendations from Malgady, Rogler, and Cortés (1996), Straub and Gefen (2004), Vogt, King, and King (2004). We started with the operationalization of research constructs based on the existing measures and modified it with a set of new target-specific measures. Content validity was ensured, besides using an extensive literature review, by using focus groups that involved experts in the field of pedagogy, e-learning, assessment, and teaching methodology. The final measurement instrument (see Table 1.) was translated into all target languages of students. Students could record their answers on a 5-point Likert-type scale.

4.3 Procedure

The final instrument was administered to students using the LimeSurvey. This online survey tool was set not to collect personal data or track IP addresses of respondents. The process of gathering data among students was supervised by their teachers during the class. Afterwards, data were calculated using R (R Core Team, 2017).

Table 1. Instrument after content validity

ITEM
System Use
SU1 I would like to use the CRISS platform again in the future.
SU2 I have all the necessary equipment to use the CRISS platform (e.g. computer/tablet/mobile phone, internet connection).
SU3 I use the CRISS platform to organize and publish my work (ePortfolio).
SU4 I use the CRISS platform to work with other students (teamwork).
SU5 I use the CRISS platform features to tag my work (e.g. homework, seminar, project, images, videos, etc.).
SU6 I use the CRISS platform to see my progress and achievements (grades, badges, etc.).
SU7 I use the CRISS platform to see the progress of other students.
SU8 I use the CRISS platform to communicate with my teacher(s).
User Satisfaction
US1 I like using the CRISS platform.
US2 I find the CRISS platform useful for my learning.
US3 I think it is interesting to use the CRISS platform.
US4 I feel confident using the CRISS platform.
US5 I am satisfied with the CRISS platform possibilities.
Net Impacts
NI1 The tasks in the CRISS platform enable me to be creative in solving them (ingenious, original).
NI2 The CRISS platform makes my learning easier.
NI3 The CRISS platform helps me to see my progress.
NI4 Seeing my progress helps me to improve my learning.
NI5 Earning badges motivates me.
NI6 The CRISS platform helps me to develop new skills (making presentations, sharing my work, finding information on the Internet, online communication ...).
NI7 Within the CRISS platform I easily understand how my work is being assessed.
NI8 I get feedback from my teacher more quickly with the CRISS platform.
NI9 The CRISS platform enabled me to show my work in a more attractive way(s) (e.g. my presentations are more visible and organized/my videos can be accessed easily/I can use portabily to show my different works…).
NI10 The CRISS platform enables me to participate in my assessment (i.e. self-assessment, my comments to the teacher).
NI11 The time spent on activities has been useful to learn.
NI12 When I work in the CRISS platform, I realise the process I follow to solve the tasks.
Notes. Answers on 1-5 point Likert-type scale (1 – Strongly disagree; 2 – Disagree; 3 – Uncertain; 4 – Agree; 5 – Strongly agree; NA – not applicable).

5 Results

During the school year 2018/2019, students used the CRISS DC platform every day (1.9%), almost every day (9.9%), at least once a week, but not every day (47.3%), at least once a month, but not every week (25.3%) and never or almost never (15.5%). Their experience of using the system outside school, but also the use frequency of other digital technologies for learning is shown in Table 2.

The mean values at construct levels are 2.79 (*SD*=1.55) for System use, 2.71 (*SD*=1.48) for User satisfaction and 2.80 (*SD*=1.52) for Net impacts. As expected, the median value for all three question categories is 3.00 which indicates the mostly uncertain perception of system use, satisfaction and impact.

Table 2. Descriptive statistics of use frequency

	a. (%)	b. (%)	c. (%)	d. (%)
Never or almost never	46.9	7.9	6.8	36.6
At least once a month, but not every week	20.6	19.1	19.2	16.8
At least once a week, but not every day	26.8	35.1	27.7	17.6
Almost every day	4.9	23.9	28.2	14.4
Every day	0.8	14.1	18.1	16.6

a. Use of CRISS platform outside the school timing.
b. I use digital technologies in school related to schoolwork (e.g. assignments, communication with other students or communication with teachers).
c. I use digital technologies at home related to schoolwork (e.g. assignments, communication with other students or communication with teachers).
d. I use digital technologies outside the school for learning that is not related to school (e.g. robotics or computer classes).

Table 3 displays a summary of the mean and standard deviation of students' responses for each item. Furthermore, survey responses "5 - strongly agree" and "4 - agree" are combined within column "Agree", column "Neutral" represents all "3 - uncertain" answers while "1 - strongly disagree" and "2 - disagree" are combined within column "Disagree".

Table 3. Aggregated survey response of students

Items	Mean (Std. dev)	Agree (%)	Neutral (%)	Disagree (%)
SU1	2.41 (1.47)	467 (27%)	334 (19%)	924 (54%)
SU2	3.96 (1.33)	1311 (76%)	176 (10%)	238 (14%)
SU3	2.86 (1.53)	728 (42%)	345 (20%)	652 (38%)
SU4	3.10 (1.48)	877 (51%)	290 (17%)	558 (32%)
SU5	2.65 (1.49)	586 (34%)	397 (23%)	741 (43%)
SU6	2.74 (1.50)	664 (38%)	329 (19%)	732 (42%)
SU7	2.30 (1.47)	428 (25%)	303 (18%)	994 (58%)
SU8	2.33 (1.39)	415 (24%)	337 (20%)	973 (56%)
US1	2.47 (1.48)	514 (30%)	343 (20%)	868 (50%)
US2	2.75 (1.45)	643 (37%)	352 (20%)	730 (42%)
US3	2.73 (1.50)	635 (37%)	340 (20%)	750 (43%)
US4	2.76 (1.50)	655 (38%)	352 (20%)	718 (42%)
US5	2.84 (1.47)	683 (40%)	359 (21%)	683 (40%)
NI1	2.95 (1.44)	721 (42%)	399 (23%)	605 (35%)
NI2	2.61 (1.43)	528 (31%)	424 (25%)	773 (45%)
NI3	2.81 (1.49)	683 (40%)	365 (21%)	677 (39%)
NI4	2.91 (1.52)	732 (42%)	367 (21%)	626 (36%)
NI5	2.46 (1.66)	560 (32%)	353 (20%)	812 (47%)
NI6	3.02 (1.49)	783 (45%)	381 (22%)	561 (33%)
NI7	2.94 (1.52)	753 (44%)	352 (20%)	620 (36%)
NI8	2.67 (1.55)	627 (36%)	363 (21%)	735 (43%)
NI9	2.82 (1.54)	678 (39%)	399 (23%)	648 (38%)
NI10	2.7 (1.52)	618 (36%)	429 (25%)	677 (39%)
NI11	2.83 (1.52)	695 (40%)	361 (21%)	669 (39%)
NI12	2.93 (1.50)	755 (44%)	346 (20%)	624 (36%)

The mean of answers for System use fluctuates from 2.30 (SU7) to 3.96 (SU2). The highest standard deviation was reported for item SU3 (1.53) regarding the organization and publication of students' work via

ePortfolio. In the satisfaction category, item US5 has the highest mean value of 2.84 and US3 the lowest (2.73). Items NI6, NI1, NI7 and NI12 have the highest mean values 3.02, 2.95, 2.94 and 2.93, respectively. The lowest mean value is reported for NI3 (2.81). Although, there are many items that students are in disagreement with, here we will single out items with a higher percentage of positive responses – SU2, SU3, SU4, NI1, NI3, NI4, NI6, NI7, NI9, NI11 and NI12.

The Pearson correlation coefficient is calculated for variables across three constructs and results are interpreted according to Evans (1996): 0.00 - 0.19 (very weak), 0.20 - 0.39 (weak), 0.40 - 0.59 (moderate), 0.60 - 0.79 (strong) or 0.80 - 1.0 (very strong). The significance of correlations among the variables is tested at $p<0.01$. In Table 4, there is a very strong and significant relationship between SU1 and US1 (r=0.86; $p<0.01$) indicating that students who like to use the platform would like to use it in the future as well. Variable SU2 has weak, although significant relationships ($p<0.01$) with all the other satisfaction variables. Although the correlation between SU1 and US3 is fairly large, it is not significant ($p>0.05$), so there is a high chance this relationship does not exist in the population. All other relationships in Table 4 are moderate to strong and significant ($p<0.01$).

Table 4. Correlations between System use (SU) and User satisfaction (US)

	US1	US2	US3	US4	US5
SU1	**0.86**	**0.76**	0.80**	**0.67**	**0.74**
SU2	0.26	0.32	0.30	0.34	0.34
SU3	**0.60**	**0.63**	**0.64**	0.58	**0.63**
SU4	0.48	0.53	0.51	0.47	0.53
SU5	0.58	**0.60**	**0.60**	0.54	**0.62**
SU6	**0.66**	**0.66**	**0.67**	**0.60**	**0.68**
SU7	**0.60**	**0.60**	**0.60**	0.54	**0.60**
SU8	**0.62**	**0.63**	**0.60**	0.54	**0.60**

Notes. All correlations are significant at the 0.01 level (2-tailed); **except between the variables SU1 and US3. Bold correlations are considered 'strong' or 'very strong'.

Table 5. Correlations between System use (SU) and Net impacts (NI)

	SU1	SU2	SU3	SU4	SU5	SU6	SU7	SU8
NI1	**0.71**	0.41	**0.67**	0.56	**0.64**	**0.69**	**0.61**	0.59
NI2	**0.74**	0.30	**0.63**	0.55	**0.65**	**0.71**	**0.65**	**0.67**
NI3	**0.70**	0.35	**0.65**	0.56	**0.68**	**0.75**	**0.64**	**0.65**
NI4	**0.67**	0.30	**0.61**	0.48	**0.61**	**0.68**	0.59	**0.60**
NI5	**0.68**	0.29	0.59	0.49	**0.63**	**0.68**	**0.62**	**0.60**
NI6	**0.67**	0.39	**0.62**	0.54	**0.62**	**0.67**	0.58	0.58
NI7	**0.64**	0.39	**0.61**	0.51	0.59	**0.65**	0.59	0.56
NI8	**0.65**	0.31	**0.60**	0.51	**0.60**	**0.66**	0.59	**0.61**
NI9	**0.72**	0.36	**0.66**	0.57	**0.66**	**0.72**	**0.67**	**0.64**
NI10	**0.68**	0.34	**0.65**	0.54	**0.65**	**0.70**	**0.65**	**0.64**
NI11	**0.75**	0.31	**0.63**	0.54	**0.62**	**0.71**	**0.64**	**0.64**
NI12	**0.71**	0.39	**0.64**	0.55	**0.61**	**0.68**	**0.62**	**0.63**

Notes. All correlations are significant at the 0.01 level (2-tailed). Bold correlations are considered 'strong' or 'very strong'.

In Table 5 there are numerous moderate to strong and significant relationships (r between 0.40 and 0.79; $p<0.01$). Variable SU2 has only one moderate and significant relationship with the NI1, while all others are weak (r between 0.29 and 0.39), but significant.

6 Discussion

Data from the survey instrument is used to assess and identify the most relevant factors of students' satisfaction, use and net impacts of CRISS DC platform.

The first research question was: *In what ways the CRISS DC platform in primary and secondary schools impacts students' work?* For that purpose, we identified twelve items under Net impacts category. Results indicate that students perceived platform helpful in developing new skills and they could easily understand how their work is being assessed. Furthermore, they were able to be more creative in solving the tasks. On the other hand, student less considered earning badges was essential to their motivation to use the platform.

The second research question was: *What is the relationship between students' use of CRISS DC platform and its impact on the work of students?* The decision of students to reuse the platform in the future would be impacted by all twelve listed net impacts, but only the strongest relationships will be listed: usefulness of spending time on the platform, easier learning, more attractive way of presenting solved tasks, insight into the process of solving the tasks, and others. Both, necessary equipment to use the platform and teamwork with other students are to a less extent influenced by net impacts. Although, the strongest relationships in both cases are related to creativity, the attractiveness of their work and progress tracking. Generally, most of the people found important they can creatively express themselves and get proper feedback for it. Students used ePortfolio to organize and publish their work, but they could not earn the badge which is confirmed by a weaker connection. The same case is between tagging their work and understanding of assessment because they are related to a lesser extent. Results confirmed the CRISS DC platform helps students to effectively track their progress and achievements which in turn makes their learning easier than usual. Knowledge of what they have achieved in real-time gives them a sense of useful utilized time. The fact that students can see the progress of other students positively affects their work. Findings also confirmed the significant relationship between the communication with the teachers via the platform and students' easiness of learning.

The third research question was: *What is the relationship between students' use of CRISS DC platform and their satisfaction?* In this research we did not found a statistical significance between students' decision to continue using the platform again in the

future and whether they consider it to be interesting to use. On the other hand, their decision would be impacted by whether they like using the platform, found it useful for learning or feeling confident and satisfied while using it. Also, they would use ePortfolio for organizing and publishing their work because they have found it interesting. Furthermore, they can use the CRISS DC platform to tag their work and it seems to them as a satisfactory possibility. Overall, the platform gives them proper feedback which they like, consider useful, interesting and it boosts their confidence. It is interesting observing that seeing the results from their colleagues influence their confidence less. The same result is with communication with their teachers.

7 Conclusion

This research addressed the problem of measuring and investigating the relationship between user satisfaction, system use and net impacts of cloud-based infrastructure for acquisition, evaluation and certification of digital competence in primary and secondary education focusing on students' perspective.

It can be concluded that students' confidence is a result of being able to check self-progress and achievements in real-time. It can also impact their decision to use the system again in the future. Whether they have the necessary equipment to use the platform will not affect their satisfaction because most of them have optimal requirements at school. Possibly, they haven't worked a lot with other students in teams, because no stronger relationships were found. Use of educational platforms can be improved if students consider it useful for their learning and if it has satisfactory possibilities. Future studies should analyse which possibilities students liked the most and practitioners could implement it as a baseline in future platforms. Regarding the CRISS DC platform, students were most satisfied with the possibility to track their progress and achievements (grades, badges, etc.) as results of their learning. Nevertheless, they also found it important that they can organize and publish their work, but also to see the progress of other students and to efficiently communicate with their teachers.

Although, students' decision on whether they will use the system in the future greatly depends on how the platform contributes to the success of their learning processes. Students found it important to be able to creatively express themselves, attractively publish their work and get proper feedback for it. The gamification elements of the system like earning badges form an important aspect based on which learning can be directed. It is also important that students can see the achievements of other students because it positively impacts their motivation toward education. Their learning is also much easier when they have effective communication with their teachers gained via the platform.

According to our knowledge, CRISS DC platform is the first attempt to create a comprehensive, cloud-based solution for digital competence acquisition, evaluation and certification in Europe, and to pilot such solution within a formal curriculum of primary and secondary schools in six European countries. In that sense, this research further contributes to the field by identifying the most important impacts such system has on the target audience. Also, the results should be encouraging for schools that plan to implement such systems or for those who plan to develop them.

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Aspects of Information Literacy in Higher Education - An Overview

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Abstract. *The paper presents the concepts of information society and knowledge society, their importance for general social development and improvement, with an emphasis on the role and contribution of higher education and academic libraries in the realization of these concepts. Their implementation and full development potential depends on training students to navigate information abundance, search, evaluate and use information, in other words – on improving their information literacy skills. Information literacy has been extracted as a key component that libraries in higher education must include in their new, redefined approach to their work and support provided to sudents by the home institution. In order to achieve this, it is necessary to implement information literacy in the curriculum. Information literacy skills are particularly important in today's business environment that is increasingly dependent on knowledge management systems.*

Keywords. Information society, information literacy, academic libraries, knowledge management

1 Introduction

The changes faced by modern society have necessarily initiated changes in the higher education system, whose basic tasks and goals must be harmonized with the basic features and requirements of the information society and the knowledge society. Terms such as information society, networked society, knowledge society or new economy all refer to the achievement of a common goal, which is global social and cultural development. The process of globalization and its impact on the world economy, politics and culture has benefited most from the developed world, and implies constant participation and investment in knowledge, technology and development. People, their knowledge, skills and ideas have been identified as the most important resources in this process. The prosperity and progress of the society are most closely linked to the ability and willingness to monitor and anticipate change, wherein one of the important conditions is a satisfactory number of highly educated individuals who are able to actively participate in the modern information society. In this sense, higher education has a key role to play in preparing citizens for inclusion and participation in the information society, which is determined by knowledge and technology. It is not surprising, therefore, that the term information literacy originated in the academic sector where it achieved its greatest rise. Information literacy plays an important role as a driver of change in higher education, which is increasingly determined by the dependence of national economies on knowledge (Špiranec, 2008). The quality of the educational process is closely related to the skills that are relevant and competitive in the labor market. It is information literacy that provides the competencies through which students - future employees, are trained to solve problems, find and use available information sources, and thus be prepared for lifelong learning.

The paper proposes models of integrated or embedded approaches to information literacy at the higher education level, because in this way they develop not only generic but also specific skills of information literacy, with information literacy itself included in the learning outcomes within the institution's curricula. This extends the activities of higher education institutions to address broader issues of society. The paper is organized as follows: The following chapter gives a brief overview of the origin and development of the concept of information literacy and its impact on the knowledge economy. Section 3 explains the importance of information literacy in business. Section 4 discusses the importance of information literacy and its relationship with the academic environment. Changes in higher education have necessarily triggered changes in the organization and operation of academic libraries. This is particularly pronounced in the context of information literacy, which in the academic environment begins precisely in libraries. The section of the paper therefore emphasis systematic advocacy and encouragement of various forms and models of user education as a regular activity found in most libraries of Croatian higher education institutions. Models and types of information literacy in higher education are presented. Chapter 5 introduces a case study on the ways and possibilities of implementing information literacy in higher education institutions in

Croatia on examples of particular academic libraries. Finally, Section 6 concludes the paper.

2 The Role of Information Literacy in Information Society

The World Summit on the Information Society (WSIS, 2015), held in two phases - in 2003 in Geneva and in 2005 in Tunisia, adopted the basic starting points of the United Nations member states on global development goals in the field of information society, as well as established the obligation to meet the set goals. In its first phase, held in Geneva, the chapter entitled Capacity Building discussed education and information literacy as key factors in building the information society in a way to enable each person the opportunity to acquire the necessary skills and knowledge to understand, actively participate and make full use of the benefits offered by the information society and the knowledge economy. To become a full member of the information society depends to a large extent on the possibilities of increased capacity building in the field of education, know-how technology and access to information, which are the main factors in determining development and competitiveness. In his article Foundations of information literacy, the library science theorist Badke (2010), gives an overview of the work of Paul Zurkowski, who first used the term information literacy over forty years ago, including a quote from the Report to the Narional Commission for Libraries and Information Science by Zurkowski: "Information is not knowledge; it is concepts or ideas which enter a person's field of perception, are evaluated and assimilated reinforcing or changing the individual's concept of reality and/or ability to act ." To clarify this concept, Zurkowski continues: "People trained in the application of information resources to their work can be called information literates. They have learned techniques and skills for utilizing the wide range of information tools as well as primary sources in molding information solutions to their problems" (Badke, 2010). In the review of his work it is also argued that Zurkowski saw the information age as a new reality, a completely new age in which our ability to possess and use the best information means the maintenance and prosperity of the society. He believed that every citizen, in the interest of democracy and personal well-being, must be as information literate as possible (Badke, 2010). Since the introduction of the term information literacy, many theorists have been concerned with defining that concept. One of the most commonly used definitions is certainly one that is published by the American Library Association (ALA), which defines information literacy as a set of individual abilities which allow an individual to recognize when information is needed and enable them to locate, evaluate and use the required information effectively. Furthermore, information literate individuals are those who have learned how to learn, because they know how knowledge is organized, how to find information and how to use it in a way that others can learn from them. They are prepared for lifelong learning, because they can always find the information for any task or decision (American Library Association [ALA], 1989). Such skills appear to be particularly important in a business environment. Knowledge-management-oriented organizations often face challenges that can be more easily addressed through information literacy. Regardless of the presence of the technological infrastructure, the skills that employees have to convert information into resources needed for problem solving and decision making are also necessary (Špiranec, 2008).

3 The Importance of Information Literacy in Business

Knowledge-based economy is one of determinants of modern business.. In the knowledge-based economy, high priority is put on knowledge which means that most jobs require highly skilled workers (i.e. human capital) for problem-solving activities, technological innovations of new products and processes (i.e. research community), use of information and communication technologies (including big data management, effective work and exchange of knowledge, performance measurement, and similar), learning organization (acquiring and creating new knowledge through collaborative relationships), among others (Sekovanić and Lovrenčić, 2019). Timely access to information and knowledge is an important strength of an organization (Mizintseva and Gerbina, 2018), which is why business is increasingly focused on knowledge management (KM). In short, KM implies the processes of creating, managing, sharing and using organizational knowledge and information (Girard & Girard, 2015). People are a source of knowledge (in particular, valuable tacit knowledge), so they are the most important element of KM. In addition to people, KM technologies are especially important as support for ensuring information flow. In general, KM technologies include a range of support for communication, collaboration, dynamic learning, problem solving, strategic planning, and decision support. Graph databases, knowledge bases, learning managment system (LMS), conferencing tools, webinasr, data analytics and visualisation, document management systems (DMS), decision support systems (DSS), expertise localization systems and artificial intelligence technologies are just some of the examples of KM technologies. There are also many new technologies that can be incorporated in KM, such as big data and analytics, semantic

technology and natural language processing, machine learning, cognitive computing, augmented reality, Internet of Things and smart machines (Lovrenčić and Sekovanić, 2019). KM technologies make people's work easier (daily work or routine, quick access to information and knowledge regardless of the source or location of employees, decision support, learning, codification of knowledge, establishment of an innovation platform, and so on), provided that they know how to use them, in other words - that they are information literate. Contemporary business requires effective knowledge exchange and better job performance (Mizintseva and Gerbina, 2018), improved productivity, innovation, customer satisfaction, competitive advantage, and improved organizational performance (Gholami, Asli, Nazari-Shirkouhi and Noruzy, 2013), as well as constant improvements in learning and problem-solving skills (Akram andHilman, 2018) and organization's decision making process, teamwork, among others. Employees become a source of knowledge, ideas and improvements for products, services, new business models, strategies, organizational or technology processes and applications, and so on (Sekovanić and Lovrenčić, 2019). Employee knowledge, expertise and commitment are crucial elements of innovation (Fındıklı, Yozgat and Rofcanin, 2015). Activating acquiring, creating, or integrating capabilities of the organization would not be feasible without knowledgeable and skilled employees (Akram and Hilman, 2018). The complexity of the job increasingly requires information literate individuals. A man who works poorly in a modern job (not information literate) is holding back a job and cannot survive in a particular occupation in the long run. It is therefore extremely important to prepare students for the changing labor market so that they know, not only how to retrieve information, but also how to turn it into knowledge.

4 Information Literacy and Academic Libraries

4.1 The Role of Libraries in Academic Information Literacy Education

One of the documents that elaborates and describes in great detail the elements of information literacy that are specifically relevant to the higher education level.is the American Society for Higher Education Libraries' Information Literacy Standards. In that document an information literate person is described as a person who is able to:

- Determine the scope of the information need
- Access the necessary information effectively and efficiently
- Critically evaluate information and its sources
- Use information in a way to achieve a specific goal
- Understand the economic, legal and social issues of using information, and access and use information in an ethical and legal manner (The Association of College and Research Libraries [ACRL], 2000).

The mission of every higher education institution as well as any library that operates within it is to produce educated young people who are able to successfully participate in a society based on knowledge and technology. As higjlighted in Divjak et al. (2008), the mission of a modern university is to participate in the development of the society, and for achieving this goal its fundamental educational role must be completed, which ultimately results in enabling the student to learn, understand and know how to do it. In a society whose main potential lies in highly educated people, the importance of the higher education system with higher education libraries as a systematic support for action comes to attention. Libraries in higher education as units within higher education institutions have always been considered as an active partner in the process of learning and knowledge production. However, in the current circumstances, they inevitably have to change the ways and patterns of action. Since libraries, as an important part of the higher education system, are faced with changes in the way they work and operate, they must necessarily follow modern social concepts and trends. This is primarily realized in their support for the new, modern education system, whereby libraries can contribute to the excellence of their home institutions. The skills of searching, evaluating and using information are the skills of an information literate person that are necessary for successful inclusion in the modern information society. Active participation of libraries in educational programs that enable and train students for independent learning and research is therefore vital. In this way, higher education libraries partly take on the role of bridging towards successful inclusion in the information society. Information literacy is recognized as a key category in the process through which higher education libraries should fulfil their task of advancing academic education and thus in encouraging information literacy projects, as highlighted by IFLA, ACRL and other professional associations. Providing training about searching, evaluating and using information to all students is a requirement set by the information society today to higher education institutions. Teaching about searching, evaluating and using information must be provided to all students and this is what the information society today sets as a requirement for higher education institutions. Librarians have begun to recognize the need to move away from a library and information retrieval centred view of information literacy towards a broader understanding of the role of information literacy and the librarians as information professionals in fostering student learning (Bruce, 2003). Literacy means cooperation and joint action of higher education libraries and teaching. In particular, by adopting and advancing through undergraduate and graduate

programs, students must have the ability to continually search, evaluate, manage, and apply information gathered from a variety of sources and obtained through research methods for a particular discipline. This trend is best reflected in the well-known concept of transforming learning from tool-based learning to concept-based learning. This means that, owing the changing technologies, it is necessary to move away from teaching students how they work, and instead focus on the concepts of solving information problems regardless of space or medium (Špiranec and Banek Zorica, 2008, 96-97). Achieving information literacy in such a way implies an understanding that it is a development that follows the curriculum, and represents an integral part of its content, structure and outcomes. Likewise, information literacy is not the outcome of a single subject or course, it is a cumulative experience, shaped by a series of subjects and learning-based experiences, that together create an information literate person (Bundy, 2004).

4.2 Information Literacy Models for Higher Education

Bruce (2003) highlights four critical components of an information literacy program:
1. Resources that enable the learning of specific skills, e.g. web based information skills enhancement packages and other point of need, or self-paced instruction.
2. Curriculum that provides the opportunity to learn specific skills at the beginning of the course or at point of need (integrated)
3. Curriculum that requires engagement in learning activities that require interaction with the information environment (embedded)
4. Curriculum that provides opportunities for reflection and documentation of learning about effective information practices (embedded).
Based on the above division, the current practice of designing information literacy curricula incorporates a mix of generic, parallel, integrated and embedded components and could be presented as four basic models of information literacy (Table 1):

Table 1: Information literacy program components

Generic	Extra curricular classes and/or self paced packages
Parallel	Extra curricular classes and/or self paced packages that complement the curriculum
Integrated	Classes and packages that are part of the curriculum
Embedded	Curriculum design where students have ongoing interaction and reflection with information

Source: Australian over New Zealand information literacy framework: principles, standards and practice. / editor Alan Bundy. Adelaide: Australian and New Zealand institute of information literacy, 2004.

The most effective model is the embedding of information literacy throughout the curriculum where information literacy is included into learning objectives and outcomes as an integral part of the curriculum. The contents of course in such a curriculum is interlaced with information literacy, which improves the quality of teaching, and is implemented through a partnership between teachers and librarians. On the other hand, extra curricular or parallel and generic models are courses of a general type focused on neutral skills and techniques of searching and finding information, and are conducted by librarians themselves. In the integrated model, classes are offered in addition to a course and are organized by the librarian at the request of the teaching staff. Like two previous models, the integrated model is not effective enough because of a lack of systematic and continuous processes in its implementation.

5 Academic Libraries in Croatia - A Case Study on the Inclusion of Information Literacy in the Curriculum

In most cases academic libraries in Croatia maintain their own information literacy programs and methods of implementation. As a consequence, no unique model of information literacy exists, as can be seen in published reviews of libraries' experiences. The most common forms of lectures are workshops with voluntary participation, although there are some examples of the inclusion of information literacy in the curriculum.

5.1 Library of the University of Zagreb, Faculty of Organization and Informatics

The Library of the University of Zagreb Faculty of Organization and Informatics is systematically developing services intended for user education in the form of training and printed and online tutorials. There are several different forms and ways of training that the library conducts. In addition to the workshops that take place in the library, they are also organized and performed within particular courses at the invitation of the teaching staff. Workshops that take place in the library represent the so-called extracurricular or parallel information literacy model to which students respond voluntarily and on their own initiative. The content of such workshops can be thematically determined and organized for smaller groups of participants. Library workshops at the invitation of the teaching staff within one of the courses are organized

and conducted at the beginning of each academic year. All students enrolled in the first year of study undergo an education that includes an introduction to library services and broader aspects of academic literacy. This type of workshop corresponds to the intercurricular or integrated model where information literacy is offered as a supplement to the subject, and the presence of students in the workshops is mandatory. The library provides its educational content to users through printed and online tutorials, and is also present on Moodle with topics in the field of searching and using available resources, through which the library has become involved in e-learning.

5.2 Best Practices in Information Literacy

5.2.1 Central Medical Library of the University of Zagreb, School of Medicine

The Central Medical Library of the University of Zagreb, School of Medicine has the longest tradition of participating in the curriculum with its own information literacy modules. There is a compulsory course at the graduate study called *Introduction to Scientific Work in Medicine*, which is performed entirely by the Central Medical Library. The course is taught in the second and fifth year of medicine, and is combined with two other subjects - Medical Statistics and Medical Informatics. The total of hours, including lectures, seminars and exercises is 30. In addition to this compulsory course, at the graduate level of study there is an elective course named *It is important to find valid evidence* that also focuses on student information literacy processes. Both courses represent an embedded model of information literacy, which is an integral part of the curriculum.

5.2.2 Library of the University of Rijeka, Faculty of Law

In cooperation with the teaching staff and librarians, the Faculty organizes and carries out different programs for developing information literacy, such as workshop and lectures, intended for students at different years of study and in different courses. Such activities are carried out at the first year of the integrated study of Law and Administrative Studies in the course - Legal Writing, as well as at the third year of the integrated Study of law, as part of the research seminar - European Law II. The library has developed a model of embedded approach to information literacy within which information literacy is included in the goals and outcomes of each course in the field of law (Golenko, 2016).

5.2.3 Library of the University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture

The Library of the Faculty of Mechanical Engineering and Naval Architecture of the University of Zagreb is a partner in a course called *Academic Literacy*, where the librarian conducts laboratory exercises for students. The course consists of 30 hours of lectures and 15 hours of laboratory exercises, which totals 45 hours, which amounts to 6 ECTS credits. The aim of the course is to provide students with the knowledge and skills necessary for quality information retrieval and analysis, to enable them to evaluate information sources, for written expression and publication, as well as for lifelong learning. The course represents an embedded model of information literacy, which has been identified as the most acceptable model.

5.2.4 University Library of Zadar

At the Universiti of Zadar, information literacy is carried out in the form of an elective course which is also an example of the embedded model of information literacy. It is intended primarily for first-year undergraduate students, but can also be enrolled by senior students. The course *Information Literacy* is commonly taught by teachers from the Department of Information Sciences and librarians from the University Library of Zadar. The aim of the course is to enable students to search, find, evaluate and use information and information sources in academic education. The course amounts 3 ECTS credits.

6 Conclusion

Information literacy is a concept that represents the umbrella literacy of the information society. Education in this area is the activator needed for the transition of the information society to the knowledge society as the society of the future. Successful participation in the new knowledge-based society requires information literate citizens trained for lifelong learning. It follows that information literacy with its basic goals and tasks largely solves this problem. The technology and skills needed to use it are no longer sufficient, as information management skills are needed to fully exploit the potential of the information society. In a business sense knowledge is a crucial asset that enables organizations to act while ensuring a positive return (e.g. competitive advantage, innovation, improvements in productivity, financial and staff performance, customer satisafaction, among others). In the field of higher education, academic libraries have been developing models and strategies for including information literacy in the curriculum to enable a more efficient preparation for the knowledge society. In this sense, it is necessary to encourage the development of information literacy programs in accordance with models based on collaborative and integrative approaches of academic and library staff in curriculum design. In this both generic and contextual information literacy skills of students in different educational fields can be equally developed.

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Users' Needs Assessment for Chatbots' Use in Higher Education

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Abstract. *Higher education comprises an important field for the application of chatbots, especially for large-scale use. This paper reports on a needs assessment that was conducted with higher education users (i.e., educators and students) for examining their needs and expectations on chatbots' integration in educational settings. The study was conducted in the context of a research project that includes a series of iterative pilot studies of the use of chatbots in higher education. We report on findings from one of the pilots based on data from semi-structured online interviews with higher-education students and educators. A thematic analysis of the interview data resulted in different themes of needs that users have in education. The outcomes of this study indicate that higher-education users need technological solutions that can support content delivery, formative assessment implementation with the provision of qualitative feedback, research tasks processing and social bonding facilitation. Those findings, along with interviewees' suggestions on functionalities and features that chatbots should have, provide guidelines and recommendations for the design, development, and implementation of different scenarios of the use of chatbots in higher education.*

Keywords. Higher Education, Chatbots, Needs Assessment.

1 Introduction

'A computer, program, algorithm or artificial intelligence which communicates with a person or another participant of the communication can be called a chatbot' (ZEMČÍK, 2019, p. 14). Chatbots comprise computer programs that are used to simulate auditory and/or textual conversations with users, or other chatbots using natural languages (Shawar & Atwell, 2007). Chatbots - also called machine conversation system, virtual agent, dialogue system, and chatterbot - commonly appear in customer services responding to frequently asked questions (FAQs) and offering technical support, in business webpages for selling products, and as personal assistants on mobile devices (Serban, et al., 2017). They are becoming a trend in many fields such as medicine, product, and service industry, and lately in education.

Chatbots' conceptualization emerged from the need of human to interact with computes in a natural human language. A key milestone in the pre-history of chatbots holds in the so-called Turing test. In the 1950s, the possibility of training a computer machine to launch conversations with users led Alan Turing proposing the Turing test; a program that developed a text message conversation with a prober for five minutes (Turing, 2009).

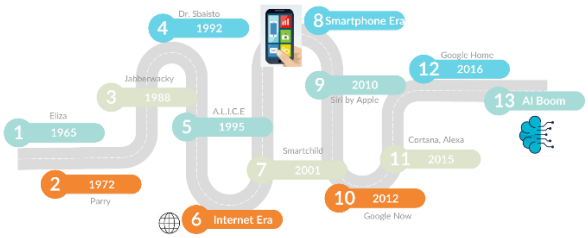


Figure 1. Timeline of chatbots

Following this, ELIZA, the first chatbot in the history of Computer Science was created in 1964-1966 by Joseph Weizenbaum at Massachusetts Institute of Technology (MIT) (Kane, 2016; Khan & Das, 2017; ZEMČÍK, 2019). ELIZA used simple pattern matching and a template-based response mechanism to imitate the conversational style of a nondirectional psychotherapist, in the early scenario called DOCTOR. A record of resultant chatbots which were developed following this critical milestone, encompasses, among others, Parry (1972), Jabberwacky (1988), Dr. Sbaisto (1992), and A.L.I.C.E. (1995) (see Figure 1). The use of chatbots increased dramatically with the massive expansion of the Internet and especially social networking sites. Chatbots have been further advanced in the last decade, due to the development in natural language processing and machine learning algorithms, such as deep learning and neural networks which

perform Artificial Intelligence (AI) tasks like Image Recognition, Natural Language Generation, Speech Recognition and Text to Speech Synthesis (Khan & Das, 2017).

1.1 Global Trends and Analysis

The chatbot industry has flourished a lot in recent years, demonstrating the strength and opportunities in this direction. Even though the idea of chatbots appeared first in the 1960s, it took more than half a century for the world to become ready for implementation into real life -- mainly thanks to the rapid progress in natural language processing, AI, and the global presence of text messaging applications. At the same time the text communication became the socially acceptable form of personal interaction, as this can has become evident from the massive usage of messaging apps worldwide. People increasingly prefer chatting over a mobile device, rather than personal contacts or even making phone calls. Technology high rollers, such as, Microsoft, Facebook, Google, Amazon, IBM, Apple, Samsung etc., provide several possibilities to the users for accessibility in open platforms and chat applications, in which chatbots make their appearance.

In relation to the current trends on the use of chatbots, statistics from Statista (2018) demonstrate the preferences of customers who interact with different customer services online, between a chatbot or virtual assistant and a live customer service representative, as of 2017. At the time of the survey, 34 percent of respondents stated they would be comfortable receiving customer service from AI in an online retail situation, whereas, healthcare and telecommunications were detected to be the second and the third in respondents' preferences correspondingly.

Essential to consider along these lines is the fact that, many consumers are showing reluctance to use new applications, let alone that it is unprofitable to create, promote and bring into operation some new application, that will ultimately make no use (Commerce Times, 2017). This trend may be considered by developers while choosing the medium through which new chatbots are developed and can be accessed (i.e., web-based applications that run on a remote serves and can be accessed through a web page, Vs stand-alone applications).

1.2 Chatbots in Education

While the presence of chatbots, on web platforms and/or standalone applications, is already substantial in customer services, business webpages, products sales, and in health interventions, their use for educational purpose is still in its infancy. A meaningful integration of chatbots in higher education presupposes a good understanding of users' needs and expectations, as well as, an examination of their perceptions towards educational technology (Keller & Cernerud, 2002; Popovici & Mironov, 2015), the adoption of an appropriate pedagogy (Gonda, Luo, Wong, & Lei, 2018), and last but not least, a confrontation of technological challenges and potential limitations, that relate to the Natural Language Processing (NLP) research field (Yan, Castro, Cheng, & Ishakian, 2016). In this paper we focus on the examination of users' needs and expectations in relation to the use of chatbots in education.

Previous research focusing on the examination of higher education users' needs and expectations on the use of chatbots in education has already been done to some extent, projecting possible uses of chatbots in education (e.g., Gupta, et al., 2019; Lee, et al., 2019; Stathakarou, et al., 2020; Thies et al., 2017). Findings of those studies outline the potential use of chatbots as career advisors (see Lee, et al., 2019), or intelligent tutors answering student questions (Gupta, et al., 2019). Furthermore, the intentional design and development of personalities for chatbots - building on a need analysis outcome derived from exploratory interviews and focus groups with students - is documented in the work of Thies et al. (2017). Their findings revealed students' needs and expectations on having a chatbot helping them become knowledgeable and successful in their career aspirations; interviewees in the same study also referred to the need of having an entertaining chatbot, with whom they could share fun experiences. Finally, there were a few others who wanted the bot to listen to them, help them improve their soft skills and help them become desirable in their social circles (Thies et al., 2017). Those findings indicate an association between the chatbot personality and the kind of user-chatbot interactions that might take place.

Moreover, chatbots have been examined for their potential in healthcare education with a focus on how the design characteristics of chatbots (i.e., recognition; visibility of system status; anthropomorphism in communication; knowledge expertise, linguistic consistency; realistic interaction) may enhance the feeling of trust (Stathakarou et al., 2020). Even though those findings emerge from healthcare education, they suggest the potential of chatbots to support students in a personalized and interactive way.

2 This Study

This manuscript reports on a needs assessment study which took place in the context of the EDUBOTS (Best practices of pedagogical chatbots in higher education) Erasmus Plus Project and a European Union's Horizon 2020 Project. This work contributes to the current state of knowledge on chatbots, in the sense that we tried to explore in a more holistic manner the needs of higher education users (i.e., both students and educators) who have different backgrounds. We report a qualitative

investigation of the potential use of chatbot in higher education. In this respect, the present study focuses on fulfilling the needs and expectations of higher-education students and educators, with the introduction of a chatbot in higher education settings. The following research questions were sought to be addressed:

(1) What are the needs and expectations of higher education students and educators for the use of chatbots in higher education?
(2) What are the proposed features and functionalities that chatbots should have to meet these needs and expectations?

3 Methodology

3.1 Participants

Ten higher education instructors (3 females and 7 males) and eight undergraduate students (2 females and 6 males) from different local universities in Cyprus and with different backgrounds (i.e., Multimedia and Graphics Arts, Computer Science, Sports & Exercise Science) participated on a voluntary basis in this study. All the participants consent to anonymously use the data for research purposes.

3.2 Data Collection

Semi-structured interviews were driven by a protocol, developed by the authors. The interview protocol included a demographic data section, followed by a second section with eight questions concerned with users' previous experience with chatbots (e.g., *Have you ever interacted with a chatbot before? If yes, how did you use the chatbot exactly? How was your overall experience? Positive, negative? Why?*), and a third section of four questions focusing on their expectations on a potential chatbot use in education for easing the learning/ teaching process, the social bonding among users, and any other scenarios that they could think of (e.g., *In your opinion, could a chatbot facilitate your learning/teaching progress? How? Please explain your reasoning. Can you describe a scenario where the chatbot serves your needs in this context?*). During the interviews and while discussing questions from the third section, the interviewees were prompted to also refer to specific features and functionalities that chatbots should have for meeting their needs and expectations.

3.3 Data Analysis

The interviews were transcribed verbatim. A thematic analysis approach (Patton, 2015) was adopted, involving an open coding process followed by clustering of the emerged codes into broader themes portraying: (1) users' needs and expectations for the use of chatbots in higher education, and (2) proposed features and functionalities that chatbots should have for meeting their needs and expectations.

4 Results

First, the findings disclose that all the interviewees appeared to have had experienced at least once in the past, a chatbot interaction, mostly in customer service instances. Three of the instructors were also involved in chatbot development processes, for simple solutions, and as part of research projects. Previous experience with chatbots was characterized as either positive or negative (see Table 1). Interviewees' responses were clustered, as illustrated in the table that follows.

Table 1. Self-evaluation of interviewees' previous experience with chatbots

Positive experience	Negative experience
The bot responded to the user's questions.	The bot cannot handle complex conversations.
The bot had a character.	Absence of anthropomorphism in communication (at a certain point the user can understand that it is a software, not a human)
24/7 availability and fast response of the bot.	Felt uncomfortable talking to a machine.
Realism.	Expected reactions / answers from the bot were received.
A degree of personalization.	Not adequate personalization: the bot did not address user's needs.

Based on previous experience, suggestions for improvements were proposed, such as: (1) the chatbot should have a character, (2) there should be a consistency in the responses of the chatbot, (3) the chatbot should be able to understand culture-related factors, if possible, and (4) the chatbot should be able to delve into a topic. Despite the references to some negative previous experiences, all the interviewees were positive with respect to a future prospect of chatbots.

4.1 Needs and Expectations of Higher Education End Users for the Use of Chatbots in Higher Education (RQ1)

Interviewees' expectations for the use of chatbots were clustered into different themes (see Table 2). In particular, chatbots were envisioned as facilitators in the teaching and learning process for supporting

formative assessment, remote tutoring, and administrative work. Also, chatbots were envisaged as digital assistants in research-related processes (e.g., grant preparation), and in other scenarios not related to education (i.e., health care, customer service, in society addressing citizens' needs, and in the fitness industry). Interviewees were explicitly questioned about their potential needs and expectations for the use of chatbots for social bonding; this type of use was tolerated by some of the interviewees, while others did not express concerns. We elaborate on the emerging themes related to educational applications, further below.

Table 2. Interviewees' expectations on the use of chatbots

Themes	Uses	Proposed by
Learning and Teaching	1. Formative assessment	Students and educators
	2. Remote tutoring and course content support	Students and educators
	3. Admin work	Educators
Research	1. Grant writing	Educators
	2. Conference / seminars organization	Educators
Social bonding	1. Student – student and student – mentor bonding facilitated by a chatbot	Students and one educator
Other uses	1. Health care	Educators
	2. Customer service	Students and educators
	3. Societal role	Educators
	4. Fitness industry	Educators

4.1.1 Teaching and Learning

According to the student and educator interviewees, chatbots can help to facilitate the teaching and learning process; specifically, chatbots were envisioned as virtual/ digital assistants, smoothing the implementation of formative assessment, by providing grades and/or qualitative and personalized feedback to the students, but also for conducting short quizzes, during an academic semester, for assessing students' conceptual understanding. The educators in particular, mentioned that this need is imperative especially in large-scale classes, in which the provision of personalised feedback, in a formative and qualitative manner, during the semester might be an unrealistic scenario. Indicative quotes are given below.

"After each lecture you could have some questions, to test students' conceptual understanding" (educator 2)

"A chatbot to offer personalized feedback to the students. If there was such a bot, that would be a blessing. Especially for large audiences. But it should be a smart chatbot, so that it does not give feedback just to give, but a chatbot that is really capable of judging the quality of the work" (educator 3)

"[…] or if the chatbot could be used for giving feedback to our assignments" (student 2)

The interviewees were particularly asked about the potential and envisioned role of chatbots in education, for facilitating formative assessment practices (Figure 2), but also their current needs for tools that could ease the implementation of formative assessment. The educators referred to an extensive list of tools/ platforms that they already use in their classes for file sharing, assessment, and communication purposes (e.g., Blackboard, Moodle). However, they admitted that they currently miss a tool and/or an agent that can somehow link all the platforms and tools that they use, or they miss a tool that supports, in a smart way, all the kind of different tasks that the aforementioned tools/ platforms support. In this respect, chatbots could somehow offer a solution.

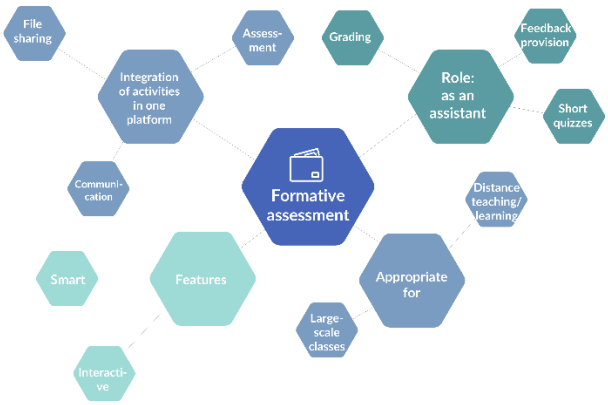


Figure 2. Potential role of chatbots in formative assessment practices

Related to the assessment need, one of the educators particularly proposed the possible use of a chatbot, at the beginning of each semester, for assessing students' prior and prerequisite knowledge that is required for a given module. Overall, it was stressed by the interviewees that chatbots could add value in formative assessment practices and would be especially considered as appropriate for large-scale classes and distance teaching and learning.

Furthermore, chatbots could add value by offering content support to the students, in course related topics,

especially for addressing students' content-related questions. In this respect, chatbots could act as remote tutors, offering tutorials to the students, sharing, and filtering relevant to the course resources and having a mediating role to the instructor to intervene when needed.

"If we could have a chatbot offering support step-by-step to the students, that would be useful. That is, to have a chatbot, as a remote tutor, guiding the students on how to solve a problem" (educator 7)

"We are interested in having something to assist us on bibliography search or to help us find a specific reference […] Also, when you are learning a new language would be nice to have some advice […] chatbots could offer useful tutorials in coding" (educator 8)

"Anything related to lecture content, so content that the students need to learn about; I think the chatbot can replace the teacher in some basic content concepts" (educator 9)

The 24/7 availability of chatbots could then allow students to seek for support, at any time of the day. Some of the students referred to the value of having a chatbot acting as a remote tutor, especially for those who study late hours and when it is not feasible to directly communicate with the educator. Also, it appears that the students need a facilitator in understanding content-related concepts; as proposed, the user could enter some keywords in the conversation and then, the chatbot could filter and retrieve relevant resources.

"When I need help and support at any time of the day, instead of waiting for an answer from the teacher via email or until I go back to class or through some other social media platforms, I think it would be a good solution to have a chatbot answering my questions" (student 2)

"A chatbot could do what the google scholar does, for example. Where you enter some keywords and then the engine provides you with relevant resources […] For example, you study for the Chemistry class and you come across terms and concepts that you do not know, e.g., molecular coupling. Then you could ask the chatbot for help for those concepts." (student 6)

"I usually read very late at night and when I have questions it is not possible to directly reach my teacher at that time. If I could have a chatbot answering my questions, well, this way my questions will be answered faster" (student 8)

Moreover, few of the instructors stated that there is a need of having a chatbot that responses to commonly asked questions, posed by students; yet, the chatbot should be able to recognise when the educator should intervene in the conversation, and at that point, it should initiate the conversation/ communication between the student and the educator.

"The bot could answer students' content-related questions that are trivial; ideally, the chatbot should be able to understand when I – as an instructor- need to intervene in the chatbot-student conversation and thus the chatbot should initiate such a communication with my students" (educator 3)

Apart from that, most of the interviewees, acknowledged the potential added value of chatbots in responding to frequently asked questions (FAQs), while most of those often relate to administration (e.g., deadlines). Educators referred to the struggle of handling a large amount of administrative work, on the top of their teaching and research duties, such as, collecting assignments, sending to the students reminders for their assignments' deadlines, responding to FAQs related to the course, and even responding to questions on how to handle a submission of an assignment. It was proposed by the interviewees, that chatbots could provide a lot of support in this direction, thus, reducing the often-observed workload due to such matters. As one of the educators explicates:

"[…] in this way, the integration of chatbot in education could reduce the teacher's time by saving valuable hours." (educator 2)

The particular educator, emphasized that, it is more important having a chatbot responding to content-related issues, than administrative matters, since the latter can be also addressed now through the mass amount of information that students already receive in social networks and e-learning systems.

4.1.2 Research

Interestingly, two of the educators expressed the need for having a virtual assistant for fulfilling a grant application (mostly on the technical parts of an application), and for offering support during the organization of conferences and seminars (e.g., a chatbot contacting the participants, responding to queries, sending the agenda). An indicative quote is given below.

"My work is not so standard, and I often fight with colleagues to do the basics, to organize a meeting. Another thing is that I would like to have a tool guiding me, as a researcher, to fill in a grant application. Something like a form filler, something effortless to the user." (educator 7)

4.1.3 Social Bonding

On the social bonding scenario, one of the educators acknowledged the need for using a chatbot for social bonding among students and/or with other colleagues. However, the rest of the educators appeared to be reluctant for the use of chatbots for social bonding; they explicated their view with reference mainly to cultural factors that might hamper such a use. Also, based on their own personal

experiences, social bonding with peers was not considered an issue, thus, making the application of chatbots in this scenario inappropriate to them. However, three of the student interviewees referred to the need of having a chatbot facilitating inter-social bonding with peers and with mentors. Such a solution would establish connections among students or between students and mentors, which could then comprise channels for communication for resolving any course or university-related issues that the students confront during the academic semester.

"A chatbot could actually accommodate social bonding with peers. Ok, with friends and fellow students there are other means of communication, such as, messenger, Viber, or anything else that we use now. But there are some researchers, so-called mentors, who are at the university and we do not see them often, but they help in some way to conduct the course. Other times we have tutoring with mentors. With the use of a chatbot, we will be able to communicate with them, just like having a remote tutor at any time, without requiring getting to know the mentor in person." (student 8)

4.2 Proposed Features and Functionalities That Chatbots Should Have (RQ2)

For the successful integration of chatbots in higher education, features and functionalities were proposed by the interviewees (see Table 3). Features that the chatbots should have for successfully enacting the role of virtual assistants include intellectual independence (smart chatbots) and interactivity. In particular, the expectation of having a chatbot that can delve into a topic, handle complex conversation, respond to content-related questions and offer personalized feedback, requires intellectually independent/ smart chatbots, which generate responses out of the input with the help of machine learning techniques.

"I think especially for the integration of chatbots in education, it is essential to have a smart chatbot, that understands what I have asked, that responds in essence and to the point" (educator 3)

Adaptation and personalization for addressing users' needs and particularities (e.g., adapting to culture-related factors) was also mentioned as essential for the meaningful integration of chatbots in education in general.

"The chatbot should be able to understand more culture-related factors; in HCI fields a focus on emotional and cultural factors has already arisen. In this way, the chatbot's response will not feel such automated" (educator 4)

Table 3. Proposed features and functionalities of the chatbots for their meaningful integration in Higher Education

Features and functionalities	Details	Proposed by
Smart chatbot	Delve into a topic, handle complex conversations, and offer personalized feedback.	Educators
Adaptation and personalization	Respond to different user needs, e.g., understands culture-related factors.	Educators
Appropriate design	Has a character, is friendly and sustains interaction with the user. It can also offer visual input.	Students and educators
Low maintenance cost	Safeguarding sustainability of use.	Educators

In addition, the need for having an appropriate design was stressed (e.g., friendly-user interface), the chatbot having a character, which can safeguard and sustain the chatbot-user interaction, but also the possibility to support functionalities such as, offering visual input (e.g., video tutorials), and filtering information available on the web. Last, the maintenance cost was proposed as one of the factors that might hinder the sustainable use of chatbots. Specifically, even though it was acknowledged by the educators that the design and development of chatbots might cost less compared to other conventional methods of using human assistants, the need for having also a low maintenance cost was proposed as another necessary feature.

5 Discussion

Chatbots are emerging as potential facilitators in higher education. The design and development of solutions requires an assurance that the end users' needs are met. As part of our need's assessment, aiming at understanding the needs of educators and students, we tried to extract the perceived features and functionalities that chatbots should have.

Findings from this study indicate that higher education instructors currently struggle with content delivery, formative assessment implementation and time-consuming administrative work. Likewise, students confirmed the need of having a tutor for content support provision, a finding consistent with the work of Gupta, et al. (2017; 2019). Students also expresses their need for having a chatbot responding to FAQs at any time of the day (such as: Watson, reported in Goel et al., 2015; EduBot, reported in the study of

Verleger & Pembridge, 2018). In fact, solutions have previously been developed for addressing such issues to some extent. For instance, Goel and colleagues (2015) developed a chatbot, called 'Jill Watson'[1], built on IBM's Watson platform, that functioned as a teaching assistant, to handle forum posts by students enrolled in a computer science course at the University of Georgia (Goel, et al., 2015). In this case, there was a need by the instructor to address numerous questions of students during the semester. The Jill chatbot is recorded as the world's first AI teaching assistant, that was available 24/7 for responding to M.S. Computer Science students' queries. It was observed that the use of the chatbot by students enhanced their engagement in the course. Therefore, the development of the teaching assistant chatbot helped in solving this problem to a great extent. In the same direction, Dutta (2017) describes in detail the development process of an intelligent chatbot to assist high-school students for learning general knowledge subjects. The proposed intelligent web-based and free access chatbot tool makes use of NLP techniques to answer the queries by high-school students and be trained on a knowledge base comprising of general knowledge questions and answers. In relation to formative assessment solutions, Yi-Chieh and Wai-Tat (2019) explored the use of a conversational chatbot interface for guiding students to perform peer assessments. Even though their findings are promising in this area, as grading consistencies were exhibited among students' and teachers' evaluations, the use of chatbots for the provision of qualitative feedback continues to comprise an area for further investigation.

Overall, the challenge remains on building and sustaining the use of a smart chatbot, capable of delving into content-related topics of a course and offering personalized guidance and feedback to the learners. Even though chatbots can evolve via machine learning techniques and through evaluating conversations with users, the error rate at which a chatbot works is initially high (Molnár & Szüts, 2018). Also, according to the same authors, even though chatbots can simplify the administrative work of educators by disclosing supplementary information to students about their courses, they often fail to solve content issues. This becomes a bit problematic when chatbots are meant to be used for meaningful formative assessment purposes and content-related guidance provision. Therefore, the need for having chatbots that support formative assessment and tutoring in a meaningful manner and content-wise remains.

Moreover, another need that was identified through our interviews relates to a use of a chatbot for easing research grants preparation procedures, such as, filling in parts of an application. To the extent of our knowledge, there is no such a solution at the moment for addressing this need; hence, this may be another direction for further design and development.

In addition, the social bonding scenario was endorsed by some of the interviewees; in this case, the need for connecting and communication with peers and mentors within an academic environment, without the prerequisite establishment of relationships and/or friendship among the users, was proposed. In this direction, a chatbot could be used for initiating such connections, with further implications on student retainment at the university, establishment of study groups among students of the same department and provision of feedback and support from mentors to freshmen who struggle with content but also administrative matters of the academic life. Nevertheless, potential constraints should be encounter in such a solution, such as, cultural differences of users, as pointed out by our interviewees who displayed reservations on the successful use of chatbots for this purpose.

In relation to the essential features that chatbots should have for addressing interviewees' needs, intellectual independence was proposed. The first characteristic was viewed as crucial for a chatbot to have, in order to be able to aide significantly in formative assessment and tutoring solutions, which prerequisite a meaningful content analysis and interpretation of users' responses in chatbot-user interactions. This would also result into linguistic consistency and a realistic user-chatbot interaction, needs which have been outlined also in the study of Stathakarou, et al. (2020). Adaptability in users' personal needs was also proposed along these lines, including acceptance of cultural differences among users. Such a feature would allow the accommodation of chatbots' use not only for teaching and learning, but also for social bonding uses. Those features would then result in the presence of anthropomorphism in communication, as the latter has been also been proposed by users as an essential design characteristic of chatbots for uses in education (see Stathakarou, et al., 2020). In terms of design, our interviewees additionally proposed the requirement for a chatbot to support visual input (e.g., video tutorials), and to exhibit a character, in order to sustain user interaction with the system. The development of personalities for chatbots have been explored in more depth in the needs' assessment study of Thies et al. (2017), and its necessity has been confirmed through our findings as well. Last, technical matters, such as, the maintenance cost, was noted as one of the factors that might affect sustainability of use, especially in the education sector.

6 Conclusion and Limitations

In response to the current trend of integrating chatbots in education, we report a needs assessment study.

[1] https://www.ibm.com/watson

The purpose of our study was to identify and explore higher-education users' needs and expectations for the use of chatbots in higher education, through the conduction of semi-structured interviews. It has been shown that users have several needs related to the teaching and learning processes, related to research and to social bonding matters, that chatbots could potentially address, through an appropriate design. The findings of this study have implications for our future steps for the design, development and testing of specific pedagogical scenarios for the meaningful integration of chatbots in higher education. Yet, it must be mentioned that, in this work, the interviewees came from a single country, as they were reached by convenience. Thus, the findings presented in this manuscript, reflect the needs and expectations of a particular group of users. In our future work, and as part of the iteration cycles of design in our project, we aim to include participants from a wider region and other cultures.

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An Instrument for Evaluation of the Use of the Web Conferencing System BigBlueButton in e-Learning

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Abstract. *The use of web conferencing systems in distant education and e-learning gained very much attention after the onset of the pandemic of the COVID-19 virus, when traditional academic teaching in the classroom was predominantly replaced with synchronous and asynchronous e-learning. After 16th March 2020 at all of the colleges at the University of Zagreb a fully online teaching modality was applied with less than one week of preparation. The predominant web conferencing tools that were used for that purpose were BigBlueButton, Adobe Connect and Zoom. The authors of this paper thus found it opportune to develop an instrument for the evaluation of web conferencing tools used in the context of academic teaching. Therefore, an evaluation instrument was created by combining scales designed to measure selected constructs of the DeLone and McLean IS success model with several constructs from the models of usability and user experience in software use. This paper presents the results of a pilot study of the evaluation of this newly developed instrument and of the BigBlueButton web conferencing system.*

Keywords. E-learning, survey, web conferencing, BigBlueButton, IS success model, usability, user experience, internal consistency, regression analysis

1 The Use of Web Conferencing Systems in e-Learning

Webinars are an important means of distance education and *BigBlueButton* web conferencing tool is commonly listed among the most popular applications for this purpose in related review papers (Černý, 2016). Webinars are widely applied in distance education and learning training programs (Gegenfurtner et al. 2020) as well as in blended online classes (Khechine et al., 2014).

BigBlueButton, Zoom, Adobe Connect and *Skype* can be used not only for the delivery of synchronous video lectures but also in various online learning designs such as, for instance, cooperative learning (Jacobs & Ivone, 2020). Such tools facilitate individualization of the learning process and cooperation in a multi-sited setting (Bernardi et al., 2018).

Web conferencing tools (software) allow different groups of users to conduct remote meetings via the internet. Their most important role is facilitating synchronous audio and video communication of participants in online teaching and learning. Features of web conferencing tools generally include audio calls and video conferencing, screen sharing, collaboration options (live chat, audience pooling, file sharing) and other functionalities like presentation slideshow or meeting recording. These activities increase online student engagement and contribute to student satisfaction with online classes (Kuo et al., 2010).

In our pilot study the *BigBlueButton* (BBB) web conferencing tool was used that was integrated with the Moodle learning management system at the level of one college in the northwestern part of Croatia. *BigBlueButton* (https://bigbluebutton.org/) is open source web conferencing and collaborative software for online learning that enables sharing of audio, video, screen, presentation slides, white board and chat in real time. *BigBlueButton* is an HTML5 client that, when used in Firefox and Chrome browsers, delivers a high-quality, low-latency WebRTC audio. One of the main advantages of *BigBlueButton* is that it can be integrated as a plugin in various types of learning management systems (LMS) such as *Moodle, SmartClass, IServ* or *Sakai*, as well as in content management systems, e.g. *Drupal* or *WordPress*. This web conferencing tool is a professional solution for remote online teaching.

The important features of *BigBlueButton* for educators who use it integrated in *Moodle* LMS are (Moodle, n.d.):

- It enables recording of lessons or meetings and sharing them later with students;
- Teachers can use the whiteboard to annotate most important parts of the presentation which are immediately displayed back to the students in real-time. Highlight, zoom, draw and write options are also available;
- At any time during the use of the system the teacher can download the list of users who attended an online lesson;
- The number of webcams being shared in one session is not limited (it is only limited by bandwidth).

Students using *BigBlueButton* can be more engaged in online lectures through pooling options, sharing of emoji and break rooms, which are perfect for collaborative work. There are two basic types of users in *BigBlueButton* – moderator and viewer. The *moderator* can have a complete control of the session by assigning and, if necessary, taking away user options: making any student presenter, (un)muting users or expelling a student from a session in case of misconduct. The *viewer* (which is a typical role for students) can raise a hand to ask questions, as well as use a public or private chat. Both types of *BigBlueButton* users can join a session using a microphone or/and a webcam.

2 The Importance of Web Conferencing in Fully Online Teaching During the COVID-19 Pandemic

Research regarding the COVID-19 pandemic conducted in 20 countries in 2020 revealed significant challenges for the global higher education community, with adaptive activities by higher education providers ranging from (a) providing no response to social isolation strategies on campus to (b) rapid teaching and curriculum adaptation for fully online education (Crawford et al., 2020). In 2020 *web conferencing tools* have become an inevitable part of teaching activities at all levels of education due to the global COVID-19 virus pandemic. They provided the most immediate and convenient solution for an unprecedented new situation of a lockdown of universities and cessation of traditional education in physical facilities like classrooms and laboratories. In their prompt reaction, most colleges, universities and their teachers turned to technological alternatives and distant learning to appropriately replace classroom teaching with virtual learning environments (for an example of tips for rapid migration to online learning during the COVID-19 pandemic see: Sandars et al., 2020).

The adaptive pedagogical measures after the onset of the COVID-19 pandemic are well denoted by the term "emergency remote teaching" (ERT). According to Hodges et al. (2020.), it represents a temporary change of means of instructional delivery in the classroom to an alternate delivery online mode due to a health crisis. These authors emphasize that in ERT the fully distance-based teaching solutions rapidly replace face-to-face or blended/hybrid courses with a possibility to return to the original format after the crisis has ended. It can be concluded that the primary goals of *emergency remote teaching* are medium-term or long-term when re-creating a "robust educational ecosystem" is concerned, as opposed to immediate or short-term goals in the sense of enabling "quick and reliable temporary access to instruction" until the end of an emergency or crisis.

One way to immediately respond to the challenge of transferring from traditional university lectures in the classroom to fully online lecturing is to use a web conferencing system. It is this approach that was taken by many colleges in the Republic of Croatia after the onset of the COVID-19 pandemic and shutdown of universities beginning on 16th March 2020. The university institutions and their teachers predominantly chose *BigBleButton*, *Zoom* and *Microsoft Teams*. They were among the most popular web conferencing tools at the beginning of 2020 together with *GoToMeeting*, *Bluejeans Meetings*, *RingCentralVideo* and *Google Meet* (TechRadar, 2020).

3 IS Success, Usability and User Experience Models

In this section the *DeLone and McLean model of IS success* as well as the concepts of software *Usability* and *User Experience* will be described to encompass both pragmatic and hedonic aspects of the *BigBlueButton* web conferencing tool from the students' point of view.

In 1992, DeLone and McLean (DeLeone & McLean, 1992) developed an information systems success model that is used as a framework for measuring complex dependent variables in different domains of IS research. The main assumption of this model is that the *quality of the system* directly affects the *use of the system*, i.e. the *intensity* of its use. The baseline model was improved in 2003 by its authors with the newer and innovated model containing the following dimensions in assessing IS performance: *System Quality*, *Information Quality*, *Service Quality*, *Intention to Use*, *User Satisfaction*, and *Net Benefits* (DeLone & McLean, 2003). The newer model was initially developed for the e-commerce context, but has been used in various empirical research in the educational context, e.g. in relation to e-portfolio in education (Balaban et al., 2013), learning management system success (Lin, 2007), blended learning (Ghazal et al., 2018), or e-learning in terms of students' perceptions (Freeze et al., 2019). Considering the constructs and their relationships, the model can be explained as follows: a system can be evaluated in terms of its quality, information and quality of service. These characteristics affect the use or *Intention to Use* the system, as well as *User Satisfaction*. Certain benefits arise from the use of the system. Consequently, "*Net Benefits* have a positive or negative impact on *User Satisfaction* and future use of IS" (Urbach, & Müller, 2014). Furthermore, the creators of the model believe that the selected/proposed dimensions of information systems success should be observed through their interrelationships rather than independently, and they also indicate the temporal and causal interdependence of dimensions (DeLone & McLean, 2003). *Information Quality* is a dimension related to measuring the quality of the output of an information system, which, in case of the pilot research presented in this paper, is the *BigBlueButton* system. In literature, this dimension has been highlighted as key for measuring *performance* and its association with *System Use*. The construct of *System Quality* refers to the means of data processing and the view of the system from the perspective of its technical specifications. Due to the changing role of IS and technology development, the *Service Quality* dimension was added in the new IS performance measurement model, although it is partly a subset of *System Quality*. The dimension *Intention to Use* refers

to the purpose and level on which an individual uses the functionalities of the system. In the model, this dimension is two-component: the intention to use is related to the attitude of the user and his future intentions, while (actual) use is related to the behavior of the user. *User Satisfaction* is a construct that refers to how much users like and approve of IS and its results (Petter & McLean, 2009).

The basic function of IS should not be observed only as *utilitarian*, since the *hedonistic* features of the system – how much an individual enjoys using the system – are also important. Because of that, *Usability* and *User Experience* concepts should also be considered when examining *BigBlueButton* and other web conferencing tools. The traditional *Usability* framework looks at an individual's work in interaction with the technology, while *User Experience* models go beyond the utilitarian aspects of interaction (see: Law et al., 2009). A frequently used method for evaluating *Usability* and also, to a certain degree, *User Experience*, are Nielsen's heuristics which assess: (1) the visibility of system status, (2) consistency between the system and the real world, (3) control and freedom of users, (4) consistency and standards, (5) error prevention, (6) recognition versus recall, (7) flexibility and efficiency of use, (8) aesthetics and minimalist design, (9) helping users recognize, diagnose, and resolve errors and (10) assistance and documentation (Nielsen, 1994). *User Experience* extends the concept of *Usability* beyond efficiency, effectiveness and satisfaction. According to ISO 9241-210 (2010), *User Experience* includes all user emotions, beliefs, preferences, perceptions, physical and psychological reactions, behaviors and achievements that occur before, during and after the use of a product, system or service.

4 Methodology

This pilot study had two main research goals: to develop a preliminary version of a survey (questionnaire) with scales designed to measure relevant constructs that could be suitable for the evaluation of web conferencing tools that can be used for *synchronous distant learning* in higher education, as well as to evaluate one of those tools in detail, namely the *BigBlueButton* system.

4.1 Instrument

After an extensive literature review, the authors of this paper developed a measurement instrument to investigate (1) the applicability of the web conferencing tool *BigBlueButton* in synchronous online teaching and (2) the experiences of students who attended online lectures delivered with *BigBlueButton*. This new measurement instrument was created on the basis of selected constructs from the theoretical backgrounds of: (a) DeLone and McLean IS success model, (b) *Usability* and (c) *User Experience*. This measurement instrument was in form of a survey with assessment scales. The first part of the survey consisted of socio-demographic questions, while the rest of the survey included rating scales with questions related to the experiences and evaluations of the *BigBlueButton* system and the courses students attended after the onset of the COVID-19 pandemic in which *BigBlueButton* was used. This part of the survey included students' rating of quality, functionality and usability of the *BigBlueButton* system which was used as the main web conferencing application in online teaching at one college in the northwestern part of Croatia from 16th March 2020 until the end of the summer semester of the 2019 /2020 academic year. In all of the rating scales the same five-point Likert-type response scale was used ranging from "1 – *I don't agree at all*" to "5 – *I totally agree*".

In the continuation of this section the selected constructs (variables) from the *DeLone and McLean IS success model*, as well as from *Usability* and *User Experience* research, will be specified with an example of one of the items from each scale adapted for the evaluation of *BigBlueButton*.

The categories of *Information Quality* that are most commonly measured when the DeLone and McLean IS success model is used are *Accuracy*, *Completeness*, *Consistency*, *Timeliness*, *Comprehensibility*, *Security*, *Personalization*, *Relevance*, *Accessibility* and *Uniqueness of Information* (DeLone & McLean, 2003; Urbach & Müller, 2012). However, for the evaluation of *BigBlueButton* only 6 items were included in the measurement scale (e.g. "*Easy and successful exchange of information between different users was achieved by using the BigBlueButton system"*).

Attributes such as *Tangibility*, *Reliability*, *Response Time* and *Security* from the *SERQUAL* model are characteristic of the *Service Quality* dimension (Pitt et al., 1995). This measurement scale was also adjusted regarding the *BigBlueButton* context to comprise 8 items (e.g. *"The educational processes in which I participated were very well supported by the BigBlueButton system"*). The most common attributes that are evaluated for *System Quality* are *Utility*, *Availability*, *Reliability*, *Customization*, *Flexibility*, *Functionality*, *Ease of Use*, and *Data Quality* (DeLone & McLean, 2003). In our research the related measurement scale included 8 items (e.g. *"BigBlueButton is a reliable system that works without difficulties and errors").*

The *System Usability Scale (SUS)* is a frequently cited instrument for measuring *Usability*. It has gained popularity among HCI (*Human-Computer Interaction*) experts due to its brevity (consisting of 10 items only), confirmed reliability and validity, as well as availability in different world languages (Lewis & Sauro, 2009). In models available in the literature (Nielsen, 1994; Shneiderman & Plaisant, 2010; Shackel, 1991) *Usability* predominantly consists of the following attributes: *Efficiency*, *Effectiveness*, *Suitability for Learning*, *Ease of Memory*, and *Reliability/Safety*. For this research a measurement scale consisting of 9 items was used (e.g. *"I mastered the use of the BigBlueButton system without any difficulties"*).

In technology acceptance models, *Intention to Use* reflects an individual's desire to use a specific technology in the future. *Intention to Use* is criterion variable in this pilot study because it has been proven as a reliable predictor of the actual technology use among students in various educational research contexts (Teo & Zhou, 2014). For the purpose of this study the related measurement scale consisted of 8 items combined from

scales used by other researchers (Park, 2009; Wu & Chen, 2017) (e.g. *"I hope to be able to use the BigBlueButton system in the future as much as possible"*).

The *Cognitive Involvement* scale combined the existing and newly developed items that reflect various constructs that appear in research papers on *User Experience*. In particular, the items in this scale reflect the quick passage of time when doing something interesting, the ability to perform for a longer time an activity which demands concentration, the sense of immersion when being fully mentally engaged in an activity, the little or no effect of distractions when someone is attentive and focused during certain activity, the hedonistic effects of using a technical system (satisfaction and fun), as well as the feeling of control over the functions and reactions of the system. An example of an item from this scale is *"It seems to me that time quickly passes by when I use the BigBlueButton system".* It must be noted that *Cognitive Involvement* is rather scarcely investigated in relation to *Usability* and *User Experience* (Kiili et al., 2014) even though it may be a potential predictor of *Intention to Use*.

The development of the *Design Appeal* scale was inspired by the *User Experience* scale in the research paper by Wani et al. (2017). The *Design Appeal* scale consists of items related to attractiveness and modern design of a user interface, interesting technical features that arouse curiosity, as well as the potential of a system to facilitate creativity and innovation when used. One item from this scale is *"The user interface of the BigBlueButton system appears modern and up-to-date".*

4.2 Subjects

The subjects in our pilot study were 193 students who attended a college in the northwestern part of Croatia. These students were enlisted in three courses at different levels of study: (1) first-year undergraduate course on organizational communication, (2) first-year graduate course on managerial communication and leadership, and (3) second-year undergraduate vocational study course on computer-mediated communication. This was a *convenience sample* with an equal number of students of male and female gender, of which 93.8% were aged 18-23 years, and 97.4% were full time students. Until the beginning of the lockdown at Croatian universities on 16th March 2020 all of the students had participated in traditional university courses at their college which were only partly delivered online. Also, before the lockdown, the students had never attended lectures in the form of *BigBlueButton* webinars since the delivery of synchronous online lectures was not a practice at their college. However, between the beginning of the lockdown and the end of the summer semester of the 2019/2020 academic year most of their courses included synchronous *BigBlueButton* lectures. In fact, *BigBlueButton* was integrated with the college learning management system Moodle, including the possibility to record and playback the sessions.

4.3 Procedure

The survey in our pilot study was conducted after the students had attended the fully online teaching at their college for three consecutive months. The online survey was created in Google Forms and applied from 17th to 25th of June 2020, at the end of teaching in the summer semester of 2019/2020 academic year. The aim of the pilot study was to evaluate the newly developed measurement instrument and investigate how the *BigBlueButton* web conferencing tool performed from the students' viewpoint.

It must be noted that in our survey the students were asked to evaluate the use of *BigBlueButton* at their college in general, that is, the way it performed in all of the courses that they had attended during the lockdown and not only in the three courses (on organizational, managerial and computer-mediated communication) that were selected in the pilot study. Before carrying out the research in our pilot study, the approval of the *Ethics Committee* was obtained. Participation in the online survey was voluntary and anonymous.

5 Results

5.1 Reliability Analysis

To determine if the assessment scales that were developed for the evaluation of the *BigBlueButton* web conferencing system reflect the constructs they were supposed to measure, a reliability analysis was performed. For this purpose, the Cronbach's alpha coefficient was used, with respective alpha values for each scale presented in *Table 1*. The results of the reliability analysis indicate that all of the scales have an acceptable level of reliability. Cronbach's alpha values greater than 0.7 are acceptable for social science research in which the Likert-type scale is used (Gliem & Gliem, 2003). After the intercorrelation of each item with the corrected scale total was inspected, it was also determined that almost all of the items that were included in each of the scales measured the corresponding constructs. In the case of the *Usability* scale, the value of the Cronbach's alpha coefficient, and thus the reliability of the scale, increased significantly (from 0.60 to 0.779) by excluding the item *"I think that I would need to learn a lot of other things before I could get going with using the BigBlueButton system well".* Therefore, this one item was excluded from the *Usability* scale before further data analysis.

Table 1. Cronbach's alpha values for constructs/scales included in the questionnaire (N=193)

Construct label	Number of items in scale	Cronbach's alpha coefficient
Usability (corrected)	7	0.779
System Quality	8	0.827
Information Quality	6	0.878
Service Quality	8	0.836
Cognitive Involvement	8	0.880
Design Appeal	6	0.845
Intention to Use	8	0.904

5.2 Regression Analysis

In this research, a regression analysis was used for the investigation of the relationships between a *dependent* (criterion) variable *Intention to Use* and *predictor* (explanatory) variables: *Usability, System Quality, Information Quality, Service Quality, Cognitive Involvement,* and *Design Appeal*. The regression analysis was employed to determine potential causal relationships between variables that were included in this pilot study. Multiple correlation coefficient (R) is the measure of the strength of association between the *predictor* (explanatory) variables and the *dependent* (criterion) variable. From the results presented in *Table 2*, for the dependent variable *Intention to Use* the obtained R is 0.759, which indicates a strong association between the predictors *(Usability, System Quality, Information Quality, Service Quality, Cognitive Involvement, Design Appeal)* and the dependent variable *Intention to Use*. The R square (R^2) coefficient of determination indicates the percentage of variation in the dependent variable that is shared by predictor variables. More precisely, it indicates the proportion of the variance in the dependent variable that is predictable from the independent variables.

Table 2. Model summary – dependent variable *Intention to Use* (N=193)

Model	R	R square	Adjusted R square	Std. error of the estimate
1	.759[a]	0.576	0.562	0.5212

a. Predictors: (Constant), *Usability, System Quality, Information Quality, Service Quality, Cognitive Involvement, Design Appeal*

To determine which variables were the greatest statistically significant predictors of *Intention to Use* the *BigBlueButton* system, a stepwise regression analysis was performed and its results are presented in *Table 3*. For variables *Cognitive Involvement* and *Design Appeal* the t values were 5.32 and 6.73, respectively, with $p < 0.01$, and are therefore considered as the greatest predictors of the dependent variable *Intention to Use*. The p value for other variables in this regression model was above 0.05. The value of non-standardized coefficients (B) indicates how much the criterion variable *Intention to Use* varies depending on the predictor variables *Cognitive Involvement* and *Design Appeal*. Interestingly, the scales that measured the constructs from the DeLone and McLean IS success model (*System Quality, Information Quality, Service Quality*), as well as the scale that measured *Usabilty*, were not the most influential predictors of *Intention to Use*. This apparently justified the introduction of the scales *Cognitive Involvement* and *Design Appeal* in our pilot study of the use of web conferencing tool *BigBlueButton* for synchronous e-learning. Furthermore, these two scales (that are considered as components of *User Experience*) could be valuable for the evaluation or other web conferencing tools like *Adobe Connect* or *Zoom.*

Table 3. Statistical significance of independent variables and estimated model coefficients (N=193)

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. error	Beta		
(Constant)	0.569	0.36		1.58	0.11
System Quality	0.044	0.108	0.035	0.41	0.68
Usability	-0.048	0.096	-0.031	-0.50	0.61
Information Quality	-0.013	0.106	-0.01	-0.12	0.90
Service Quality	0.062	0.103	0.048	0.60	0.54
Cognitive Involvement	**0.381**	0.072	**0.374**	**5.31**	**0.00**
Design Appeal	**0.448**	0.067	**0.431**	**6.73**	**0.00**

a. Dependent variable: *Intention to Use*

By calculating the F value shown in *Table 4* we examined how well the overall regression model corresponds to the data set used in this pilot study. From these results it is evident that independent variables from the model statistically significantly predict the dependent variable *Intention to Use* since $F(0.562) = 42.077$, $p < 0.0005$, which means that the regression model is well suited to the data set. As was previously mentioned, stepwise regression analysis was used to predict the dependent variable *Intention to Use* of the *BigBlueButton* system from predictor variables which were statistically significant ($p < 0.01$) – *Cognitive Involvement* and *Design Appeal.*

Table 4. Determining the statistical significance of the model (N=193)

Model	Sum of squares	df	Mean square	F	Sig.
Regression	68.582	6	11.43	42.077	.000[b]
Residual	50.527	186	0.272		
Total	119.109	192			

a. Dependent variable: *Intention to Use*

b. Predictors: (Constant), *Usability, System Quality, Information Quality, Service Quality, Cognitive Involvement, Design Appeal*

5.3 Students' Evaluation of the Web Conferencing Tool *BigBlueButton*

In our pilot study the students were asked to evaluate various aspects of the *BigBlueButton* system by the use of assessment scales that were developed on the basis

of the *DeLone and McLean IS success model*, as well as on literature on *Usability* and *User Experience*. It must be noted that for the students in our convenience sample the *BigBlueButton* system was used in the range from 2 college courses to as many as 6 or more courses (depending on the students' major and year of study) during the lockdown from 16th March 2020 until our survey was started on 17th June 2020. Also, most of the students (69.4%) stated that they had attended a *BigBlueButton* web conference on average 3-4 times a week during this period. Also, most of the students (76.2%) stated that they had spent on average a total of 3-6 hours per week using *BigBlueButton* for all of the courses that they were enlisted in during the summer semester of the 2019/2020 academic year.

The general evaluation of the students' satisfaction with the *BigBlueButton* system and teaching with the use of *BigBlueButton* is presented in *Figure 1*. The Likert-type scale ranging from *"1 – I am exceptionally dissatisfied"* to *"5 – I am exceptionally satisfied"* was used for this purpose. As can be concluded from the data presented in *Figure 1*, as many as 89.7% of students were generally satisfied with the use of the *BigBlueButton* system.

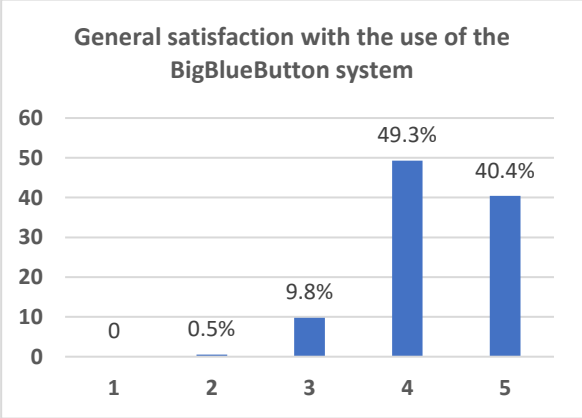


Figure 1. Students' general evaluation of their satisfaction with *BigBlueButton* and teaching with this system; N=193; response scale: from *"1 – I am exceptionally dissatisfied"* to *"5 – I am exceptionally satisfied"*

Students' average responses to selected items of the scales in our online survey/questionnaire which can be used for detailed evaluation of the *BigBlueButton* system are presented in *Table 5*. In all of the ratings of individual items the same five-point Likert-type response scale was used ranging from "1 – *I don't agree at all*" to "*5 – I totally agree*". The average ratings in *Table 5* indicate that, regarding the *Usability* construct, most of the students mastered the use of *BigBlueButton* without difficulties (M=4.62) and many of them found the various functionalities to be well integrated (M=4.21). It must be emphasized that in the continuation of this paragraph, only selected items from the scales in the survey instrument used in our pilot study will be included in *Table 5*.

Table 5. Average responses of subjects to selected items from the scales of the survey instrument (N=193)

Construct	Example of item(s)	Mean	Std. deviation
Usability	I mastered the use of the *BigBlueButton* system without any difficulties.	4.62	.6108
	I find that the various functionalities in the *BigBlueButton* system are well integrated.	4.21	.7830
System Quality	***BigBlueButton* is a reliable system that works without difficulties and errors.**	**3.86**	.899
	In my experience, *BigBlueButtom* is well designed for teacher-student interaction.	4.42	.710
Information Quality	The *BigBlueButton* system made it possible to obtain accurate and relevant information.	4.47	.757
	There was no loss of information when using the *BigBlueButton* system.	**3.98**	.946
Service Quality	**The *BigBlueButton* system worked equally well regardless of the time of its use and the number of concurrent users.**	**3.92**	1.070
	The educational processes in which I participated were very well supported by the *BigBlueButton* system.	4.38	.762
Cognitive Involvement	At all times, I felt that the *BigBlueButton* system would respond quickly and in the right way if I wanted to manage its functions.	4.10	.944
Design Appeal	I like the visual interface design of the *BigBlueButton* system.	4.27	.842
	The technical aspects of using the *BigBlueButton* system seem interesting to me.	4.11	.846
Intention to Use	**I hope to be able to use the *BigBlueButton* system in the future as much as possible.**	**3.78**	.987
	I will strive to get to know well and successfully master all the important functionalities of the *BigBlueButton* system for future use.	4.06	1.008

When selected items from the *System Quality* construct are observed, it must be noted that, while somewhat lower average evaluation was given by the students to reliability and performance without difficulties and errors (M=3.86), the design of *BigBlueButton* for

teacher-student interaction (M=4.42) was rated more favorably.

Having in mind certain items that measure the *Information Quality* construct, the evaluation of potential loss of information was rated less favorably (M=3.98) than the possibility to obtain accurate and relevant information (M=4.47).

When two of the items which are part of the scale designed to measure the *Service Quality* construct are observed, it can be concluded that the support of the educational processes in which the students participated was evaluated with a greater average value (M=4.38) than the performance of the system regardless of time and the number of concurrent users (M=3.92).

The average response to the presented item from the *Cognitive Involvement* scale indicated that students perceived the system as manageable at all times in the way they wanted it to perform (M=4.10), while the average responses to the *Design Appeal* scale suggested that the students liked the visual interface (M=4.27) and found the technical aspects of using the system as interesting (M=4.11).

Finally, regarding the selected items of the *Intention to Use* scale, it is noticeable that the intention to get to know well and successfully master all the important functionalities of the *BigBlueButton* system for future use received a rather high average evaluation (M=4.06), while the item that reflected hope to be able to use the *BigBlueButton* system in the future as much as possible received a somewhat lower average response (M=3.78), which may partly be accounted for by the wording in this item (i.e. "as much as possible" could have been perceived by the students as an overstatement).

It is obvious from the data in *Table 3* that there was a total of 51 items in all of the scales that measured constructs related to *IS success model*, *Usability* and *User Experience* that were included in the survey instrument for our pilot study. However, because of the limited number of pages for this paper, only the average ratings for 13 selected items from those scales are presented in *Table 5*. Still, it can be concluded that the average responses above 4.0 for the items in *Table 5* can be considered as favorable evaluations. This includes the evaluation of the usefulness of the *BigBlueButton* system for teaching/education activities, as well as its technical possibilities and design. Slightly less favorable, but still ranging between M=3.86 and M=3.98, were the evaluations associated with its reliability and working without errors/difficulties, potential for loss of information and stability regardless of time of use and number of concurrent users. In fact, when the students in the survey were asked about the *quality of their internet connection* and potential problems when using the *BigBlueButton* system, a considerable number stated that occasionally the speed of the internet connection was sometimes poor and that they had problems when using the system. In fact, the authors of the pilot study in this paper also experienced occasional brief loss of the audio signal during students' presentations, faculty meetings and responses of students during oral exams using *BigBlueButton*. This was predominantly attributed to slow internet connection of those speakers whose vocalizations were occasionally disrupted with noise and information loss in audio transmissions.

6 Discussion of Results

The pilot study that is presented in this paper was designed with the aim of creating a measurement instrument (survey/questionnaire) for the evaluation of web conferencing tools that can be used for synchronous e-learning like *BigBlueButton*, *Adobe Connect* and *Zoom*. The evaluation of such systems in practical educational use became very important during the lockdown of universities due to the COVID-19 pandemic. According to the Croatian Bureau of Statistics, in the winter semester of 2018/2019 academic year there were 158 thousand students (Croatian Bureau of Statistics, 2019) enlisted in higher education institutions in Croatia and in the academic year 2019/2020 there were more than 12 thousand teachers working in higher education (FTE – *full time equivalent*) on employment contract and contractual agreement basis (Croatian Bureau of Statistics, 2020). It must be emphasized that all Croatian students and their teachers were forced to convert to distance education after March 16th 2020.

At the University of Zagreb, the *BigBlueButton* web conferencing system prevailed at institutions that used Moodle because it could be integrated with this LMS. Therefore, for the pilot study that is presented in this paper the evaluation of measurement scales was performed in relation to *BigBlueButton*. These assessment scales for an online survey were designed according to literature on (a) the *DeLone and McLean IS success model*, (b) *Usability* and (c) *User Experience.* As can be concluded from the data presented in *Table 1*, all of the scales adapted for the evaluation of the *BigBlueButton* system manifested acceptable internal consistency (Cronbach's alpha were in the range from 0.779 to 0.904) and were considered appropriate for data collection and analysis.

As presented in *Table 2* and *Table 3*, a *stepwise regression analysis* was performed with predictor variables (scales) that measured potentially useful constructs for the evaluation of web conferencing tools in synchronous e-learning *(Usability, System Quality, Information Quality, Service Quality, Cognitive Involvement, Design Appeal).* Their association with *Intention to Use* as a *dependent* variable was investigated. In fact, stepwise regression analysis was used to identify the *most influential* predictor variables. Interestingly, when the results of the stepwise regression analysis are observed, the variables from the *DeLone and McLean IS success model* and *Usability* turned out to be of lesser predictive value than *User Experience* variables measured by the newly constructed scales labelled *Cognitive Involvement* and *Design Appeal.* Even though data analyses of the initial application of our measurement instrument indicated that it could be improved for a more detailed forthcoming study (which would include *Zoom* and/or *Adobe Connect* for comparison purpose), it is the

opinion of the authors of this paper that even this early version of the survey (questionnaire) has applicative and scientific value.

The practical use of our 'battery' of scales for the evaluation of web conferencing tools in the educational setting is proven by the data presented in *Table 5*. It specifies how in our pilot study the *BigBlueButton* web conferencing system was evaluated although, due to the limited length of this paper, only average responses of students to *selected items* from the scales of our measurement instrument could be presented as an example of a possible means of evaluation of a distance learning technology. It is common knowledge that many instructional design models that are used in e-learning imply or recommend an *evaluation phase*. Having in mind the number of higher education students and teachers that were forced to use some form of distance learning in Croatia during the summer semester of the 2019/2020 academic year, as well as the likely necessity to repeat the extensive use of e-learning technology at least in a part of the 2020/2021 academic year, evaluation of distance learning technology that was (or can be) used for that purpose should be regarded as an imperative. Our findings regarding how the *BigBlueButton* web conferencing tool performed at one higher education institution in the northwestern Croatia (after the analysis of average students' responses presented in *Table 5*) indicate that it is both applicable and useful, with only minor disadvantages due to a slow internet connection of some users. Firstly, average students' responses to selected survey questions presented in *Table 5* were rather high and, secondly, an inadequate speed of internet connection that some students and teachers experienced from their home is not an issue that a higher education provider could easily compensate for.

7 Conclusion, Limitations of Study and Future Research

Due to the regional onset of the COVID-19 pandemic, at the beginning of the summer semester of the 2019/2020 academic year in Croatia "emergency remote teaching" (ERT) was introduced as a temporary change of the means of instructional delivery in the classroom to an alternate delivery online mode. One of the opportune means for immediately replacing traditional teaching with distance education is the use of web conferencing tools. In our pilot study we demonstrated that this replacement was rather successfully performed in the segment where the web conferencing tool *BigBlueButton* was used as a substitute for classroom teaching at one college in the northwestern part of Croatia. In addition to that, a preliminary version of a measurement instrument with acceptable internal consistency of constituent scales was developed, based on relevant research literature, that could be used for the evaluation of other web conferencing tools (*Adobe Connect*, *Zoom*, etc.) as well as for the evaluation of diverse e-learning tools if properly adapted/modified. Finally, the results of our stepwise regression analysis of predictors of *Intention to Use* indicated that, from the perspective of their successful adoption in the educational settings, web conferencing tools that are used for synchronous distance education could benefit from *User Experience* qualities, e.g. possessing attributes associated with *Design Appeal* and stimulating *Cognitive Involvement* of students.

No relevant limitations of this research were identified by the authors if it is regarded as a pilot study aimed at the evaluation of the *BigBlueButton* web conferencing system in educational settings and creation of an initial version of a survey instrument with scales designed to measure constructs associated with *DeLone and McLean* IS *success model, Usability* and *User Experience*. However, in further research that would aim to reach beyond a pilot study framework a more representative sample of subjects from different higher education institutions should be used.

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The Occupational Standards Development according to CROQF*

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Abstract. *Fast development of ICT, specifically AI, IoT and smart environment influence both society and everyday lives. The manner in which knowledge is collected, processed and disseminated has changed and ICT affects the growth of skill, learning and employability. It is important for universities to have modern study programs that will enable them to educate young professionals to gain competitive knowledge in this continuously evolving field. This article describes the development of occupational standards covering four very attractive areas: data technologies and artificial intelligence, management of information security and privacy systems, distributed and interactive systems and business systems transformation and innovation management.*

Keywords. occupational standards, CROQF, ICT trends

1 Introduction

Because the information and communication technologies (ICT) sector is characterized by innovation, support for parts of the industry of high value and significant dependence on continuous technological advances, ICT professionals in the future will have to combine new digital skills with managerial skills and trends such as digital leadership, big data, cloud computing, the Internet of Things and smart systems, so the creation of new occupations is envisaged (Skills challenges in Europe (2016) | Skills Panorama). According to the assessment of the World Economic Forum from 2018 (The Future of Jobs Report 2018 | World Economic Forum), changes in ICT occupations are expected, so the focus will be on occupational group: analyst and development engineer, information security analyst and data analyst, where there will be major changes in requirements for new skills of ICT professionals. These data indicate the need for new competencies and knowledge for future jobs and about parallel increase in demand for ICT professionals. Therefore, there is a need for education and training that will create adequate staff and meet the demand in the labour market and raise the level of ICT skills.

The purpose of the project "DIP2Future: Development of educational programs, qualification standards and occupational standards in the field of ICT in accordance with the CROQF" is to develop educational programs, qualification standards and occupational standards in the field of ICT in accordance with The Croatian Qualifications Framework (CROQF). The project will be implemented by University of Zagreb, Faculty of organization and informatics (FOI) Varaždin in partnership with the Department of Informatics of the University of Rijeka (OIRI), and 4 new study programs will be developed: 1) Data technologies and artificial intelligence, 2) Management of information security and privacy systems, 3) Distributed and interactive systems and 4) Business systems transformation and innovation management.

In the paper we first describe Croatian qualifications framework and proposed occupational standards, and then methodology for developing occupational standards. We also present a case study for the first part of methodology, adjustment and optimization of the survey.

2 Description of the Croatian Qualifications Framework

In Croatia the efforts and the process of modernization of education, training and qualifications systems, matching education and labour market, are incorporated into an agenda known as the Croatian Qualifications Framework (CROQF) (Institut društvenih znanosti Ivo Pilar 2019).

The Croatian Qualifications Framework (CROQF) (Agency for science and higher education 2020) is an important tool and reform mechanism to govern the qualification system in the Republic of Croatia at all levels by qualification standards focused on learning outcomes and the needs of the labour market, individuals and community. CROQF is a system that sets in place of a qualification obtained in Croatia

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where the core element is the learning outcomes or, in other words, the competencies acquired by the individual through the learning process and proved after the learning process. The important precondition for CROQF is the existence of a quality assurance system that validates the success of educational processes and research (Ministry of Science and Education n.d.).

The legislation on the Croatian qualification's framework was adopted in 2013. The Croatian Qualifications Framework Act (NN 22/2013) defines the qualification, occupational and qualification standard. The qualification applies to the set of integrated learning outcomes units for a given level, volume, profile and quality. The occupational standard is a list of all tasks performed by persons employed in a specified profession, as well as a set of competencies needed to properly execute them. Qualification standard is the content and form of the qualification. It induces all the data required to establish its level, volume and profile, as well as the data needed to ensure and encourage high quality of a qualification. Although the same qualification may be achieved at various educational institutions and by specific educational programs, there are some requirements that a qualification requires to meet in terms of specified learning outcomes. The CROQF register is a system in which occupational standards are entered and connected to qualification standards by means of competence sets and learning outcome sets. The CROQF registry is freely accessible and can be used to create innovative educational programs focused on learning outcomes, i.e. collections of qualifications that the job force has found essential. Ordinance on CROQF registry (Ministarstvo znanosti obrazovanja i sporta 2014) regulates the content and manner of keeping registry, submission of applications for entry in the registry, content and form of application forms, evaluation of applications for registration, registration procedures, names of sectors, names of sector councils, manner selection and criteria for the selection of members of sectoral councils, job description of sectoral councils and internal and external quality assurance system.

CROQF is an significant precondition for governing the lifelong learning framework in Croatia, and is the foundation of a knowledge-based community and social inclusion (Lučić et al. 2011). In accordance with the Republic of Croatia's foreign policy, it also integrates the rules of the European Qualifications Framework (EQF), EU standards and external legislation. Creating a sustainable European economic region includes the mobility of competences (and the mobility of citizens), their identification and usage for the advantage of workers, employers and the whole society.

Currently, 29 occupational standards are entered in the register, which define a total of 317 sets of competencies. A total of 8 occupational standards are enrolled that define 329 sets of learning outcomes. A total of 167 requests are in the process of being entered in the register, 226 requests are being processed after the formal verification, 29 requests are in the process of expert evaluation and 25 requests are being processed after the professional evaluation (ISRHKO - Standardi n.d.).

In their research paper Klarin, Nazor and Celar (2019) recommended that for the process of establishment of national qualifications (CROQF) is important for them to be related to learning outcomes. The reason for that is the aim of learning outcomes to increase transparency, understanding and comparability of qualifications.

3 Proposed Occupational Standards

For the purpose of development of new master study programmes, four new occupational standards should be developed:1) Intelligent information systems architect for data technologies and artificial intelligence, 2) Security and privacy architect for management of information security and privacy systems, 3) Distributed and/or interactive system architect for distributed and interactive systems development and 4) Business systems transformation architect for business systems transformation and innovation management.

Information systems in various domains incorporate artificial intelligence technologies that improve the management of large amounts of data, information and knowledge, and thus the efficiency of these systems and the organizations that use them. Intelligent information systems enable the acceleration of the development of business, science and society in general. Therefore, it is necessary to educate information systems experts for the development and application of artificial intelligence technologies. The occupation is being developed to include knowledge and skills that enable a person to successfully work in several jobs depending on the character, size and needs of the business system. An intelligent information systems architect is an expert who, based on business requirements, uses artificial intelligence technologies in combination with other modern information technologies to design and develop intelligent information systems that provide organizations with optimal data, information and knowledge management for decision making and business improvement.

The society has acquired the conditions for building integrated security and privacy systems of business entities, so it requires specific knowledge about the activities to be carried out in order to timely protect the security and privacy of both the individual and the entire business system of the organization. The security and privacy system must be manageable, so an occupation is proposed that will include the necessary theoretical and factual knowledge and skills of system organization, risk assessment, implementation of vulnerability reduction measures, managing system

adaptation to work in an environment where threats change very dynamically. The occupation proposal is described so that a person can work in multiple jobs given the character, size and needs of the business system. The information security and privacy architect is an expert who, by applying new information technologies, will be able to offer solutions that will improve the company's business and business environment, taking into account all security and privacy protection requirements.

The development of society creates an increasing need for systems or services that are based on the innovative and efficient use of ICT. A direct consequence of this is the need to acquire the specific knowledge and skills that the development of these systems or services requires. One of the developed standard of occupation will be related to distributed and/or interactive systems and will include the necessary theoretical and practical knowledge and skills. The occupation should include the knowledge and skills necessary for a person to work in multiple jobs according to needs of the business system. Distributed and/or interactive system architect is therefore an expert who is primarily in step with upcoming ICT technologies, understands business requirements and is able to model them, design future architecture, taking into account all business aspects and implement it through the development of distributed and/or interactive system.

The development of technologies and the speed with which this development takes place open the possibility for the development of new key jobs and accompanying knowledge and skills. The key question, along with the development of technology, is how to achieve a competitive advantage by applying them, i.e. how to transform the company's business in the direction of achieving greater business success. The business systems transformation architect is described as an expert who, by applying new information technologies, will be able to offer solutions that will improve the company's business and the business environment in which the company operates. The business systems transformation architect should know the methods of analysis of the environment, factors arising from business and technology in order to be able to propose initiatives in business improvement and realization of technological potential of companies to implement the process of digital transformation.

4 Methodology for Developing Occupational Standards

To facilitate the process of the development of the occupational standard proposal, Ministry of Labour and Pension System issued the methodology that contains a set of guidelines for the development of occupational standards and provides detailed information and examples on: steps and procedures in activities related to the organization and implementation of the occupational standard survey, systematization of information and data collected by the survey as well as information on activities related to formalizing occupational standard proposals.

The first section of the methodology describes CROQF and the second section explains how a form for occupational standard proposal should be filled with the goal to assess strategic, sectoral and analytical grounds of the proposal (Ministarstvo rada i mirovinskog sustava n.d.).

4.1 Description of Guidelines

The aim of the guidelines is to establish a uniform, identical and standardized framework for all occupations for which an occupational standard is being developed.

The guidelines include supporting materials and forms necessary for the implementation of steps and activities in the implementation of the survey, systematization of information and data collected by the survey and formalization of proposals for occupational standards, as well as for verification of their implementation. They also provide examples that clarify certain concepts (e.g. examples of key jobs, examples of certain types of knowledge and skills), as well as examples that illustrate the expected outcomes of individual tasks and activities in the development of occupational standards (e.g. lists of key jobs, lists of knowledge and skills, lists of sets of competencies). They are mainly taken over and/or adapted from existing documents, registers and databases (e.g. CROQF Register - Sub-Register of Occupational Standards, European Skills/Competences, Qualifications and Occupations (ESCO), Slovenian Database of Professional Standards).

The first part of the guidelines presents the content of the occupational standard survey, detailing the parts of the survey and the questions contained in each part of the survey. The survey structure includes an introductory part, which collects basic technical information and five thematic parts that focus on different sets of information. Given that the development of occupational standards is divided into four groups of activities, the further content and text of the guidelines are designed accordingly in four parts that describe:

- tasks and activities related to the adjustment and optimization of the survey to a particular occupation or group of occupations, with examples showing the expected outcomes of individual tasks and activities,
- the procedure of conducting the survey,
- the procedure of systematization of information and data collected by the survey,
- the procedure of formalizing the proposal of occupational standards.

Adjustment and optimization of the survey

The aim of this step is to adapt and optimize the general form and content of the survey to individual occupations in order for employers and employees to fulfil it, and it is described in terms of the goal, outcome of activities and responsibilities for the implementation of activities. The guidelines define the adjustment and optimization of the survey through 3 tasks: (1) adapting and optimizing of the list of key jobs; (2) adapting and optimizing the list of knowledge and skills; and (3) a report on the adjustment and optimization of the survey. A "group of experts" is formed to implement this step, and general guidelines are given for their selection and engagement.

Conducting the survey

The aim of the survey is to collect and confirm information relevant to the development of occupational standards from the perspective of employers and employees. The guidelines define this step through the following related tasks: (1) selection of employers and employees to participate in guided surveys and structured interviews; (2) preparation of facilitators and assistants for guided surveys and structured interviews; (3) conducting guided surveys and structured interviews; and (4) systematization of information and data through the preparation of reports on the implementation of the survey.

Systematization of collected information and data

This part of the guidelines describes the activities of systematization of information and data collected by the occupational standard survey. These activities need to be started during the implementation of the survey, by keeping detailed notes and observations, and after collecting information from employers and employees, they need to be completed. The aim is to make lists of key jobs, knowledge and skills that will be included in the proposed occupational standard. The set of activities related to the systematization of information and data collected by the survey consists of 2 basic tasks: (1) making a list of key tasks and (2) making a list of knowledge and skills.

Formalization of occupational standard proposals

According to the guidelines, the process of formalizing the proposal of occupational standards takes place after the implementation of the survey with employers and employees and the activities of systematization of information and data collected by the survey. The aim is to create a list of competencies, sets of competencies and key tasks with associated individual competencies for their performance, description of occupations and working conditions and fill in a defined form (Form HKO_SZ (PART B)). basic tasks: (1) compiling a list of competencies; (2) associating individual competencies and key tasks; (3) defining sets of competencies; (4) defining occupational descriptions and working conditions; and (5) filling in a defined format. Occupational standards should rely on their professional knowledge related to the occupation for which the standard is developed, as well as on systematized information and data collected by the Survey from employers and employees and possible external experts.

In the next chapter, the first activity, adjustment and optimization of the survey, will be described in more detail.

4.2 Activities Related to the Adjustment and Optimization of the Occupational Standard Survey

The survey was conducted with the aim of aligning future study programs in higher education with the needs of employers in the fast-growing and innovative labour market. In order to examine the needs of employers, a survey on occupational standard was carried out by the Ministry of Labour and pension system, the Croatian Employment Service and the Ministry of Science and Education (Bedeković, Kadlec, and Tolušić 2016). The first phase in the occupational standard survey preparation is to adapt and refine the general type and content of the survey to a specific profession or occupational category. Two basic activities need to be carried out: (1) adapting and optimizing the list of key jobs and (2) adapting and optimizing the list of knowledge and skills.

The first activity refers to adjustment and optimizing of the list of key jobs in the survey. There are nine types of jobs: (1) Analysing, planning and organizing work; (2) Workplace preparation; (3) Operational activities related to the occupation/job; (4) Administrative affairs; (5) Commercial affairs; (6) Communication and cooperation with others; (7) Research, development, innovation; (8) Quality assurance; (9) Health and environmental protection. Key jobs are listed only in those of the nine offered types of jobs that are assessed to be performed by the occupation.

The occupational standard should contain a list of key jobs in which each key job is associated with all the individual competencies necessary for its successful performance. The second activity refers to adjustment and optimizing of the list knowledge, skills and competencies necessary for a worker to be able to successfully perform the work in the workplace where he/she works. In reviewing knowledge and skills, it is important to ensure that the lists of knowledge and skills include all the knowledge and all the skills needed to perform the tasks listed in the list of key jobs. Knowledge can be factual or theoretical. Factual knowledge applies to a collection of facts learned independently. The facts gained could be concepts, their definitions, as well as other factual knowledge that may not in itself offer up a strong prospect of generating fresh knowledge. Theoretical knowledge refers to a set of linked information which have been acquired. Linking separate information may apply to various ideas, models, as well as other theoretical knowledge that allows the more valuable separate information being generated unambiguously.

Skills refer to whatever enables knowledge to be properly applied. Skills can be cognitive, psychomotor and social. Cognitive skills apply to a collection of objectively and creatively learned ideas. Psychomotor skills relate to the learned physical strength and the application of techniques, devices, resources, and materials previously identified. Social skills refer to a set of acquired skills that are needed to create and develop interpersonal relationships.

Furthermore, knowledge and skills need to be grouped into (1) occupation-specific, (2) sector- or cross-sector-specific, and (3) transferable knowledge and skills. Occupational-specific knowledge and skills are usually applied within only one occupation. Sector-specific knowledge and skills relate to one sector, but are important for more than one occupation within that sector. Cross-sectoral knowledge and skills are important for several economic sectors. Transversal knowledge and skills are important for a wide range of occupations and sectors. They are often called basic, basic or "soft" knowledge and skills and represent the foundation of an individual's personal development

4.3 Case Study of the DIP2Future Project

Research can be divided according to different criteria: applicability, methodological approach, types of data collected and studied, frequency of implementation, objectives and scope of research, time and object of research (Tkalac Verčić, Sinčić Ćorić, and Pološki Vokić 2014). The methodology defines conducting the survey of employers 'and employees' opinions related to key jobs, knowledge and skills required for a certain occupation with the obtained Guidelines for the development of occupational standards. A set of methods was used to define key jobs/knowledge/skills for those interviews.

The first step in defining key jobs was to review existing classifications and frameworks that can be incorporated into the domains of a particular occupational standard. The ESCO classification (European Skills/Competences, Qualifications and Occupations) (ESCO - Using ESCO - European Commission n.d.) and the ISCO classification (The International Standard Classification of Occupations) (ISCO - International Standard Classification of Occupations n.d.) were used as the basic to create pool of key jobs, skills and knowledge. Furthermore, European e-Competence Framework (European e-Competence Framework n.d.) and SFIA (Skills Framework for the Information Age) (About SFIA — English n.d.) were consulted. Both describe skills and competencies required by professionals in roles involved in information and communication technologies, digital transformation and software engineering and applied at the ICT workplace. For data technologies and artificial intelligence was also used EDSF (EDISON Data Science Framework) (EDISON Data Science Framework (EDSF) | Edison Project n.d.)

The second step included the study of the content of professional certificates that can be related to the field of security, interactive and distributed systems, data technologies and artificial intelligence, management of transformation and innovation of business systems.

The third step was to get acquainted with the content and structure of existing study programs in a particular domain, where the consulted foreign study programs, domestic study programs and organized study trips. It was identified that there are no similar study programs in Croatia that would cover the vision of new occupational standards, so the most similar study programs abroad have been identified. Therefore, study visits were organized to the faculties that conduct study programs most similar to the required domains.

The fourth step was the analysis of job vacancies related to a particular occupational standard. Job vacancies on EU and Croatian portals were studied. For certain jobs, job descriptions were obtained from the companies themselves, which in their organizational structure have defined jobs that are related to a certain standard of occupation.

The last step was to define the final set of key jobs, required knowledge and skills. For this step, four focus groups were organized with the aim of validating the content as well as adding key jobs, knowledge and skills that were not included. In this step, a group of experts was engaged who had the same task as the focus group. Groups of experts are teachers from the Faculty of Organization and Informatics and the Department of Informatics, University of Rijeka who are experts in the field of occupational standards.

Table 1 shows the systematization of the described steps for each occupation in DIP2Future case study.

5 Conclusion

Adoption to the new digital culture, or digital future is necessary for grow and change, even more for educational institutions (Hinchcliffe n.d.). Digital technologies are among the main change accelerators that can transform educational systems, and these changes demand action and decisions in educational institutions (Begičević Ređep, Klačmer Čalopa, and Tomičić Pupek 2020).

To be competitive in today world job market in the field of ICT, computer science professionals need knowledge and skills for specialised occupations that are dealing with new challenges, such as large amounts of data, information, and knowledge, various applications of artificial intelligence, distributed and interactive systems, disruptive force of digital transformation and growing problem of security and privacy. University study programs must ensure acquiring knowledge and skills that will enable graduates to enter job market prepared for those challenges.

Table 1: Systematization of the DIP2Future case study

Steps / Occupational standards	Information security and privacy architect	Distributed and interactive systems architect	Intelligent information systems architect	Business systems transformation architect
Review existing classifications and frameworks	ESCO: ICT security legislation; Information architecture; Information categorization; Information extraction; Information security strategy; Information structure etc. ISCO: sub-major groups Science and Engineering Professionals; Business and Administration Professionals; Information and Communications Technology Professionals; units Software Development, Database and Network Professionals, ICT Services Managers etc.	ESCO: Embedded system designer, Software architect, Embedded system developer European e-Competence Framework 3.0: DevOps Expert SCRUM Master, Digital Media Specialist, Developer, Systems Administrator, Network Specialist, Technical Specialist	ESCO: ICT intelligent systems designer, ICT information and knowledge manager, Chief data officer, Knowledge engineer, Data scientist, Data analyst European e-Competence Framework 3.0: Data Analyst, Data Specialist EDISON: Data Science / Big Data Infrastructure Managers, Data Science Professionals, Database and Network Professionals	Four key frameworks for digital transformation: The Adaptable Digital Transformation Framework, A Digital Transformation Initiation Framework, A Leadership Framework for Digital Transformation, The Digital Transformation Target Model ISCO: sub-major groups Business and Administration Professionals; Information and Communications Technology Professionals; ICT Services Managers etc.
Study of the content of professional certificates relates to the fields	ISO/IEC 27001, ISO/IEC 27032, ISO/IEC 27002, ISO/IEC 27034, ISO/IEC 27005, ISO/IEC 27035, Risk Assessment Methods were contemplated. CompTIA - Security+, (ISC)2 - Certified Information Systems Security Professional (CISSP), EC-Council - Certified Ethical Hacker (CEH), ISACA - Certified Information Systems Auditor (CISA), Cisco Certified Network Associate - Security (CCNA Security), and others	***	***	***
Acquainted with the content and structure of existing study programs in a particular domain	No similar study programs in Croatia. Study visits to: École Supérieure d'Informatique, Électronique, Automatique (ESIEA) and Université Paris-Est Créteil (UPEC)	No similar study programs in Croatia. Study visits to: École Supérieure d'Informatique, Électronique, Automatique (ESIEA) and Université Paris-Est Créteil (UPEC). Foreign master study programs: Distributed Systems Engineering (TU Dresden), Software Engineering of Distributed Systems (KTH), Distributed Systems and Web Technologies (TUIASI), Parallel and Distributed Computer Systems (VUA), Informatics: Programming and Networks(UIO), Communication Technologies and Multimedia (UNIBS), ICT for Internet and Multimedia (UniPD)	No similar study programs in Croatia - there are programs oriented to data science but with no or little orientation on business organisations. Foreign master study programs – Data Science and Artificial Intelligence (TU/e), Artificial Intelligence and Data Engineering (UniPisa), Artificial Intellgience (UvA), Artificial Intelligence (UU), Data Science and Entrepreneurship (JADS – Tilburg University and TU/e), Data Science for Decision Making (UM)	No similar study programs in Croatia. Study visits to: École Supérieure d'Informatique, Électronique, Automatique (ESIEA) and Université Paris-Est Créteil (UPEC)
Analysis of job vacancies related to a particular occupational standard	Keywords: cyber security, data protection, information security	Keywords: Distributed systems, Interactive systems, embedded development, software architect, Internet of things specialist	Keywords: data scientist, data engineer	Keywords: digital transformation, Business Intelligence, digital innovation
Defining the final set of key tasks, required knowledge and skills	Focus group with Companies: AKD, Privredna bak, Diverto, EGCP	Focus group with Companies: Mobilisis, Ericsson Nikola Tesla	Focus group with Companies: Poslovna inteligencija, IBM Hrvatska	Focus group with Companies: Omega Softwaerre, Speck, Northwest, Erste Bank

To develop modern study programs, corresponding qualification standards and prior to them, occupational standards should be developed. Although various classifications and frameworks, as well as existing study programs and description of job offers give insight into needed knowledge and skills, development of occupational standards is not possible without the cooperation of employers and employees. They are solving current problems in organisations and improving business with the help of ICT, and also foreseeing possible future issues. Their contributions in generating conclusions and recommendations to improve study programs in accordance with the principles of the Croatian Qualifications Framework are of utmost importance. Therefore, next parts of methodology, conducting the surveys and their analysis should be approached with particular attention.

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Satisfaction With Distance Education at the Time of the Outbreak of the COVID-19 Virus Epidemic Among Pupils and Students

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Abstract. *The outbreak of the Covid-19 virus epidemic forced educational institutions to transfer their educational activities to the online environment. Distance education brings some positive benefits: such as (1) the ability to independently organize learning, (2) individual learning methods, and (2) work in a home environment. Many disadvantages were also noted: (1) lack of explanation and misunderstanding of the subject matter; (2) lack of conversation and communication; and (3) various technical problems. The workload of students has increased, and learners are now busier and spend more time studying. As a result, most learners want to go back to school.*

Keywords. satisfaction, distance education, (IT) information technology, web services, education.

1 Introduction

We live in a time of evolving modern technology that unconsciously affects the course of life of each of us. There are also constant changes in the field of education. Distance education involves the use of several electronic devices, through which the educational process can proceed smoothly, considering the appropriate conditions. The educational process was thus moved from educational institutions to the private sphere of the individual. It enables the individual to allocate his/her time for learning at his/her discretion, save time and reduce costs, and become more easily accessible, while strengthening knowledge of information and communication technology. However, distance education requires more individual work and responsibility from the learner and consequently more time. Moreover, the way of teaching also changes, which can be a problem for many teachers. Both students and teachers lack social contact in such work, which enables spontaneous communication, real-time problem solving, and facilitates the learning process itself.

2 Distance Education

There are many different definitions of distance education, but in general is distance education a form of independent study (Wedemeyer, 1971) an educational process where students and teachers are spatially separated (Bregar, Zagmajster, & Radovan, 2010). The learner or other participant in the pedagogical process, which takes place at a distance, is not in physical contact with the teacher. The key difference between distance education and traditional (classical) education is that learning does not take place in designated areas, such as schools, colleges, universities … The task of an educational institution in distance education is to plan and create adapted learning materials. It is also important for assisting learners. The teacher imparts knowledge through various media – computer programs, materials, and presentations (Bregar, Zagmajster, & Radovan, 2010). Distance learning is becoming more and more popular over the years (Berge, 2019). Distance education potentially enables higher education of the population and thus the development of society itself (Krajnc, 2008).

At the time of the outbreak of the epidemic, in Slovenia as well as abroad, the learning process was transferred to the online environment, which was supported by most teachers (Dragoshi, Kapllanaj, & Zeneli, 2020).

There are many advantages of distance education which have already been researched in Latvia (Katane, Kristovska, & Katans, 2015). The researchers in Slovenia have come to similar results (Hrenko Podergajs & Osrtman Renault, 2010). Despite some concerns about the equivalence of learning outcomes between the two teaching methods and the satisfaction with distance learning, several studies have shown that learners are satisfied with distance learning (Allen, Omori, Cole, & Burrell, 2019). They also found that there are no differences in successfulness between learners, depending on whether they are distance learning or not (Hrenko Podergajs & Osrtman Renault, 2010). As a result, the number of learners who use this

way of learning has been increasing recently (Drobnjak & Jereb, 2007) and that is why many colleges and universities are interested in how to best deliver course content for online learners (Dumford & Miller, 2018). The learner can plan his/her learning schedule and thus reduce costs (transport to school, food …). Well-prepared learning materials encourage the learner to think, be creative, and look for sources of information more broadly. This way of learning is also more interesting for learners compared to traditional learning, which additionally encourages and motivates the individual (Anderlič, Antlej, & Duraković, 2008).

Motivation in education is a very important factor that affects an individual's success. It has an impact on his thinking and behaviour. Distance education requires the teacher an even deeper understanding of the learner's motivation, which helps to form and develop the individual's positive learning experiences (Hartnett, 2019).

Some children feel more relaxed in the home environment, which allows them to be more effective in learning (Učenje Na Daljavo: Prednosti In Slabosti, Ocene. Študija Študentov Priložnosti Za Učenje Na Daljavo, b. d.). Distance education can be a challenge for both learners and teachers (Anderlič, Antlej, & Duraković, 2008). By prior arrangement with the lecturer and participants, the lesson can also be recorded during teleworking to allow those who were not present to make up for the missed subject matter with an appropriate explanation. The web provides access to many learning materials and is a widely available source of information that can be obtained in an easy and fast way (Učenje Na Daljavo: Prednosti In Slabosti, Ocene. Študija Študentov Priložnosti Za Učenje Na Daljavo, b. d.). At the time of the outbreak of the epidemic, RTV Slovenia also came to the aid with informative and educational content. They broadcast programs, for example, Izodrom (Izodrom, 2020), How to write an official/unofficial apology/invitation/message? (Kako se napiše uradno/neuradno opravičilo/vabilo/sporočilo?, 2020) and Young to young (Priprave na maturo in učenje ter študij na daljavo, 2020), which helped learners facilitate the acquisition of the subject matter and the course of the learning process. Besides, most of the participants prefer to attend the online lessons regularly because of availability concerns, traveling, and comfort of their home (Saltan, 2016).

The disadvantages of distance education are most often reflected in the lack of control over the individual, so self-discipline is important (Anderlič, Antlej, & Duraković, 2008). With a lack of self-discipline, distance education can be ineffective and unsuccessful. This is particularly noticeable in younger students who need more encouragement and help from adults to stay focused on the subject matter (Učenje Na Daljavo: Prednosti In Slabosti, Ocene. Študija Študentov Priložnosti Za Učenje Na Daljavo, b. d.). Another problem is the lack of social contact, which is very important for everyone because humans are social beings and we need it. One-way communication predominates between the student and the teacher in distance education, where the teacher explains the subject matter and the learner is a passive listener. Not all participants in the pedagogical process have the same opportunities to access the technology needed to carry out the learning process. The reasons for this are diverse (number of users, the financial situation of the family). A survey conducted by PISA found that more than 90 % of learners in Europe have access to relevant technology, while in other parts of the world less than 50 % (PISA, 2020).

The implementation of examination and assessment of knowledge is also more demanding, as course providers find it more difficult to control the correctness of assessment, and for learners, this represents additional stress and burden (Anderlič, Antlej, & Duraković, 2008).

It is necessary to adjust the assessment method during the epidemic. All the learners need to be familiar with new assessment methods and criteria, and teachers need to find parallels between classical assessment and distance assessment. A smaller amount of learning material is recommended. It is essential that the student can improve the product or evidence of what has been assessed based on feedback (Zavod Republike Slovenije za šolstvo, 2020).

Considering technical capabilities and contacting all learners is also important and we need to pay special attention to students with special needs (Kinash, Birt, & Judd, 2019). Also, the ethical aspect of distance learning is important. Both teachers and students must strive for a positive, respectful attitude and nurture positive values (Thompson, 2019).

The inability to access libraries also caused a problem during distance education at the time of the outbreak of the epidemic. It should be emphasized that libraries support distance learning, but they also face some challenges, as they want to ensure the widest possible access to materials for all learners which is not always possible (Fabbro & Rempel, 2019).

At the time of the outbreak of the epidemic, many teachers were forced to face distance education and one such teacher is a teacher from the primary school in Zagorje, who also shared her experience with the public (Učenje na daljavo, 2020). She stressed that students lack physical contact with teachers and feedback on their knowledge. Especially with younger students, parents are actively involved in the learning process, as they need more help and support, which can be very burdensome for parents (Šašek & Volčič, 2020). The experience of other schools with distance education was also reported on the RTV Slovenia program. Among other things, the teachers at the Elementary School Bojan Ilich in Maribor introduced themselves, pointing out the problems they face when working from a distance and how they deal with problems (Učenje na daljavo, 2020).

3 Research

3.1 Method and Sample

One of the positive features of the web is a new way of collecting data. The online survey could replace the traditional way of collecting data soon, as it offers researchers many positive effects. It offers us systems that are affordable and verifiable. If we research in that way it is easier to get feedback (Kaye & Johnson, 1999).

The acquired survey data was analysed using descriptive and inferential statistics where were used only test differences between groups of respondents. The decision to use $\chi 2$ test was strait forward and in accordance with methodology (Kožuh, 2010).

A quantitative research method was used to analyse the current situation and satisfaction with distance education during the epidemic between pupils, high school students, and students in universities studying in Slovenian educational institutions. We used a measuring instrument – a questionnaire consisting of 9 closed and combined questions. There were several possible answers to some questions. Questions ranged from general questions about distance education to more specific questions about the satisfaction of distance education. The questionnaire was published and distributed via the web portal for the survey questionnaires (www.1ka.si). The weblink to the survey questionnaire was viewed by 5448 respondents and completed by 2641 respondents from Slovenia (-833 primary school students, 1004 secondary school students, and 796 university students). The sample was selected randomly. Data were collected in the period between 8 to 22 May 2020. Based on results we used descriptive statistics (percentage, average mean) and inferential statistics (chi-square).

Table 1: Sample by gender and age

	Age			
Gender	Less than 10 yr	10 – 20 yr	20 – 30 yr	Total
Male	83	454	145	682
Female	130	1308	521	1959
Total	213	1762	666	2641

Table 2: Sample by gender and education

	status			
Gender	Primary school	Secondary school	Tertiary education	Total
Male	308	195	179	682
Female	530	811	618	1959
Total	838	1006	797	2641

The survey involved 74 % of female respondents and 26 % of male respondents.

3.2 Results

Based on the survey it was found that about 90 % of respondents had not yet been familiar with distance education before the outbreak of the epidemic. The student population had the most experience with distance education. Of the 10 % of respondents who were already acquainted with distance education, most of them became acquainted with it as part of education, while other respondents became acquainted with it through various media, through personal experience or abroad.

Table 3: Students experience with distance education before the Corona pandemic

	Prior experience with distance education		
Level of education	Yes	No	Total
Primary education	67 8 %	771 92%	838
Secondary education	88 8.7 %	918 91.3 %	1006
Tertiary education	99 12.4 %	698 87.6 %	797

The χ^2 statistic has shown that there is a significant difference between groups in the question of prior experience (χ^2=10.62; p=0.005). At the tertiary level of education there was more experience with distance education but no more than 12.4 % according to the sample.

In our research, we wanted to know in what ways the students used different services for distance education. The selectable options were e-mail, e-courses (in LMS), and videoconferences. Not surprisingly tertiary education was significantly different than the rest of the education population in any given type of distance education.

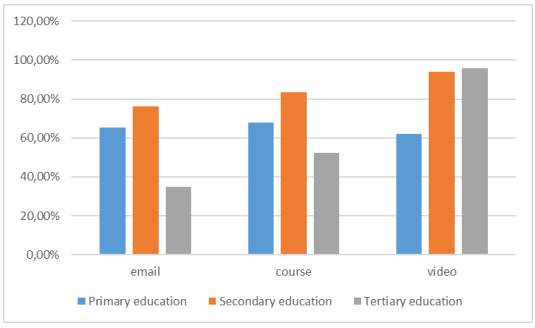


Figure 1: Use of different types of web services for distance education

The χ^2 statistic has shown that there is a significant difference 26between groups in the question of using e-mail (χ^2=326.57; p=0.000); e-course (χ^2=203.48; p=0.000) and videoconferences (χ^2=464.29; p=0.000).

The most common way of distance education during the epidemic was via videoconferencing, but it was not possible to identify the predominant way of learning in primary school children. The pedagogical process took place via e-mail, online classrooms, and

videoconferencing. For secondary school students, classes were mostly via videoconferencing and online classrooms, and little less via e-mail. However, the use of videoconferencing was very common among the tertiary student population (more than 95%). Respondents stated that in addition to the aforementioned methods, they also used several web portals (Arnes, E-assistant, Google Drive, Google Classroom, Lopolis), e-textbooks (lilibi.si), websites of educational institutions, social networks and telephones.

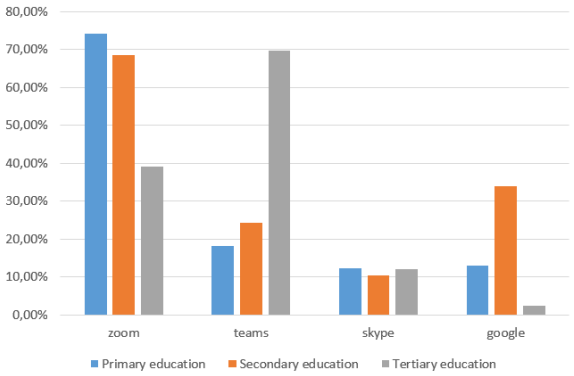


Figure 2: Use of the videoconferencing system in education

The χ^2 statistic has shown that there is a significant difference between groups in the question of using videoconferences services in Zoom (χ^2=210.69; p=0.000); MS Teams (χ^2=486.02; p=0.000); Google meeting (χ^2=291.80; p=0.000); but not in the use of Skype (χ^2=1.98; p=0.372).

Nearly half of the respondents used the Zoom application, which was prevalent among primary and secondary school students, to conduct video conferencing. Almost 70 % of the tertiary students who completed the questionnaire used Microsoft Teams in addition to the Zoom application. Respondents also mentioned other apps like Cisco WebEx, Jitsi.org, Gotomeeting, Google hangouts, Viber, Discord, Google Classroom, Google Drive, Moodle, BigBlueButton, WhatsApp, Outlook, Quizlet, E-assistant, iCloud, Messenger, Wiziq, CCC Confer, Instagram, and Facebook. Respondents most often mentioned the independent organization of learning time as the advantage of distance education (50 %), followed by work in the home environment (34 %). Some also liked the independent choice of learning method (9 %), but also pointed out the cost-effectiveness and accessibility of distance learning, improving their knowledge of information and communications technology, adjusted schedule, and assessment.

Table 4: The advantages of distance education.

Level of education	Time control	Learning style	Home environment	other
Primary education	**404 48 %**	107 13 %	264 32 %	63 7 %
Secondary education	**619 62 %**	76 8 %	252 25 %	59 5 %
Tertiary education	301 39 %	42 5 %	**394 50 %**	60 6 %

As expected, there are significant differences between groups (χ^2=162.07; p=0.000).

Distance education brings some disadvantages, which were also mentioned by the respondents. Their biggest problem was the lack of explanation and misunderstanding of the subject matter (43 %), as well as the lack of conversation and communication between teachers and learners (33 %). Respondents also listed poor organization and the lack of information and adjusted schedule of the pedagogical process and assessment, a change in the learning environment, and technical difficulties as disadvantages.

Table 5: The disadvantages of distance education.

Level of education	Communi-cation	Feed-back	Explanation (misunder-standing)	Other
Primary education	297 35.4 %	68 8.1 %	**391 46.7 %**	82 9.8 %
Secondary education	264 26.2 %	136 13.5 %	**517 51.4 %**	89 8.8 %
Tertiary education	**300 37.6 %**	137 17.2 %	236 29.6 %	124 15.6 %

There are significant differences between groups (χ2=119.18; p=0.000). The data shows interesting things on this topic of research. Secondary education students do not particularly miss communication, but they do need explanation. In primary schools, students almost do not miss the feedback, but they do need communication and explanation. Tertiary students miss communication at a higher percentage than any other type of nuisance of distance education.

More than 60 % of all respondents stated that they needed more time for learning while distance learning than during the learning process in educational institutions. The same percentage of respondents also commented on the workload, namely that they felt more burdened by distance education. It turned out that half of the respondents are still satisfied with the implementation of the distance education process because of all the advantages that this way of working brings. The slightest satisfaction with distance education was by the students. Nevertheless, more than 60 % of respondents still wanted to be able to continue with the classical way of learning within educational institutions.

Table 6: Time needed for learning (no significant differences between groups ($\chi 2$=59.59; p=0.000).

	Do you need less time for studying while distancing education?		
Level of education	Yes	No	Total
Primary education	397 47.4 %	441 52.6 %	838 100 %
Secondary education	369 36.7 %	637 63.3 %	1006 100 %
Tertiary education	231 29 %	566 71 %	797 100 %

Despite most of the respondents agreeing they have more workload in distance learning, there are significant differences between groups. Primary schools' students were fairly equally subjected to the workload as in schools whereas this is not true for the other two groups.

Table 7: Workload due to school obligations ($\chi 2$=35.08; p=0.000).

	Do you perceive more workload?		
Level of education	Yes	No	Total
Primary education	435 51.9 %	403 48.1 %	838 100 %
Secondary education	648 64.4 %	358 35.6 %	1006 100 %
Tertiary education	506 63.5 %	291 36.5 %	797 100 %

During the corona lockdown weeks, we could hear many experts saying that students were getting bored with distance learning. The data shows that students were generally pleased with distance education. There are significant differences between groups where we could see that secondary school students were less satisfied with distance education than the other two groups.

Table 8: Satisfaction with distance education ($\chi 2$=11.45; p=0.003).

	Are you generally pleased with distance education?		
Level of education	Yes	No	Total
Primary education	500 59.7 %	338 40.3 %	838 100 %
Secondary education	522 51.9 %	484 48.1 %	1006 100 %
Tertiary education	450 56.5 %	347 43.5 %	797 100 %

Table 9: Wishes about continuing distance education in the future - no differences between groups ($\chi 2$=1.62; p=0.432)

	Would you like to continue with distance education?		
Level of education	Yes	No	Total
Primary education	337 40.2 %	501 59.8 %	838 100 %
Secondary education	375 37.3 %	631 62.7 %	1006 100 %
Tertiary education	306 38.4 %	491 61.6 %	797 100 %
Total	1018	1623	2641

4 Conclusion

At the time of the outbreak of the Covid-19 virus epidemic, teachers and learners, were forced to change the way of schoolwork and adapt it to the current situation. We encountered many advantages of distance education, but also disadvantages. In the research we conducted, we found that very few learners encountered distance education before the epidemic. Later, the learning process was quickly transferred to the online environment with teachers using various ways to conduct lessons (videoconferencing, online classrooms, email, web portals, e-textbooks, social networks). The most popular video conferencing applications were Zoom and Microsoft Teams. Based on their experience, the learners cited as an advantage of the possibility of independently organizing time and work in the home environment, as well as the accessibility and cost-effectiveness of education. Disadvantages included a lack of conversation, communication, and explanation of the subject matter, as well as technical complications and a lack of feedback on independent work. Learners spent more time learning during the time of distance education and therefore felt more burdened. In general, they were satisfied with the distance education process, but they wanted to return to school.

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Emerging trends in ICT

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Usage and Role of Open Government Data and Public Policies of 54+ Citizens e-Inclusion Issues

Complex Digital Citizen Services in Coronavirus Age

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Abstract. *Digital transformation has proven itself to be of utmost importance for citizens' participation in political activities and their need for a timely and quick provision of services. Despite the recent coronavirus pandemic, we are all witnessing the true power of the European Commission's digital governance policies and actions. Changes that have occurred in a timely manner are clearly driving development and implementation of new set of citizen digital services. They represent a logical step towards digital society, considering the always-developing information and communication technology and society threats and opportunities. The aim of the paper is to present public e-services that emerged during the COVID-19 pandemics in Croatia to show efficiency of modern e-Government solutions, and to introduce some fundamental aspects of complex digital services architecture needed to level up entire digital public sector.*

Keywords. COVID-19 pandemic, digital governance, complex digital services architecture, e-Government, e-Citizen

1 Introduction

During the Croatian Presidency of the Council of the European Union, two EUPAN meetings were scheduled for April and June 2020. EUPAN meetings are a unique platform for Director Generals responsible for public administration in the Member States to exchange knowledge, experience, and best practices. In guided workshops, participants discuss solutions to common challenges faced by most public administrations of Member States. For a two days program of plenary sessions with presentations and keynote speeches, followed by the workshops, the part of agenda covered in these findings was set to tackle the development of complex digital services for citizens and businesses.

2 Going Digital

Making a transition from traditional to digital services has many benefits. Going digital, i.e. providing electronic delivery of information, reduces costs and time to market, it improves efficiency, provides higher transparency and provides full auditability joint with better customer service (Fadi, 2015). It is so important that Europe fit for the digital age[1] becomes one of six top Commission priorities for 2019-24. Empowering people with a new generation of technologies such as artificial intelligence (AI) and big data aim to encourage businesses to work with these new technologies helping to achieve its target of a climate-neutral Europe by 2050.

Making a transition from traditional to digital services in Europe started in the '90s when the general public began using the internet on a larger scale. For instance, the e-Commerce Directive, adopted in 2000, aimed to achieve the objective of freedom to provide online services across the Single Market by offering a flexible, technology-neutral, and balanced legal framework. It is a long, never-ending journey, because the European approach to digital transformation means empowering and including every citizen, strengthening the potential of every business and meeting global challenges with European core values.[2]

Nowadays, in the era of Industry 4.0, with so many technological breakthroughs and challenges, choosing, adopting and implementing right governance strategy for Sustainable Digital World is main priority of policymakers within various national governments, European Commission and international organizations like United Nations (UN) and Organization for Economic Co-operation and Development (OECD). In June 2017, at OECD Ministerial Meeting in Paris, three overarching governance options for sustainable digitalization emerged: (i) a laissez-faire, industry-driven approach; (ii) a precautionary and preemptive strategy on the part of government; and (iii) a stewardship and "active surveillance" approach by government agencies to reduce risks derived from digitalization while promoting private sector innovation (Linkov et al, 2018:441). At the level of United Nations, no matter which model or combination of models particular government choses, clear set comprising of 17 goals and 169 targets or objectives

[1] European Commision. Commission priorities for 2019-24. Retrieved from https://ec.europa.eu/info/strategy/priorities-2019-2024_en

[2] European Commision. Strategy, Shaping Europe's digital future. Retrieved from https://ec.europa.eu/digital-single-market/

are formulated as Global Sustainable Development Goals.[3]

In Europe, European Commission dedication and commitment towards digital society is also visible not only with common set of criteria, but also by the implementation of regular monitoring and encouraging progress of every single EU Member State. Indicators of digital competency are published yearly, staring in 2016 with Digital Progress report (EDPR), lately transformed to Digital Economy and Society Index (DESI). A composite index that summarizes five relevant progress indicators: (1) Connectivity (*Fixed broadband take-up, fixed broadband coverage, mobile broadband, and broadband prices*), (2) Human capital (*Internet user skills and advanced skills*), (3) Use of Internet (*Citizens' use of internet services and online transactions*), (4) Integration of digital technology (*Business digitization and e-commerce*) and (5) Digital public services (*e-Government*). A relative overall index of all five indicators for the last DESI 2020[4] report is presented in Fig. 1.

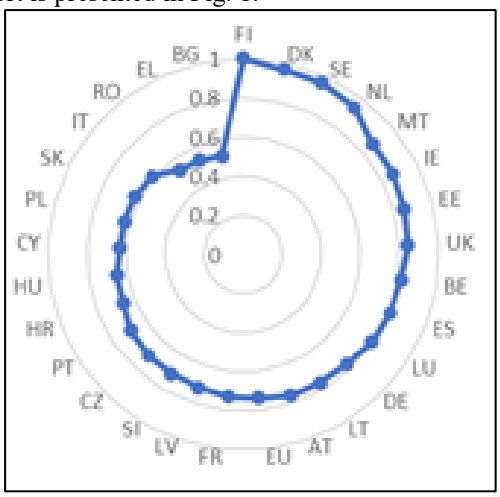


Figure. 1. Normalized composite sum of indexes of all five DESI indicators by max value of sum, Diagram by author

In the context of the development of complex digital services, regarding DESI 2020 report, it is indicative to compare the indexes for the two indicators related to adoption of Digital Services by businesses (4) and citizens (5).

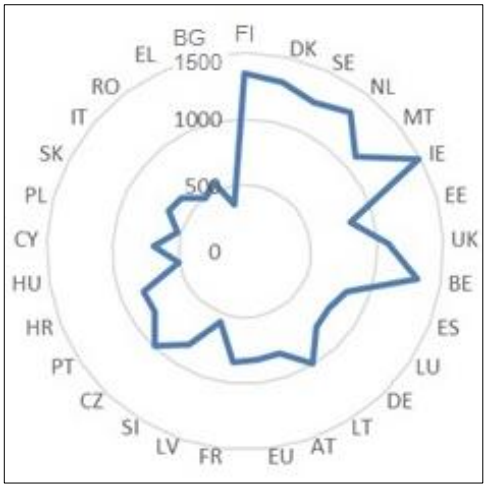


Figure. 2. DESI Indicator (4) - Integration of digital technology, Diagram by author

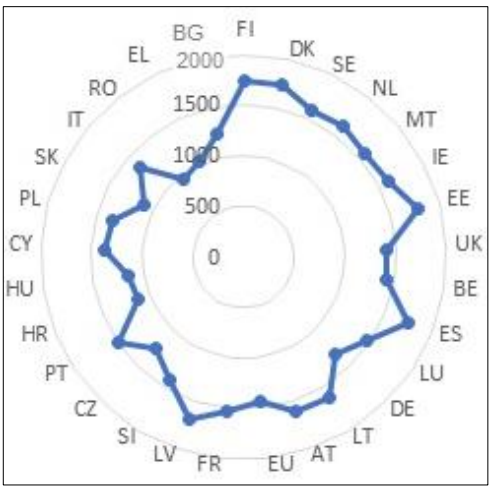


Figure. 3. DESI Indicator (5) – Digital Public Services, Diagram by author

A comparison of these Spider diagrams shows that the EU countries on the right side of the diagram have better score compared to the countries on the left side of the diagrams. However, it is interesting to see that in countries with the best scores there is a difference when compared by the above indicators (4 and 5). In the field of Digital Public Services, the EU countries Estonia, Finland, Denmark and Spain have the best scores, and in the field of Integration of Digital Technologies by businesses, top scores have EU members Ireland, Finland, Belgium, and the Netherlands. This indicates that even top scorer countries are still in phase of growth, needing to spread their own solution portfolio across public and business sector.

The report[5] states that „the data on the integration of digital technologies by businesses showed large

[3] United Nations, Department of Economic and Social Affairs. Sustainable Development, Transforming our world: the 2030 Agenda for Sustainable Development. Retrieved from https://sustainabledevelopment.un.org/post2015/transformingourworld

[4] European Commissions. The Digital Economy and Society Index (DESI). Retrieved from https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi

[5] European Commission. Integration of Digital Technology by Enterprises. Retrieved from https://ec.europa.eu/digital-single-market/en/integration-digital-technology-enterprises

variations depending on the company size, sector and also the Member State“. Enterprises were becoming more and more digitized („8.5% of large companies relied already on advanced cloud services and 32.7% were using big data analytics“) than SMEs where only 17% of them using cloud services and only 12% big data analytics.
This shows clear trend, set by business usage of cloud services and big data analytic, which is expected to be followed by public sector within delay period of 5 – 10 years. But, from public sector governance policy standpoint, both trends are in center a of very long public debates. First one, on data sovereignty, started with Government Cloud Computing and National Data Sovereignty dilemma (Irion, 2012), and second is coined as paradox of “being able to gather unprecedented amounts of information, but being largely unable to turn this information into insight and effective action and problem-solving” (Misuraca, Viscusi, 2014:440).
Those delays may finally be resolved because; on February 19th 2020 European Commission released its brand new Digital Strategy, which particularly outlines fundamental elements for the creation of Digital Europe. “It include a five-year policy roadmap, a White Paper on Artificial intelligence that outlines plans for new legislation on transparent, traceable and human-controlled AI systems and European Data Strategy, a proposal for the creation of an European single market for data”[6].

3 COVID-19 Pandemic

As World Health Organization announced COVID-19 outbreak as a pandemic on March 11th 2020, it was clear that governments across the globe besides “usual” healthcare measures need to utilize existing digital potential in order to prevent escalation. Again, similar to various options in choosing governance strategies for sustainable digital growth, each country and regions have chosen their own paths, without preparation time or clear set of indicators to follow. Everything escalated quickly and simultaneously.

3.1 Digital Paradigm Shift

Some prescriptions to set quick and comprehensive strategy of digital transformation is known from business arena. On a strategic level, according to Gartner Group, world's leading research and advisory company, digital business leaders must account for three crucial factors when trying to estimate the timing of markets and digital changes: technology progress**,** cultural evolution**,** and regulatory developments (Raskino, & Waller, 2016:41).
With the business aspect of market creation/growth in mind, they prescribe: “When all three come into alignment, new markets are created, and they often grow suddenly and rapidly. The leader's task is to estimate when that will happen and to be ready to take advantage when it does … It will be important to identify and work on all three tipping points: In technology, take care not to underestimate or be caught out by the nonlinear pace of change. In culture, evaluate social acceptability and keep testing its boundaries without crossing the "creepy line”. With regulation, innovate because of it or in spite of it, treating it as a potential source of opportunity, not just an obstacle.” Recent COVID-19 pandemic situation fully confirmed their prescription:”The best digital leaders work to nudge one or more of the three tipping points in their favor” (Raskino, & Waller, 2016:41). Translated into corona pandemic and e-government context, in order to make digital paradigm shift, governments should not be conservative in usage of emerging technologies such as big data, AI or distributed ledger. Technologies, very few governments used on larger scale before. Governments by definition have very good understanding of cultural boundaries, they should not force or break, like stronger privacy concerns in Western world. Finally, they are almost absolute owners of legislation changes, third component needed for successful transformation.

3.2 Response to COVID-19 Pandemic Situation

Facing the massive coronavirus crisis, European Commission was ready to quickly adopt its new Digital Strategy. “The strategy gains renewed importance as the Commission deploys digital tools to monitor the spread of the virus, research and develop vaccines and treatments, and ensure that European citizens can stay connected and safe online to keep on learning, socializing, and working. Trusted services, such as e-Signatures, e-Seals and electronic authentication services for businesses, e-Government and eHealth ensure continuity and availability of public services while trusted security systems protect our identities online and make sure that our activities remain private”.[7]
Most governments’ solutions needed quick regulatory interventions in order to move life online, such as education, which has adopted the e-learning paradigm in most of Europe. The same occurred with most administrative tasks where temporary regulation changes, due to the pandemic circumstances, enabled

[6] Data Governance in the EU: Data Sovereignty & Cloud Federation, Center for Media, Data and Society, Mach 23rd, 2020. Retrieved from https://medium.com/center-for-media-data-and-society/data-governance-in-the-eu-data-sovereignty-cloud-federation-f26d44032d63

[7] European Commission. Live, work, travel in the EU, Digital technologies – innovative solutions during the coronavirus crisis. Retrieved from https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/digital-solutions-during-pandemic_en

most of the digital communication to become legitimate. Many administrative tasks were at least partially digitized, thus slashing the need for administrative personnel, freeing them to work on epidemic fighting tasks like interviewing infected citizens trying to isolate coronavirus outbreaks. Therefore, adopting the regulation to use digital communication and existing services was one of the quickest, thus most effective solutions governments found.

In fighting the epidemic outbreaks, some more complex digital solutions were needed. In order to respect data security and EU fundamental rights such as privacy and data protection, on April 8th the Commission adopted a recommendation to support COVID-19 containment measures through mobile data and apps. Based on this recommendation, the Member States, supported by the Commission, developed an EU toolbox for the use of mobile applications that reflects the best practices in the use of mobile contact tracing and warning apps to tackle the crisis.[8] With this example of respecting and counting on existing cultural standards and differences, EC proved in practice the importance of Gartner's cultural strategic pillar. To achieve a successful deployment of massive digital solutions, the Government needed to take into consideration established cultural norms. In Europe or the USA, no effective solutions used in some other countries with lower individual privacy rights could be successfully applied. South Korea, for instance, implemented a full tracking system for all quarantined people, and China deployed individual QR codes that share information about the personal health status and travel history of each citizen. These codes need to be scanned before boarding buses and trains or entering airports or offices, controlling access even to their own housing complexes.[9]

3.3 Croatian Examples and Challenges

Prior to Corona pandemic Croatian e-Government, as it can be seen from Fig. 3, is among laggards. Croatia ranks 25th out of 28 EU countries. Moreover, it is component 5. Digital public services pulling down entire Croatian DESI index.

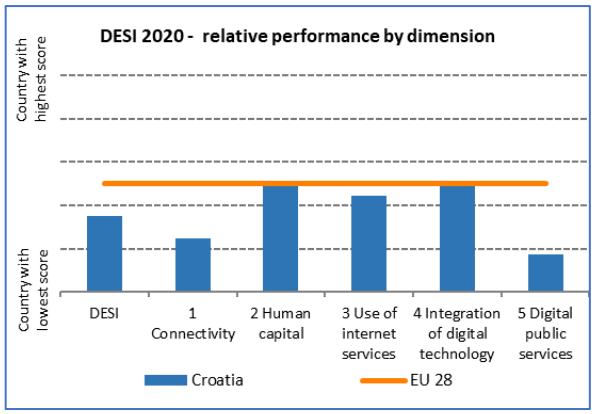


Figure. 4. Croatian DESI 2020 relative performance by dimension[10]

Indicators 2 and 4, which are around average EU28 indicators, are showing potential, and this is exactly what had happened during Corona pandemic. With excellent identity and authorization infrastructure - NIAS (National Identification and Authentication System), as confirmed in DESI chapter "The role of digital to manage the COVID-19 pandemic and to support the economic recovery, Croatia responded promptly. Croatia has taken a large number of targeted measures in digital to deal with the COVID-19 crisis. Several solutions are in the process of being developed to monitor and report persons who are in self-isolation, to minimize contagion and to support the health system".

Solution 'e-Propusnica' (*'e-Pass'*), is a typical example of simple, intuitive and effective e-Government solution for issuing and tracking people travel permits. Solution was created and deployed just a week from the Government's "Decision about the prohibition to leave the place of residence".[11]

The solution is integrated to the existing 'e-Građani' (*e-Citizens*) services infrastructure, so existing public service backbone infrastructure is utilized, exchanging necessary data from all involved stakeholders: Ministry of the Interior, Ministry of Finance - Tax Administration, Croatian Pension Insurance Institute and Ministry of Health. Thus the Civil Protection Headquarters of the Republic of Croatia was able to manage the criteria for travel permissions depending on pandemic situation practically on a daily bases. Citizens would just submit simple on-line form, and in a matter of minutes request would be resolved weather was work/health/private related travel, and all the need-to-know stakeholders were informed. Especially

[8] European Commission. Press corner, An EU approach for efficient contact tracing apps to support gradual lifting of confinement measures, April 20th 2020. Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/ip_20_670

[9] Deutsche Welle, coronavirus tracking apps: How are countries monitoring infections?, DW News, April 27th 2020. Retrieved from https://www.dw.com/en/coronavirus-tracking-apps-how-are-countries-monitoring-infections/a-53254234

[10] Digital Economy and Society Index (DESI) 2020 - Croatia, Retrieved from https://ec.europa.eu/digital-single-market/en/scoreboard/croatia

[11] Deloitte. Decision about prohibition to leave the place of residence and permanent residence in Croatia, March 2020. Retrieved from https://www2.deloitte.com/hr/en/pages/about-deloitte/articles/odluka-zabrani-napustanja-mjesta-prebivalista-stalnog-boravista.html

effective was integration inside Ministry of Interior, as the Police patrols controlling the roads were informed instantly as well, in a form of QR code. As they are equipped with QR readers, there was no need for any manual administrative procedure, se there were no traffic congestion, which saved quite a lot of productivity hours for both businesses and citizens.
In a period of only six weeks of its usage, it became sixth e-Government application with almost half of all registered citizens using it. It provided a total of 2.576.719 individual permits. Total number of unique citizens using e-Citizen services in period 1.6.2014 to 31.5.2020 is shown in Fig. 5.

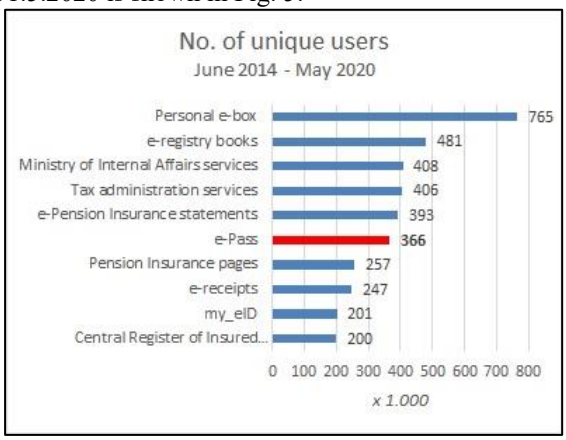


Figure. 5. Top 10 Croatian e-Citizen services[12]; Diagram by author

Second solution example is very different. Using latest AI technology, serving Citizens in time when a myriad of semi-information was circulating, helping them to obtain educated answers and at the same time alleviating the pressure from health professionals. In cooperation with the Croatian Institute of Public Health and private entrepreneurs on April 14th, First COVID-19 Digital Assistant named *'Andrija'*[13], was launched. It is a virtual assistant (chatbot), named after Andrija Štampar, distinguished scholar in the field of social medicine, founder of the School of Public Health in Zagreb in 1927. "He" is based on AI that can advise people how to diagnose and manage suspected COVID-19 infections, thus freeing congested COVID hotlines and gathering citizens' information valuable to control possible outbreaks.
In this particular case, partnering with Ministry of Public Administration established trust towards the citizens, Minister Ivan Malenica himself presented this solution as best practice example during High Level Virtual Policy Summit "Post-COVID-19 Europe´s digital Health future - from sharing to empowering", held in Zagreb, on June 26th 2020. Apart from citizen self-assessment, reporting symptoms in the household, and important telephone numbers, 'Andrija' also communicates list of current epidemiological measures in an understandable way, provides instructions for visitors and employees of nursing homes, as well as to all tourists coming to or leaving Croatia. Despite short and successful first wave in Croatia, 'Andrija' has played an effective role contacted directly by 82.817 unique users, answering more than 857.000 questions with customer satisfaction percentage of 87% (users confirmed 'Andrija' actually helped them).

Simple comparison analysis clearly points out the differences between fully integrated, efficient '*e-Pass'* and AI based 'Andrija*'* solutions. Both are quickly deployed, very valuable for all citizens during the COVID-19 pandemic, serving different people's needs. The first one is providing digital travel permission instead of the paper one, reducing administrative burden, saving everyone's time and most importantly - possible exposure to the virus. The other is typical next generation service, based on AI, with WhatsApp interface with medical (virtual) experts. Its primary purpose is to provide personalized expert opinion about ones possible medical status, providing suggestions and next steps to take. From the internal view, first ones complexity is hidden in a workflow connecting five internal government entities using existing government e-Citizen infrastructure, from National identification and authentication system (NIAS) for authentication and authorization, with inherited most of security, availability and privacy mechanisms. On the other hand, *'*Andrija*'* is full of security and especially privacy issues, which often arise when new technology like AI and proprietary interface like WhatsApp is used. There are plenty of open questions, and the most important one is - Are the obvious risks (going live into uncharted technology solutions) worth solution benefit?

4 Further Challenges and Recommendations

Previous chapter shows practical example of European Commission governance principles and actions to respond to COVID-19 pandemic threats. From the solution side, two Croatian example services are presented, illustrating how specific governments can quickly and efficiently respond to crisis. Further use of more similar scenarios, adopting emerging technologies like big data, AI or even distributed ledger is expected. Like in *'e-Pass'* solution, many more backend services will be consumed, probably in much complex workflow. They should be intuitive and easy to use for civil servants, and especially citizens. The next generation of services will be real complex digital services.
Apart from usual concerns on services availability, usability, reliability, interoperability, responsiveness,

[12] Open data portal of the Republic of Croatia, e-Citizen statistics. Retrieved from http://data.gov.hr/dataset/e-gradjani-statistika/resource/177888d5-1aec-4c85-9e92-eaf7da8f82f8

[13] Total Croatia news. Croatia Launches Andrija, First COVID-19 Digital Assistant, April 14th 2020. Retrieved from https://www.total-croatia-news.com/lifestyle/42877-digital-assistant

security, privacy, technology to use, deployment issues, etc., the focus of this paper is on fundamentals – services architecture. Proper architectural design is fundamental prerequisite of any successful digital solution, especially building one solution on another, like most e-Government systems are constructed.
Again, there is plenty of experience in the business world, many business digital services are already deployed in various industries in all kind of scenarios.

4.1 Complex Digital Services Architecture

At the architectural level of building complex digital services, many business/technical advisors can be considered, but one among esteemed experts is Jeanne W. Ross.[14] In times of increased confrontation with digital disruption of businesses and considering digital transformation wave, she published a study "Designing digital organizations" which includes case studies of over 40 companies from many industries discussing the challenges and recommendations of digital transformation. She repentantly insists that digital transformation is never about technology (Ross, et al., 2016:2). It is about redesigning a company, through these postulates:

(i) An effective digital strategy - zeroes in on one of two opportunities that are associated with digital disruption—customer engagement and/or digitized solutions.

(ii) Operational excellence is essential for digital strategy execution and sustained success. Successful companies will rely on capabilities that have been built into a powerful operational backbone.

(iii) Rapid innovation and responsiveness to new market opportunities are equally essential. To facilitate this kind of agility, successful companies will rely on the capabilities of a powerful digital services backbone.

(iv) Existing organizational designs are not well suited to building and leveraging both an operational and a digital services backbone. An ongoing organizational redesign that includes structures, processes, roles, partnerships, and skills is essential to execute a digital strategy.

4.2 Digital Services Backbone and Millennials

What needs to be pointed out is a need to design and develop a second, digital services backbone. While the operational backbone provides seamless end-to-end standard business processes optimized for "regular" business activities, the digital services backbone should be Lego brick style, innovation-driven; providing infrastructure services, data access, identity management, analytics engines, and powerful 24x7 processing enabling constant stream of loosely connected digital innovations to be quickly delivered and easily replaced or discarded. Because of the nature of new customer engagement scenarios and need for rapid solutions, a very important recommendation is also that a company would need a completely different type of people designing, running and operating this new digital services backbone, most preferable millennial generation that truly understands the nature of digital world and services (Ross, et al., 2016:10).
In context of building the new government digital services backbone and hiring Millennials, governments are not having good reputation on attracting quality workforce, especially Millennials. In Croatia, even as there is a shortage of ICT workforce, and youngsters are not so eager to join government institutions, there is very easy solution, which requires just one administrative change. Croatian government should just lower qualification ramp for hiring them from EQF level 7 to level 6. By that, applying simple administrative policy, young bachelors working on digital services would get immediate opportunity to learn and master their knowledge, at the same time resolving the lack of qualified ICT workforce in public sector.

4.3 Connecting Europe Facility Building Blocks and Digital Service Infrastructures

Surprisingly, in European e-Government realm, some services are already available, waiting for member countries to utilize them. In Government digital services space, beneath each EU Member State existing e-Government operational backbone, a set of common Building Blocks exists. On the EU level, the Commission has set up initiatives, programs, and priorities, such as the Connecting Europe Facility (CEF)[15] to facilitate the development of high-quality digital services by creating reusable digital building blocks to facilitate the delivery of digital public services across borders and sectors. It is underlying Digital Service Infrastructures (DSIs) composed of core service platforms and generic services. Core Service Platforms (CSP) are central hubs that enable trans-European connectivity, managed, implemented, and operated by the Commission, and Generic Services (GS) are the link between national infrastructures to the core service platforms managed, implemented and operated by the Member States. Currently, there are eight Building Blocks available: Big Data Test Infrastructure, Context Broker, eArchiving, eDelivery, eID, eInvoicing, eSignature, and eTranslation.

[14] Jeanne W. Ross is principal research scientist at MIT Sloan School's of Management Center for Information Systems Research (CISR), lead author of cornerstone book on enterprise architecture „Enterprise architecture as strategy: Creating a foundation for business execution".

[15] European Commission. CEF Digital, Connecting Europe. Retrieved from https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/C EF+Digital+Home

5 Conclusion

The COVID-19 pandemic situation, as life and business threatening as it is, with a timely and professional response in a way served as a catalyst to the digital transformation of Government e-solutions primarily towards citizens.

Prior to the crisis, and especially after WHO announced COVID-19 outbreak, as citizens and experts we witnessed true power of excellent European Commission digital governance policies and actions. Moreover, as solutions were bringing new, real value to citizens it pushed them to everyday use, thus enlarging the digital literate population, removing obstacles for further massive deployments.

In Chapter 3., two Croatian services are presented and discussed, showing different examples of citizen e-services. First one is 'pretty much' old style, efficient in resolving administrative burden, in the same time speeding flow of people, goods and services (*'e-Pass'*), and second one is modern (*'Andrija'*), mobile, user centric, with latest AI technology deployed. They are both quickly build, citizen centric and efficient, but, in services architectural sense, they are examples of very efficient, but still simple services.

Similar examples can be found in each Member State, which according to their own digital readiness and infrastructure, responded quickly and efficiently, with very concrete support from Commission level like EU toolbox form mobile solutions and many more initiatives, recommendations, and knowledge sharing from more advanced Member States.

From services architectural standpoint, obvious next step will be reinforcement of existing backbone infrastructure(s) and building second, flexible digital backbone, enabling constant stream of loosely connected digital innovations to be quickly delivered primarily to citizens. Build and operated by the Millennial generation that really understands the nature of new digital world and its services.

Funding of such big digital infrastructure investment should be, for instance, from recently announced EU investment of €26.6 million for 55 projects in the areas of Cybersecurity, eHealth, eProcurement, European e-Justice, Public Open Data and European Platform for Digital Skills and Jobs.[16] This particular investment is another example of efficient European Commission governance strategy. Not only delivering policy documents, like 2020 Digital Strategy, but also providing the funding for implementation.

On the other side, the rapid adoption of digital services should never compromise citizens' rights. Digital rights to control their own data and anonymity is an especially important continuation of work on the European Digital sovereignty initiative. With a unique, leading position in a World, this initiative is a true step towards a New System of Internet Governance.[17]

At the end, considering still active COVID-19 pandemic outbreak, there are very concise recommendations from UN Department of Economic and Social Affairs (UN/DESA) Policy Brief #61: 'COVID-19: Embracing digital government during the pandemic and beyond':

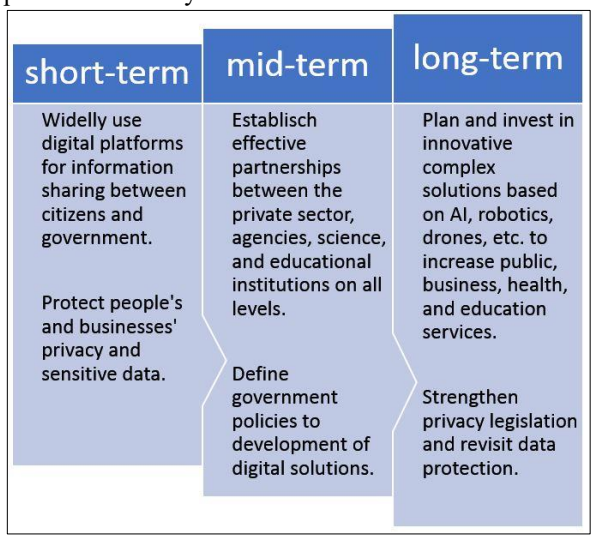


Figure. 6. Digital Government Policy Response to COVID-19[18]

Recommendations, which can be followed and/or modified in case of any new unexpected occurrence of similar catalyst phenomena.

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Adoption and Usability of Low-Code/No-Code Development Tools

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Abstract. *The low-code/no-code development approach is an increasingly important domain addressing many current software development challenges. The available reports and forecasts point towards very positive global trends. Therefore, we looked into the popularity, adoption and use of low-code/no-code development approach in the Slovenian environment. This paper presents the results of a study made within business organizations revealing the adoption and acceptance of the low-code/no-code development approach and a usability study of the representative low-code/no-code development tool, expressed with SUS, UMUX and UMUX-Lite. The results reveal that the use of the low-code/no-code development approach in Slovenian organizations is lower than reported by global research. However, a significant overlap can be found in many areas, including reasons for not using the low-code/no-code development approach. According to the encouraging results of a usability study and the positive expectations related to the low-code/no-code development approach, positive changes are expected.*
Keywords. LCNC, use, adoption, prevalence, usability, companies, SUS, UMUX, UMUX-Lite

1 Introduction

Rapid changes have a significant impact on the development process itself and consequently also on company productivity and agility. The low-code/no-code development approach is an important concept addressing current challenges in the software development domain. Its origins date back to 1980s when rapid application development (RAD) tools were introduced as an alternative to traditional text-based development environments (Wong et al., 2019). However, its recent popularity can be attributed to the growing importance of digital transformation (Hecht, 2019; OutSystems, 2019; Bloomberg, 2017).

Many benefits to the low-code/no-code development approach can be found. Its use can speed up the development process and, consequently, lower costs (Ploder et al., 2019). Also, it reduces the connection to IT developers and allows for the integration of other departments in the development process (Wong et al., 2019; Ploder et al., 2019; Pantelimon et al., 2019). The low-code/no-code development approach is supported by a variety of available platforms. According to Gartner's Magical Quadrant, visible representatives are the tools provided by Microsoft, Mendix, Salesforce, OutSystems and Appian (Vincent et al., 2019).

The forecast and assumptions about the use of low-code/no-code development platforms follow a positive curve. By 2024, more than 65% of applications will be developed using the low-code/no-code development approach and by the same year, more than 75% of large enterprises will use at least four low-code/no-code development tools (Wong et al., 2019). Even more, one of the available reports (OutSystems, 2019) indicates that 39% of the questioned organizations have already invested in the low-code/no-code development platform and 41% of the respondents answered that they have already implemented a low-code/no-code development approach.

While the above-mentioned forecasts and results apply on a global scale, the aim of this research was to look into the state of low-code/no-code development in Slovenia. Two complementary studies were implemented since the perceived positive usability can increase the intended use of the low-code/no-code development approach in the future. Therefore, the first study was aimed at researching the use of the low-code/no-code development approach in Slovenian organizations. A survey was conducted on the attitudes towards a low-code/no-code development and the adoption of available tools and platforms. Secondly, a usability study was done within the master students of the IT-related study program. Based on their practical experiences gathered in the study course, the usability of the used low-code/no-code tool was evaluated.

Consequently, our research followed the research questions:

- What is the attitude toward the low-code/no-code application development and related tools in Slovenian business organizations?
- How do master degree students evaluate the usability of a low-code/no-code development tool?

This paper is organized as follows. Section 2

presents the results of a study revealing the acceptance, adoption and popularity of low-code/no-code development in the Slovenian business environment, and Section 3 presents the implemented usability study among master degree students. Finally, the paper is concluded in Section 4, where the gathered results are discussed and compared with related research.

2 Acceptance and Adoption of Low-Code/No-Code Development in the Business Environment

Positive global trends connected with the use of low-code/no-code development, suggest that the use of low-code/no-code development platforms has also appeared among Slovenian business organizations. To gather current data, a survey questionnaire was distributed to potential participants in an online format, allowing for a greater reach and more convenient completion of the questionnaire. The structure of the questionnaire followed previously used questions by related global surveys. However, some, and in our opinion important questions, were added.

The invitation was answered by 78 participants within Slovenia, thus constituting a survey sample. The majority of respondents, 34.6%, were employed in small companies that have between 11 and 50 employees. 28.2% of the questioned participants were from companies with more than 250 employees, and 25.6% of the participants were employed in medium-sized companies, meaning from 51 to 250 employees. Only a minority, i.e. 11.5% of the participants were coming from companies with less than 10 employees. For almost 70% of the participants, software represents one of their business areas, followed by technology and the internet, chosen by 50% of participants, and consulting, selected by 34.6% of respondents. 9% of the companies were from the banking and finance sector, and 6.4% from the healthcare and pharmacy domain. 5.1% of respondents worked in insurance and 10.3% in energy.

26.9% companies employ between 50 and 100 people in the informatics department, among which, 47.6% of the companies have between 20 and 50 developers, and 28.6% companies have between 50 and 100 developers. On the other hand, 16.7% companies employ more than 100 people in the informatics department, and 19.3% employ less than 10 people in the department of informatics. 14.1% of the survey participants are CIO or CTO, and 5.1% occupy a management role not connected to IT. 10.3% of respondents were the head of IT within the company, and 25.6% had the role of a software architect. 7.7% of respondents were business analysts, 6.4% quality engineers and 53.8% of survey participants were developers.

The participants were asked about their familiarity and adoption with low-code/no-code development in their organizations. The answers are presented in Figure 1. 50% of management roles responded that they heard and know about the low-code/no-code development. The percentage is similar within technical roles, 43.6%. 25% of management respondents already tried low-code/no-code tools, but, only 10% already use low-code/no-code development approach. Within the technical roles, only 10.9% of survey participants already tried any low-code/no-code tools, while the percentage of use is similar within management roles, with 9.1%. The technical roles stand out with the answer that they did not hear about low-code/no-code approach before the questionnaire. That option was chosen by 36.4% of respondents.

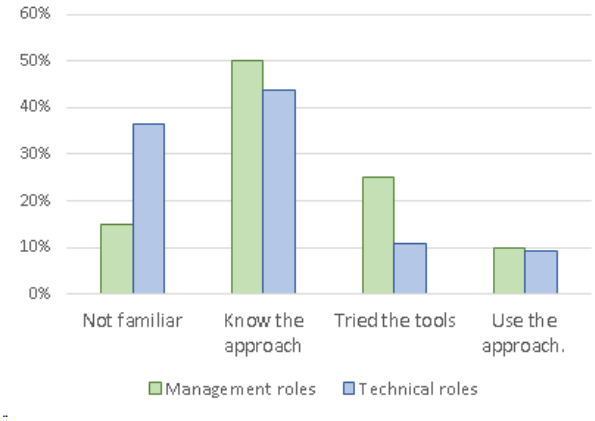


Figure 1: Knowledge and use of low-code/no-code development approach and tools within management and technical roles.

We also asked the members of management if the low-code/no-code development approach presents a part of their IT strategy. 20% of the respondents answered that they already use or are planning to implement low-code/no-code development in the near future. In contrast, 60% do not intend to use the approach in their companies. Among those who already use low-code/no-code development, the approach was used by least five people. As they stated, the low-code/no-code tools are used by business users, in one case also by professional IT developers. In the company that is planning to start implementing low-code/no-code development, tools will be used by professional IT developers. Since the majority of respondents do not plan to introduce the low-code/no-code development approach, we researched the reasons. One of the most common reasons is the lack of knowledge about low-code/no-code development and its connected platform and tools. This answer was chosen by 68.3% of respondents. Other reasons are the concern for commitment to only one low-code/no-code tool provider, and doubts about the feasibility of the mentioned approach when building their applications. The latter reason was chosen by 75%. Some of them were also concerned about the scalability and security of the application developed

using a low-code/no-code approach, with 43.8% and 37.5% of the selected answers, respectively.

The survey participants who already implement low-code/no-code approach or are planning its implementation in the near future were asked to evaluate different statements connected to low-code/no-code development. Among all of the participants, 16.7% belong to this group. The results are presented in Table 1. According to the answers, they believe that the low-code/no-code approach is appropriate for the development of web and mobile applications that are going to be used within a company, with an average evaluation of 4.0 respectively. With a slightly lower score, the participants evaluated the option of using a low-code/no-code approach for the development of applications for their customers, with an average score of 3.5. According to the answers, the low-code/no-code approach is appropriate for automating receptive tasks in the development process. However, it is slightly less appropriate for the development of mission-critical systems. With an average evaluation score of 4.1, the respondents agreed that the use of the low-code/no-code development approach could save a lot of time and could contribute to the digital transformation of a company, with an average score of 3.7.

Different no-code/low-code tools and platforms are available on the market, allowing for a rich choice among interested companies. Participants who have already implemented a low-code/no-code approach or are planning its implementation in the near future were asked to choose the tools they use or the tools they have tried and evaluated. The tools Lightning App Builder, Mendix, Appian and Microsoft Power Apps were chosen by 7.7% each and the tool Oracle APEX by 23.1%.

Participants in the management roles were also asked about the state of shadow IT within their company. Shadow IT represents the applications that are out of sight for the organization's IT personnel, possibly presenting an IT security and privacy risk (OutSystems, 2019; Gartner, Inc., 2020b). On the other hand, in citizen development, non-professional developers use the tools approved by IT, but, if not managed properly, they can present the same risk as shadow IT (OutSystems, 2019; Gartner, Inc., 2020a). 50% of the respondents were of the opinion that shadow IT does not present a risk for their organization, however, they are aware that it exists. A small portion, 10% of participants, perceive shadow IT in their company as a risk, while 40% were of the opinion that shadow IT does not exist in their company. A similar question looked into measurements taken to address challenges connected to shadow IT and citizen development. Only 10% answered that they had chosen the low-code/no-code tools and platforms that had to be used within citizen development in order to mitigate the possible risk. Others, either did not have an application developed by business users or their IT department does not manage shadow IT and citizen development, or tries to control those fields with limited resources.

According to positive expectations connected to low-code/no-code development detected in many available reports, the same question was also asked of Slovenian organizations. Among members of management, the opinion was perfectly split: 50% of the respondents believed that the positive expectations connected to low-code/no-code development will come true, and 50% disagreed. Among participants in technical roles, the opinion is slightly more pessimistic. 41.8% agreed with a positive outcome, while 58.2% did not share the positive view.

Consequently, their relationship to low-code/no-code development approach and related tools is expected. The results are presented in Figure 2. The most frequent answer among management and technical roles was sceptical, at 45% and 41.9% respectively. That emotion was followed by undecided, which accounted for 35% among management and 30.9% among technical roles. A positive attitude was found among 30% of those in management and by 29.1% in technical positions. However, only 10% of members of management and 18.2% of technical participants defined their attitude towards low-code/no-code approach as negative.



Figure 2: Participants' relationship and emotions with regard to low-code/no-code development, platforms and tools.

3 Usability of Low-Code/No-Code Tools by Students

The second part of the presented research covers a usability study for the used low-code/no-code platform representative. Low-code/no-code platforms allow development to take place using a graphical interface instead of with a traditional text-based development environment (Waszkowski, 2019; Ploder et al., 2019; Hakimi, 2019). The tools can be used for private a single user and in-company applications to visualize data from various tables and sources. A practical example of an application developed with a representative low-code/no-code development tool is an expense tracker

Table 1: The opinion of the participants already using low-code/now-code development approach or planning to implement it in the near future.

	1	2	3	4	5	Average
With the approach, it is possible to develop web and mobile applications for use within a company.	0 %	7.7 %	7.7 %	**61.5 %**	23.1 %	**4.0**
With the approach, it is possible to develop web and mobile applications for customers outside the company.	7.7 %	15.4 %	7.7 %	**61.5 %**	7.7 %	**3.5**
The approach enables successful involvement and better cooperation with business users in the process of application development.	0 %	7.7 %	23.1 %	**53.8 %**	15.4 %	**3.8**
The approach can increase company agility.	0 %	7.7 %	15.4 %	**46.2 %**	30.8 %	**4.0**
The maintenance of products developed with the approach is easy.	15.4 %	0 %	30.8 %	**46.2 %**	7.7 %	**3.3**
The implementation of the approach increases the speed of the application's development.	0 %	15.4 %	0 %	**61.5 %**	23.1 %	**3.9**
Using the approach can save a lot of time.	0 %	0 %	7.7 %	**76.9 %**	15.4 %	**4.1**
Using the approach can free up developers' time to devote their time to more complex projects.	0 %	15.4 %	15.4 %	**61.5 %**	7.7 %	**3.6**
The approach is useful for automating repetitive development tasks, such as the development of input forms.	0 %	7.7 %	0 %	**76.9 %**	15.4 %	**4.0**
The approach is suitable for the development of mission-critical systems.	7.7 %	**30.8 %**	23.1 %	23.1 %	15.4 %	**3.1**
The approach can contribute significantly to the digital transformation of a company.	0 %	15.4 %	15.4 %	**53.8 %**	15.4 %	**3.7**
Using the approach, more time can be devoted to innovation and less to maintenance.	0 %	15.4 %	30.8 %	**38.5 %**	15.4 %	**3.5**

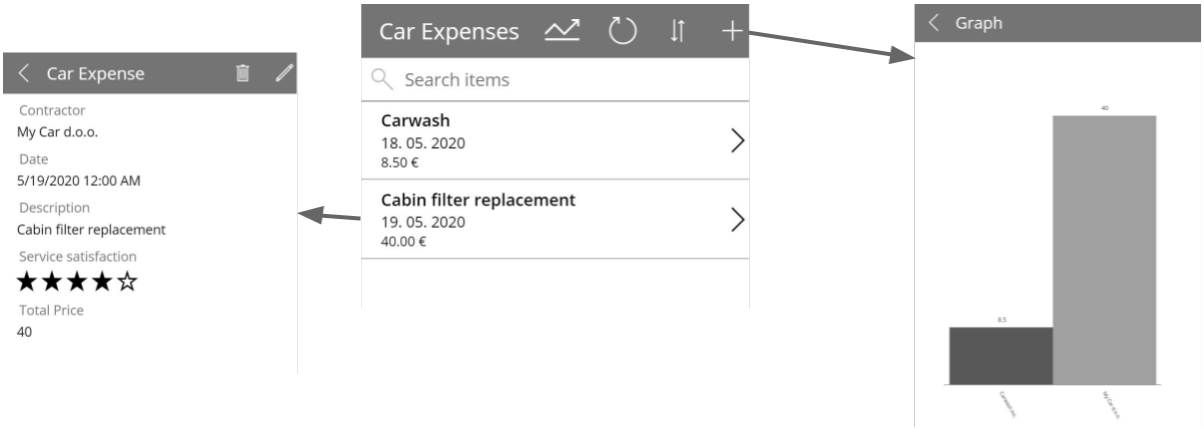


Figure 3: Example of an application developed in Microsoft Power Apps using the automatic generator from Microsoft Excel table.

for a specific business department such as vehicle management. An implementation in Microsoft Power Apps platform is displayed in Figure 3. The application was automatically generated from a Microsoft Excel spreadsheet. It lists all the expenses for a company-owned car. The left-hand side of Figure 3 presents a details screen where the rating stars were manually added using a graphical editor, while the right-hand side of Figure 3 shows all expenses by the service provider. The graphical representation was added manually using the graphical editor in Microsoft Power Apps.

The Power Apps was used as a part of practical work conducted in the Informatics and Communication Technologies master study program. We used Microsoft Power Apps since it is included in the Microsoft Office 365 package used by the University of Maribor (Leung, 2017). The students' assignment was to develop a simple application in order to get familiar with the low-code/no-code development tool. According to the students' responses, and our practical experience with the example application, the main advantages of using a Power Apps tool can be summarized as:

- The interface is intuitive and easy to use.
- Automatic screen generation.
- Quick implementation of simple applications.
- Simple integration with a database.
- Instant application testing after each change.

As students have pointed out, the approach is appropriate for use as a minimally viable product for higher tier applications. The main disadvantages of the approach using Microsoft Power Apps can be summarized as:

- Unreliability in operation and common problems with Excel table connection.
- Weaker performance.
- Difficulty adding items that are not in the Microsoft Excel table.
- Unknown errors disappearing after restarting the application.
- Weak official documentation.
- Lower tool adoption, resulting in less support on the internet.
- No automatic saving of the work, resulting in lost work.

Following a hands-on approach, a usability study was conducted amongst 35 first grade master's degree students. A five point Likert scale was used for students to self-grade their knowledge of common programming languages (Joshi et al., 2015). The students evaluated the knowledge of the programming languages that they encountered during their studies. The average scores are displayed in Table 2. According to the results, students are most familiar with C# and JavaScript, which are both higher level languages. Consequently, we assumed that students would be familiar with low-code/no-code development tools since they represent an even higher level of abstraction from computer details.

Table 2: Average grades of students' programming knowledge.

	Average grade
Java	3.23
C++	2.57
C#	4.03
PHP	2.57
JavaScript	3.83
Python	2.83

Most of the students have at least two years of programming experience due to their undergraduate studies, while on average, they have four years of experience. 37.1% of students did not know low-code/no-code development before the study course, while 11.4% were familiar with low-code development or have used it before. The rest of the respondents had already heard of the mentioned tools but did not use them in practice. The results coincide with the data about the use of the low-code/no-code tool in practice. The majority, or 87% of the students, answered that they never used low-code/no-code tools in business environments.

According to the low usage, which was also detected among a Slovenian business organizations, the usability of the used Power Apps tools was researched. The System usability scale (SUS) was used. The score can provide an insight into subjective perceptions of the usability of the evaluated system (Brooke, 2013). Students were asked to grade ten statements about the used tool answering with a five point Likert scale:

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

We calculated the SUS value for each student according to their answers using the process described by Brooke et al. (1996). The maximum SUS score is 100, however, an average SUS result for Microsoft Power Apps tools was 65.64, with a standard deviation of 12.21 and median of 67.5 as displayed in Table 3. A different interpretation of the SUS score exists. According to Brooke (2013), a score of 65.64 can be explained as OK. It would, furthermore, receive a grade D and be on the higher margin of acceptability (Brooke, 2013). There is a slight negative correlation with a correlation coefficient of -0.283 between students' average skills in programming languages and SUS results, which means that the Microsoft Power Apps tool is evaluated as more usable for people with less experience in programming.

The usability metric for the user experience (UMUX) and its lighter successor UMUX-Lite was also obtained from surveyed students. UMUX is a quicker way to assess system usability with fewer questions for respondents. Compared to 10 questions in SUS, UMUX contains only four questions, where two of them are positive and two negative, measuring usability components' effectiveness, efficiency, and satisfaction (Finstad, 2010). Similarly, as SUS, it can score between 0 and 100 (Finstad, 2010). On the other hand, UMUX-Lite simplifies UMUX even more with only two questions (Lewis et al., 2013). Therefore, we used the following statements to obtain UMUX and UMUX-Lite results:

1. The system's capabilities meet my requirements.
2. Using this system is a frustrating experience.
3. I have to spend too much time correcting things with this system.
4. This system is easy to use.

Table 3: Results of SUS, UMUX and UMUX-Lite usability metrics based on survey responses.

	Arithmetic mean	Median	Mode	Standard deviation	Correlation coefficient (average knowledge of programming languages)
SUS	65.64	67.5	65	12.21	-0.283
UMUX	66.43	68.75	75	16.71	-0.327
UMUX-Lite	67.24	71.65	71.65	11.55	-0.417

For calculating UMUX-Lite, we have used the first and fourth statement. As shown in Table 3, the calculated average score of UMUX is similar to the case of SUS, at 66.43. However, a slightly larger negative correlation coefficient on programming language knowledge can be detected, which furthermore supports the statement that the tool is more suitable for beginners in programming (Lewis et al., 2013; Finstad, 2010). As shown in Table 3, the average value of the metrics UMUX-Lite is 67.24. The graphical representation of all of the used usability metrics is presented in Figure 4.

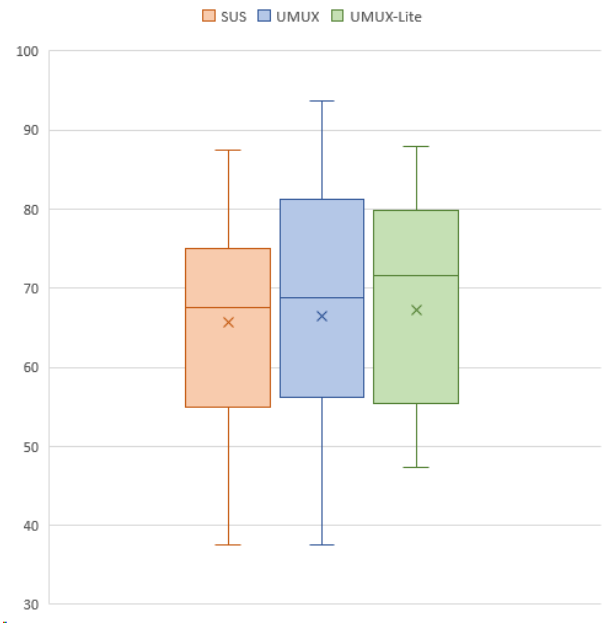


Figure 4: The graphical representation of the results of SUS, UMUX and UMUX-Lite.

At the end of the questionnaire, we also asked students about their expectations connected to low-code/no-code development. As detected within Slovenian business organizations, the current adoption of low-code/no-code development is rather low. However, a fair percentage of respondents believe in positive forecasts connected to low-code/no-code development. With an average score of 2.7, students' expectations are somehow pessimistic, not coinciding with answers from the business environment. But still, the portion of entirely negative responses is small, since more than 50% of the respondents answered with a neutral choice.

4 Discussion and Conclusion

This paper presents the results of a study researching the use and adoption of low-code/no-code development in the Slovenian business organizations, and the usability study of a representative of low-code/no-code development tool implemented among master degree students. The survey was answered by 78 business participants and 35 students. Since the sample size was small, the results could not be generalized, but still offer a great insight into the current state of affairs.

According to the gathered data, only a small portion of organizations in Slovenia are already using a low-code/no-code development approach, just 10%. What is more, 60% of respondents said they do not plan to use the mentioned approach in the near future. By contrast, the results of global research (OutSystems, 2019) significantly differs, showing that 41% are already using the low-code/no-code development approach. The low adoption of the low-code/no-code development approach in the Slovenian environment can also be detected by the students' answers, since only 5.7% of students have already used or know low-code/no-code development tools.

The main reason that business organizations in Slovenia do not use the low-code/no-code development approach are doubts about the feasibility of the mentioned approach when building their applications, the lack of knowledge about low-code/no-code development and the connected platform and tools, and a concern for getting committed to only one low-code/no-code tool provider. The top three answers coincide with the results of global research (OutSystems, 2019), although the order differed. The most common response within Slovenian companies was the third place answer in global research. The agreement between Slovenian and global research can also be detected for the kinds of projects that low-code/no-code development is used for. Both put the applications that are used within the company in first place. Furthermore, the opinion of Slovenian respondents that the low-code/no-code approach is appropriate for automating receptive tasks is aligned with the results of a global survey (IDC, 2019). The numbers connected to shadow IT also align. 40% of the asked Slovenian business organizations were of the opinion that shadow IT does not exist in their company. The percentage in global research (OutSystems, 2019) is 36%. In Slovenia, 10% of participants perceive shadow IT in their company as a risk, which can be compared to a global percentage of 15%.

The second part of the presented study looked into the usability of the Microsoft Power Apps tool. The tool was used by master's degree students within a course assignment, wherein, in the end, the usability was evaluated. According to the results, the average SUS score was 65.64, which can be interpreted as OK. Similar results were also gathered from UMUX and UMUX-Lite, with 66.43 and 67.24, respectively. Since no related study measuring the usability of low-code/no-code development tools were detected, a comparison with related work could not be made.

Based on the gathered results and the comparisons made with the global survey, we can conclude that the use of the low-code/no-code development approach and connected tools in Slovenia negatively deviates from global results. However, since the respondents believe in positive expectations connected to low-code/no-code development, a growth in its use can be expected in the next few years.

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Internet of Things Interoperability Within Communication Scope – Literature Review

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Abstract. *Nowadays, Internet of Things (IoT) trend is emerging and overflowing the reality. The issues regarding the interoperability arisen together with the IoT trend. In this article, we will summarize one of aspects of IoT interoperability to offer the overview of the existing approaches and possibly to identify new opportunities for future researches. The research is conducted by querying relevant databases, analysing relevant articles and summarizing relevant information for better overview. A focus is on communication interoperability. The interoperability is a key feature and the article shows which technologies are the most used in mentioned scope.*

Keywords. Internet of Things, Interoperability, Device Communication

1 Introduction

Industry revolution called Industry 4.0 is currently defining present reality. Internet of thing (IoT) is present quite some time and nowadays it just took off. Everybody is considering it because of digital transformation and Industry 4.0. Internet of things existed for more than 20 years and its popularity arisen just now. It has various forms and there are various vendors having their own ways of producing IoT modules. Which leads towards its heterogeneity and interoperability issues which are tackled in this article. This article is summarizing technologies which are mainly present in architectural and technological aspects of the IoT interoperability.

This article is structured in following way. The section "Research method" focuses on how the research is conducted. The next section "Overview of included papers" brings up the analysis of selected papers. "Results and discussion" contains research findings and discussion about them. The last section "Conclusions" concludes the article.

2 Research Method

The focus of the article is to summarize technologies and concepts that enables the interoperability within the defined scope. The search will be conducted on following databases: IEEE Xplore, Scopus and Web of Science.

2.1 Defined Research Question

The heterogeneity is the issue which will be tackled in this article. The research question is "*Which technologies and concepts enable the interoperability between Internet of Things and systems?*" The question is scoped according to the title after all articles were selected and now it is "*Which communication technologies enable the communication interoperability between Internet of Thing and systems?*"

2.2 Search Strategy

Main keywords are: Internet of Things, interoperability and enterprise. Simple query which would be enough is: "internet of things" AND interoperability AND enterprise. There were multiple search queries for each database according to their search engine shown below.

IEEE Xplore database was searched by conducting a query: `((`"Full Text & Metadata":"internet of things" NEAR/5 "interoperab*"`)` **AND** "Full Text & Metadata":"enterprise" **AND NOT** "testing"`)`. Scopus was searched by using following query: **ALL** `(` "internet of things" **AND** "interoperability" **AND** "enterprise" **AND NOT** "testing" `)` **AND** PUBYEAR **>** 2014 **AND** `(` **LIMIT-TO** `(` PUBSTAGE , "final" `) )` **AND** `(` **LIMIT-TO** `(` SUBJAREA , "COMP" `) )` **AND** `(` EXCLUDE `(` DOCTYPE , "re" `)` **OR** EXCLUDE `(` DOCTYPE , "cr" `)` **OR** EXCLUDE `(` DOCTYPE , "sh" `) )` **AND** `(` **LIMIT-TO** `(` **LANGUAGE** , "English" `) )` **AND** `(` **LIMIT-TO** `(` ACCESSTYPE`(`OA`) ))`. The Web of Science database is searched using this query: TOPIC: `(`"internet

of things" AND "interoperability" AND "enterprise") NOT TOPIC: ("testing"). All queries aim at the same goal: to extract relevant articles about IoT (enterprise) interoperability.

2.3 Selection Criteria

Selection criteria is presented in the Table 1. These criteria are used to determine which paper is relevant and which is not. The table shows all criteria summarized and not in iterations.

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Papers written in English	Non-English papers
Papers published between 2015 and 2019 year.	Duplicated papers
Publications in scientific conferences or scientific journals	Out of scope papers.
Papers on IoT interoperability	Papers published before year 2015
Papers which proposed new architectures or approaches	Papers who do not mention communication technologies

3 Overview of the Included Papers

Applying the queries leads to filtering all papers considering the constraints. The section will show the numbers of articles per database, per years and per paper type. Afterwards, the analysis is presented.

3.1 Included Papers

Following section will show numbers of papers selected in each iteration. There are four iterations and its structures are shown in Figure 1. The first iteration is executing the queries to get relevant articles.

The second iteration is a result of reading titles and abstracts. Next iteration is created after reading all articles which would be in scope and which are not. The last iteration is based on shrinking the scope and focusing on one segment of IoT interoperability. 42 papers are analysed and considered.

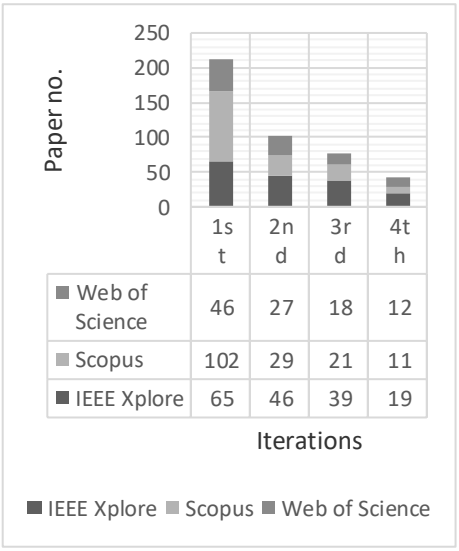


Figure 1. Number papers per database

3.2 Publications Per Years

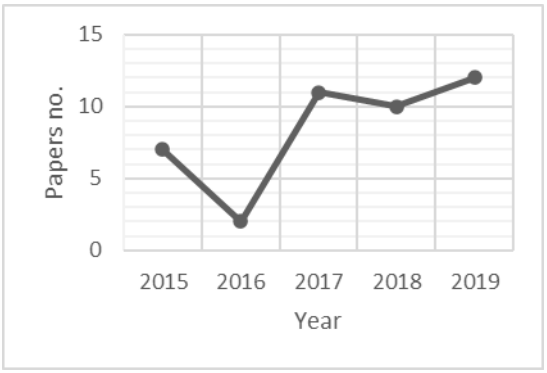


Figure 2. Number of relevant papers per year of publication

The numbers are known, now it will be shown how many papers are published per years as presented in the diagram in Figure 2. The diagram shows how published papers took off until year 2019. It can be concluded that IoT is still being researched which is not strange considering the era of Industry 4.0 and the IoT as one of its enablers.

3.3 Types of Publications

The paper classification based on its type is shown in the Figure 3. The classification is grouped by the database where the papers are found.

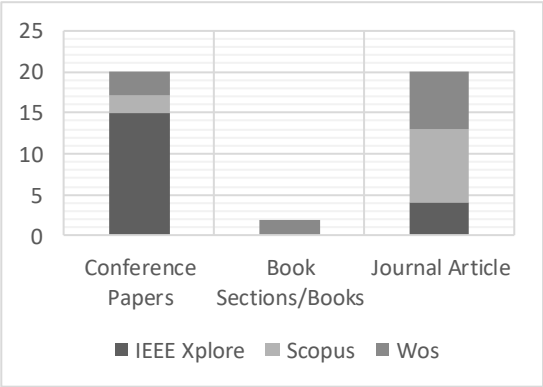


Figure 3. Numbers of relevant papers per type

The diagram shows that relevant papers selected for this article are mainly conference papers and journal articles. The most of conference papers are found in IEEE Xplore because of its search engine which gives the most relevant articles. The Scopus database gave mostly journal articles.

3.4 Citation Analysis

Citation reports are presented in this section. Google Scholar was used to create following tables. Table 2 shows that most of the papers in the article are low-cited papers. This is because of the constraint to look for papers beginning with year 2015. There is decent number of high-cited papers.

Table 2. No. of papers associated with "cited-by" group

Cited by	0	1 - 9	10 - 19	≥ 20
Papers no.	12	21	4	5

The Table 3 presents top 10 most cited papers. The high-cited papers show importance of research in area of the IoT interoperability.

Table 3. Top 10 most cited papers

Rank	Citations	Paper
1	124	(Bröring et al., 2017)
2	85	(Neisse et al., 2015)
3	48	(Derhamy et al., 2017)
4	26	(D'Elia et al., 2017)
5	26	(B. Negash et al., 2015)
6	18	(Roffia et al., 2018)
7	17	(Ismail & Kastner, 2016)
8	16	(Fremantle et al., 2015)
9	10	(Schachinger et al., 2015)
10	9	(Uviase & Kotonya, 2018)

4 Results and Discussion

Authors (Kalatzis et al., 2019) and (Zeid et al., 2019) identify a couple interoperability aspects. Many authors emphasize interoperability importance. The research brings up interesting findings and authors' tries to conquer the interoperability issues with new architecture or new concepts.

Majority of authors conducted literature analysis on their topic's background. One of authors conducted literature review to elaborate on their research area (Rejeb et al., 2019), and the other one explained the process of going towards proposed framework and performed literature analysis (Zdravković et al., 2018). These examples are not the only ones, and all literature reviews are mostly covering broader area. They mention technologies listed later in the article. Such references are not meant to be included in this article. Considering the setup constraint, the article focuses on communication interoperability proposed in new solutions. Therefore, mentioned technologies illustrate authors' preferences during the chosen time period.

A communication between components is one of important factors in achieving interoperability. There is short-range and long-range communication. The short-range communication technologies are Bluetooth, NFC, etc. The focus of the article is on long-range communication which includes using WiFi or mobile internet as enabler. Sometimes, it requires to support more than one communication protocols to reach reasonable level of flexibility in supporting different systems. A couple communication protocols are identified and presented in Table 4. Protocols displayed in the Table 4 are sorted by number of citations next to their name. The most popular communication protocols are at the top of the table. Top 3 communication protocols are Representational State Transfer (RESTful), Message Queue Telemetry Transport (MQTT) and Constrained Application Protocol (CoAP). Research shows that they are mostly used. Surprisingly, the research shows there are attempts to use Blockchain as the enabler for interoperability.

During the research, many interesting attempts to achieve interoperability in other scopes were encountered. There are attempts to use intelligent agents, blockchain, event bus and broker to achieve an appropriate level of communication interoperability.

The variety of protocols makes interoperability harder to achieve and it is a cause of heterogeneity of communication protocols. The vendors should either support multiple protocols or implement standards which would define recommended communication technologies.

Table 4. Communication protocols identified in relevant papers

Communication (#)	Papers
Representational State Transfer - RESTful (24)	(Ahmed et al., 2019; Alexakos et al., 2018; Androcec & Vrcek, 2016; W. Dai et al., 2019; Datta & Bonnet, 2018; Derhamy et al., 2017; Di Martino et al., 2017; Eruvankai et al., 2017; Fremantle et al., 2015; Jin & Kim, 2017; Kalatzis et al., 2019, 2018; Kim-Hung et al., 2017; Krishnan et al., 2018; Lomotey et al., 2017; Behailu Negash et al., 2019; Neisse et al., 2015; Park et al., 2019; Rafferty et al., 2018; Roffia et al., 2018; Saqlain et al., 2019; Schachinger et al., 2015; Touseau & Le Sommer, 2019; Uviase & Kotonya, 2018; Zdravković et al., 2018)
Message Queue Telemetry Transport - MQTT (17)	(Adesina & Osasona, 2019; Busanelli et al., 2019; W. Dai et al., 2019; Derhamy et al., 2017; Eruvankai et al., 2017; Fremantle et al., 2015; Kim-Hung et al., 2017; Lomotey et al., 2017; Behailu Negash et al., 2019; Neisse et al., 2015; Rafferty et al., 2018; Roffia et al., 2018; Saqlain et al., 2019; Touseau & Le Sommer, 2019; Uviase & Kotonya, 2018; Zanfack et al., 2015; Zdravković et al., 2018)
Constrained Application Protocol - CoAP (13)	(Adesina & Osasona, 2019; Alexakos et al., 2018; D'Elia et al., 2017; Derhamy et al., 2017; Eruvankai et al., 2017; Fremantle et al., 2015; Jin & Kim, 2017; Kim-Hung et al., 2017; Lomotey et al., 2017; Roffia et al., 2018; Saqlain et al., 2019; Touseau & Le Sommer, 2019; Zdravković et al., 2018)
Service-Oriented Application Protocol -SOAP (6)	(Androcec & Vrcek, 2016; W. Dai et al., 2019; B. Negash et al., 2015; Behailu Negash et al., 2019; Park et al., 2019; Pradilla et al., 2015)
The OPC Unified Architecture - OPC UA (6)	(Adesina & Osasona, 2019; Ahmed et al., 2019; W. Dai et al., 2019; Eruvankai et al., 2017; Ismail & Kastner, 2016; Saqlain et al., 2019)
Advanced Message Queueing Protocol - AMQP (4)	(Adesina & Osasona, 2019; W. Dai et al., 2019; Eruvankai et al., 2017; Uviase & Kotonya, 2018)
Web Socket (3)	(W. Dai et al., 2019; Kim-Hung et al., 2017; Rafferty et al., 2018)
Extensible Messaging and Presence Protocol - XMPP (3)	(Derhamy et al., 2017; Eruvankai et al., 2017; Zdravković et al., 2018)
Data Distribution Service - DDS (2)	(Lomotey et al., 2017; Murugesan et al., 2017)
Peer-to-Peer - P2P (2)	(H.-N. Dai et al., 2019; Plociennik et al., 2018)
Open Services Gateway initiative - OSGi (2)	(D'Elia et al., 2017; Htaik et al., 2017)
SPARQL Protocol and RDF Query Language - SPARQL (2)	(D'Elia et al., 2017; Roffia et al., 2018)
Decentralized Messaging Framework (1)	(Chainho et al., 2017)
Protocol on-the-fly -Protofly (1)	(Chainho et al., 2017)
Firebase (1)	(Rafferty et al., 2018)
Java Message Service - JMS (1)	(Eruvankai et al., 2017)
Smart Space Access Protocol - SSAP (1)	(D'Elia et al., 2017)
Complex Event processing – CEP (1)	(Zanfack et al., 2015)
Byzantine Fault-Tolerant (BFT) Protocol (1)	(Nuss et al., 2018)
Big IoT API (1)	(Bröring et al., 2017)
DLT intelligent agents (1)	(Plociennik et al., 2018)
Linked Data Notification - LDN (1)	(Roffia et al., 2018)
Event Bus (1)	(Uviase & Kotonya, 2018)
Broker (1)	(Weipeng Li et al., 2015)

5 Conclusions

The goal of the paper is to synthesize available communication protocols aiming at achieving interoperability to identify preferred protocols for new proposed solutions. According to identified trend while analysing selected papers, IoT is currently popular technology because of the Industry 4.0 era and opportunities it offers.

The results show that most popular technologies are RESTful, MQTT and CoAP. Authors propose new approaches and concepts to solve interoperability issue. Most of the authors use the most popular technologies. Aside from new solutions, the authors identify the importance of interoperability and standardization.

The Internet of Things is widely used technology nowadays and it opens opportunities for implementations. The main issue is the interoperability. The authors noticed that and tried to overcome it by implementing multiple protocol support and standards. The experts emphasize the security as an important issue for the future of the IoT. The users' acceptance is highly dependent on the security of the IoT infrastructure. The blockchain technology steps into a picture which is interesting attempt to integrate it into the IoT. It has a potential to resolve two of the IoT issues - interoperability and security.

Some of possible future works or improvements in this area include:

- Definition of standards of communication technologies for IoT
- Research blockchain's opportunities in IoT context
- Definition of multi-protocol solution which will support the most popular communication protocols.

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The Use of Gamification in Smart Sport Training

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Abstract*. The objective of this paper is to present the use of Gamification in Smart Sports Training. Gamification is related to the use of game elements in non-game contexts. While Smart Sports Training incorporates the use of wearables, sensors, and Internet of Things devices and or intelligent data analysis methods to improve training performance. Until recently, Gamification was rarely applied to Smart Sports Training. In this paper, we designed and proposed a gamified solution for a mobile application that represents a virtual sports trainer. The architecture of this application is systematically outlined and supported by practical use. Positive aspects of Gamification in Smart Sports Training are depicted.*

Keywords. Smart Sports Training, Gamification, mobile application, Android

1 Introduction

People generally want to live good and long lives. This largely depends on a person's physical and mental health. While they do not guarantee happiness, lack of them certainly negatively affects a person's quality of life.

One of the main ways to improve an individual's health is through physical activities and exercises. The World Health Organization recommends at least 150 minutes of moderate-intensity or at least 75 minutes of vigorous-intensity physical activity per week, due to the health benefits such activities provide (World Health Organization, 2018).

Besides the obvious benefits of regular exercise such as increased stamina and strength, numerous others exist. Some of them are reducing the risk of coronary disease, obesity, strokes, risk of some types of cancer, prevention of progressive incapacity and improvement in memory, self-esteem, calmness, mood, and psychomotor functions (Fentem, 1994).

Despite numerous benefits of physical activity, over 25% of the world population is not exercising enough (Bosley, 2018), and 39% of the world population is overweight or obese (Ritchie, 2017). Among the five possible reasons for not exercising irrelevance, unnecessary, negative feelings, too risky, and that it requires too much effort, the latter was found to be the most common (Auweele, Rzewnicki, & Mele, 1997). Lack of effort related to the inadequate motivation of an individual to perform physical exercises (Buckworth & Dishman, 2012).

On the contrary, one activity has no problem prospering and motivating users in the real world. There are more than 2.5 billion people playing video games in the world, and gaming revenue reached 152 billion $ in 2019 (Wijman, 2019). Smartphone usage has also been increasing and is projected to reach 3.5 billion people worldwide in 2020. Video games surely have no problem with the engagement and motivation of their users. They are meant to be played, so why isn't exercising meant to be *played* too? If a highly engaging system exists in video games that make the user engaged and want to play them even more, can the same be done for those who find physical exercise mundane and not engaging? A problem of motivation could be solved by Gamification, which can provide the needed encouragement for exercise (Suh, Wagner, & Liu, 2015).

Capitalizing on these worldwide trends, we propose a smart sports training solution, implemented as a smartphone mobile application. A lot of similar applications indeed already exist and are used by a large number of people. One of the most popular ones Google Fit (Google, n.d.-c), awards you cardio points for performing and recording different activities. It, however, lacks in the planning phase of training and lacks training plans and Evaluation of your results versus the community. MyFitnessPal (MyFitnessPal, n.d.) is another of the more popular apps. It features training plans, nutrition planning, but lacks in the realization phase of training; it does not allow recording the exercises with the device but merely entering them.

Analyzing 32 health and fitness applications identified in (Cotton & Patel, 2019), no application that was identified supported the training in all of its four phases (Planning, Realization, Control, and Evaluation) was found. Completeness of the support for the whole training cycle is an important thing when using an application. It allows an individual to stay within the same ecosystem, which is both convenient and may allow a better quality of training if fully utilized.

Another unforeseeable thing is that in the current 2020 world, it is sometimes better to do something alone. SARS-CoV-2 worldwide pandemic has changed people's lives. Whole communities have been put on lockdowns, and people have been asked to socially distance and reduce close contacts with one another (Lipton & Steinhauer, 2020). This is another great advocate for the establishment of a virtual training application, providing the health/fitness benefits without the need for additional health risks that arise when social distancing is not practiced.

The contributions of this paper are:

- Establishing the need for virtual trainers and presenting the worldwide trends that have created a positive environment for adoption and popularization of such tools.
- A proposal and presentation of how individual game elements could be used in each of the sports training phases.
- Linking Gamification and Smart Sports Training by proposing a Virtual Training Application that supports the user in executing all four training phases

The paper is structured as follows. Section 2 outlines and briefly presents the topics of Smart sports training and Gamification. Section 3 presents the proposal for our gamified smart sports training (running and cycling) mobile application what the application must support in each of the phases of sports training, namely planning, realization, control, evaluation. In Section 4, conclusions are drawn, the benefits and drawbacks of using a proposed training application are presented, the section is continued with, a proposal for future research, where experimental validation of the approach is recommended, and the processing of the data collected by the application with artificial intelligence algorithms.

2 Background

Physical activity and sports are two terms that can, in a broader sense, be used interchangeably. However, sport can also be defined as a formalized, competitive, and physical type of play (Fister, Fister, & Fister, 2019a). Sports training is a process with continuous interaction by an athlete and his/her trainer.

(Fister, Fister, & Fister, 2019b) proposes that sports training is composed of four interconnected tasks/phases, as is shown in **Figure 1**.

The Planning phase refers to the activity in which the trainer prepares the future training plan for the athlete. One training is composed of multiple exercise units.

The Planning phase is connected to the **Realization** phase in which the planned exercises are executed, and the trainer must prepare the necessary equipment, conduct a psychophysical evaluation of the athlete, and monitor and advise the athlete during the training session. The training data that can later be used for analysis is recorded during the training execution. Realization is followed by the **Control** phase, where the execution and performance of the exercises done are compared to the training plan. The **Evaluation** phase refers to the measurement of the athlete's performance. For professional athletes, this refers to the competition performance. The evaluation phase is interconnected with the initial planning phase because the results from the evaluation phase influence future training plans and goals of an athlete.

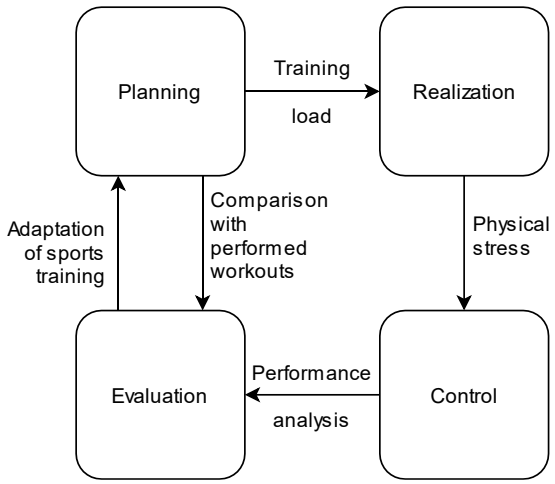


Figure 1 Phases of Sports Training

2.1 Smart Sports Training

The advances in information technology have bought upon severe changes in the way we do things. On every step of our lives, there have been optimization attempts. We are still far away from general-purpose artificial intelligence, but the fact remains that well defined specialized tasks can be delegated to the machines, and in some iterations, the machines and systems we designed will reach and overtake the ability that was previously only reserved for humans. The technology has also changed the way we train sports and information systems connected with wearable devices have started the evolution in sports as well.

In (Rajšp & Fister, 2020), we proposed the following definition of Smart Sports Training (SST). This is a type of sports training, which utilizes the use of wearables, sensors, and Internet of Things (IoT) devices and or intelligent data analysis methods and tools to improve training performance or reduce workload while maintaining the same or better training performance.

The SST approach is used in various studies, a systematic literature review (SLR) (Rajšp & Fister, 2020) done in 2020 found 109 different studies that implemented the SST methods for training sports. The approach has been used in 32 different sports, both in a team (basketball, soccer, volleyball, etc.) and solo (running, golf, swimming, weight lifting, yoga, etc.) sports.

The implementations of SST do not have to support all the four training phases and may only be used for some specific parts of the training, which is what the majority of SST implementations do. As is shown in **Table 1** found that the majority of SST research is concerned with the Realization phase of SST. Only a few implementations, 39 out of 109, are concerned with the Planning phase of training where the system would aid the user and give him some guidance on how to proceed. The planning phase can be supported by the use of advanced computational intelligence, which adapts to each user or simply by providing generalized exercise plans.

Table 1 Phases of sports training investigated in research identified in (Rajšp & Fister, 2020)

Plann.	Real.	Cont.	Eval.	Σ
39	76	64	45	109

A solution that would support all four training phases of the training could replace the human trainer altogether. To ensure that the application could fully replace the human trainer, it would need to not only aid the user with technical measurements and training plans but also provide a way to engage and motivate the user. This is a key role of a real trainer. We believe such a thing can be done by introducing Gamification to Smart Sports Training.

2.2 Gamification

Due to the popularity of modern computer games, various approaches have been tried to take the popularity of the games and use them in non-gaming applications. A great example of how games can influence behavior is the phenomenon of Pokemon Go, (Althoff, White, & Horvitz, 2016) found, by comparing the step counter values of people over a period of three months, that players playing the game increased their walking activity by an average of 25 % compared to their previous number of steps per day.

The term gamification refers to the use of game design elements in non-game contexts (Deterding, Dixon, Khaled, & Nacke, 2011).

According (Amir & Ralph, 2014) to the Theory of Gamification Effectiveness (TGE), the effectiveness of a gamified system is the extent to which the system is used and contributes to any explicit goals of the system and contributes to the goals of its users. The effectiveness is exhibited in three dimensions of Formative constructs and is influenced by Antecedents, which are factors that cause effectiveness, as shown in Figure 2.

Use relates to the consumption of the system output, which translates to the user participation of the gamified system. Purpose measures if the Gamification contributes to the purpose for which the system was originally designed. The user alignment is the connection between how the goals of the user are aligned with the gamified system.

The factors which influence the system effectiveness are Intrinsic motivation dynamics: feelings of relatedness, autonomy, and competence when using the system. Giving the user abilities to choose his/her own tasks, that are of the adequate difficulty; Extrinsic motivation: points, levels, badges, trophies awarded for completing tasks in the gamified system; Game Mechanics: space, objects (tools), actions and rules that are determined and defined in the system and; Immersive dynamics: providing the narrative and the world that user participates in.

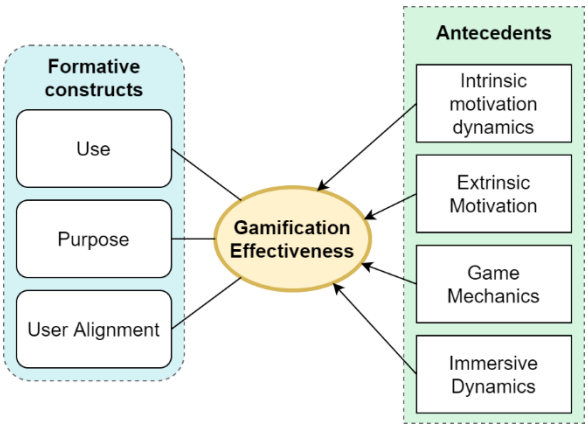


Figure 2 Gamification Effectiveness Theory

In a systematic literature review (Hamari, Koivisto, & Sarsa, 2014) of 25 empirical studies investigating the effects of Gamification in different environments found that its effects were generally positive. The researchers mostly determined that introduction of Gamification to their environments was the right choice to make. The fields where Gamification has been widely used include education, marketing, and social media.

In education, Gamification has been used to increase the students' motivation and engagement (Dicheva, Dichev, Agre, & Angelova, n.d.). In different implementations, personalized avatars, points, ranking systems, levels, virtual goods, and currency have all been implemented. Plugins are readily available to be used on different learning management systems (e.g., on Moodle, A+, Blackboard, etc.).

Marketing has applied point systems in their loyalty programs, giving customers who spend the most cash some additional benefits. In contrast to education, the measured metric in marketing was not the user motivation and engagement but mostly the sales figures resulting from the implementation of such systems (Huotari & Hamari, 2012).

Social media has also leveraged the gamification elements on their platforms (Williams, 2019). To ensure that users fill out their social media profile, they are given rewards in forms of badges or progress bars on how complete their profile is. Badges are also used for completing tasks on social media (e.g., add first ten

friends, send a private message, etc.) all to boost the interaction between users. Web forums and boards use various reputation systems, where users gain or lose points based on the quality of their content (e.g., karma system on Reddit, likes on Facebook, likes on Instagram, etc.).

(Werbach & Hunter, 2012) divided the most used game elements in Gamification into a pyramid of game elements. There the gamification elements are divided on the highest level in Dynamics, Mechanics, and on the lowest level in Components.

The Dynamics are the elements on the highest abstraction level that are not directly entered into the game but are implemented through the use of Game Mechanics and Components. These are constraints, emotions, narrative, progression, and relationships. The Mechanics are the most basic processes that drive the engagement of users in the system. This includes challenges, chance, competition, cooperation, feedback, resource acquisition, rewards, transactions, turns, and win states. To implement the mechanics game components are used; these are the actual functionalities implemented in the system. These are achievements, avatars, badges, boos fights, collections, combat, content unlocking, gifting, leaderboards, levels, points, quests, social graphs, teams, and virtual goods.

Measurable evidence exists on how properly implemented Gamification techniques improve user engagement (Koivisto & Hamari, 2014). But as is always noted and should not be overlooked, the Gamification must aid the users but remain optional. All the functionalities must still be available even if the user does not wish to participate in the gamified part of the solution. A key concept is that playing must be optional, if something is not optional but is mandatory, then it is by definition, not a game (Callois, 2001).

Gamification elements can certainly motivate the user on a short term basis, but he/she may get bored over time. A lot of gamification systems lack the transition to the real-world context. Creating such a context can ensure that the user will keep engaging with and using the system, which is, in a way, always the goal of Gamification (Nicholson, 2015).

3 The Architecture of Fitness World - A Mobile Solution for Sport Training

The development of a mobile application/solution consisted of the following steps:

- Defining the goals of our application, what needs will our application fulfill and how each of the training phases will be supported
- Selection of gamification elements to be used in each phase of the training
- Android app development on a hybrid platform (for the later possibility of porting the application to iOS ecosystem)
- Testing the application in a controlled environment (currently underway)

All the processes are outlined below in the next subsections. For our proposal to implement a Smart Sports Training solution, we developed a mobile application named **Fitness World**. It was developed using Flutter (Google, n.d.-b) framework. It is a Dart (Google, n.d.-a) language-based framework for developing native apps in both of the mobile phone ecosystems (iOS and Android OS). The backend of the application is based on the Express (Node.JS based) framework ('Express - Node.js web application framework', n.d.).

For the prototype, only the running and cycling sport were supported since they are most easily recorded using mobile phones and using smartwatches, and the application was being tested only on the Android platform.

The application in development aims to replace the human trainer for the non-professional sports enthusiast. This is achieved by providing the athletes with training suggestions, measurements of their sporting activities, and giving the users ability to compete with other users and their peers. While the benefits of human trainers certainly exist, we may not always have access to one.

Gamification was used to increase user engagement and motivation, and game elements (underlined in the following paragraphs) shown in Figure 3 were used.

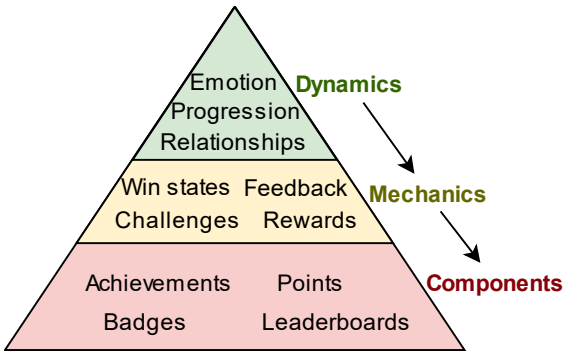


Figure 3 Game elements according to the pyramid of game elements used in the **Fitness World** app

On the most elementary level, the game elements of the game can be reduced to the model shown in Figure 4. The user must first select a training plan to follow, which serves as a challenge that once completed award achievements in the form of badges. The training plans can be sorted by duration, activity types (cycling, running, both) and goal (e.g., preparing for 5000-meter run, half-marathon, marathon, etc.). Training plan progression is done through the completion of activities, those activities also award (activity) points which rank the user on a friend list and global

leaderboards, allowing the user to compare his/her progress and activeness against other users.

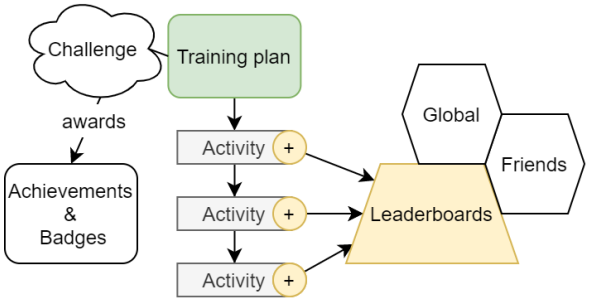


Figure 4 Core game elements in the Fitness World app

Currently, the Fitness World application was tested by the developers and their relatives as a proof of concept, but rigorous user testing will be conducted in the coming months.

3.1 Planning

The first stage of sports training is **planning**. In the first stage, we must determine what the goal of the user is and how soon does he/she need to achieve this. In our case, this may be to train to improve some results or prepare for a specific event. The planning phase is not only concerned with the prepared exercises but can also be related to nutrition planning, which was not addressed in our application. Training plans can be general or adapted to the specific user needs and their abilities. In the application, he/she can choose a specific predetermined training plan based on the competition he/she wants to participate in (e.g., 5k run, half marathon, etc.). Each plan has three difficulty levels based on his/her starting ability, namely beginner, normal, and advanced. This serves as an intrinsic motivation dynamic in the TGE model, giving the user autonomy and allowing him to advance in training with his/her own pace. he/she then receives a daily task that is made of individual exercise sessions that he/she needs to do. From the perspective of game elements, these tasks and the plan serve as challenges (gamification mechanic). The tasks were selected to be of a daily periodicity as they were found (Lally & Gardner, 2013) to be the most suited for encouraging exercise habit formation in users. This happens in 18-254 days.

3.2 Realization

In the **realization** phase, the exercise activities are recorded. The user is provided with a two tabbed screen (Figure 5). On the first screen, he/she can see his/her current sessions stats (activity type, distance, time is taken, current and average speed), and he/she also has the ability to start, pause and finish the activity. The second screen provides him with a map display, where he's currently completed training route is visualized and his/her current speed, time is taken, and distance is displayed.

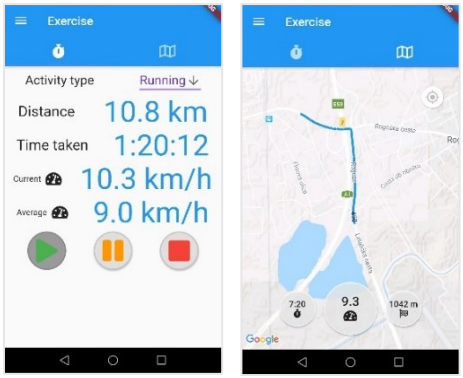


Figure 5 The exercise activity two tabbed screen

In the realization phase, the activities are merely recorded, and the user may complete any of the given daily tasks, the conditions for their completion are evaluated after the end of the exercise session. The map display and the constantly updating screen is created to serve as an link between the real world and the fitness application and functions as an immersive dynamic in the Fitness World.

3.3 Control

In the **control** phase, the user can verify if he/she is completing the determined exercises and accurately following the training plan. Successful completion of the selected training plans awards the users with achievements that are displayed as badges on the achievements screen, as shown in Figure 6. Badges are a simple gamification mechanic that can positively promote user activity and interaction with the system even over longer periods of time (Hamari, 2017).

Achievements and leaderboards also provide the user with the necessary feedback, so he/she can see that his/her actions influence his/her performance within the system.

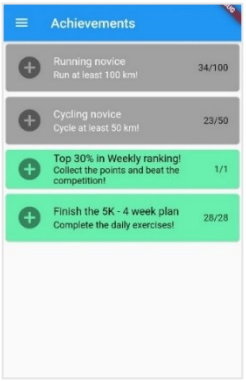


Figure 6 The users' Achievements screen

Every completed activity is also transformed into points that the user collects. The number of points an activity is worth is determined from the duration and

effort the activity required. This means that the points between different users and activity types can, in some way, remain comparable. A great advantage of games over normal sports is that in games, your progress can almost always be quantified while in sports in each training session, the abilities of the person only improve marginally, and the athlete may not notice his/her performance improving. Awarding points gives each exercise a sense of progression and value even if his/her performance is not noticeable yet in his/her real-world observations. Points have been found to positively impact user engagement in multiple studies (Gibbons, 2013), (Iosup, J Epema, & Epema, 2014) in fact (Mekler, Brühlmann, Tuch, & Opwis, 2015) found that merely adding Points and Leaderboard game elements to a higher education course increased user engagement and a ratio of completed exercises. The elements of points, achievements – badges, and leaderboards were implemented as extrinsic motivators in the TGE.

3.4 Evaluation

The points collected serve as a basis for the **Evaluation** of the users' performance on a leaderboard. Two types of leaderboards are provided global, and friend leaderboards, where he/she is competing against his/her added contacts who also use the application, facilitating the use of the relationships Gamification dynamic. He/she can see his place among his friends, as seen in Figure 7 Friends leaderboard display, and can even win by finishing the period first. The leaderboards are generated for both activities combined (the points from running and cycling are summed up) and separately. They are available for a weekly, monthly, and yearly basis. His/her progression in comparison with the previous period is shown (e.g., +20 points compared to last week) next to his/her current score.

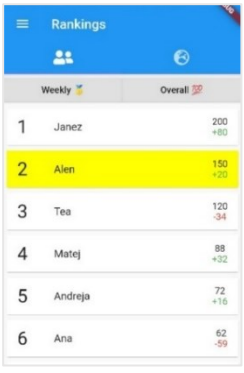


Figure 7 Friends leaderboard display

The user who reduces or ceases his/her exercise activity may quickly fall of first the weekly, then monthly, and at the end yearly Leaderboard. This is done in context with the human body, which also needs constant physical activity to maintain or improve its current fitness level and strength. (McMaster, Gill, Cronin, & McGuigan, 2013) found that the strength levels start rapidly dropping in average after three weeks of ceasing previous regular exercise routine. This shows that the fitness state of an individual will quickly regress if the user adopts a less active lifestyle, and we must be reminded that progress is not permanent.

Because leaderboards may become demotivating as shown in (Souza, Constantino, Veado, & Figueiredo, 2017), the comparison with the global players is made on pie charts. There the user is simply informed what percentage of the users he/she is leading and trailing in his/her activity points for the given sport and period, as shown in Figure 8. It is also much more informative to tell the user that he/she is rated higher than 47 % of individuals than to tell him that he/she is on the place 12451th out of 23410 users.

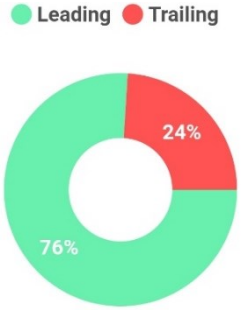


Figure 8 Pie charts displayed on the global leaderboards

The proposed training cycle will allow the user to stay engaged and keep using the application for most of his training routine. The rules on which the users receive points and their ranking in the system, which demands on his/her continuous participation, serve as the game mechanics which the user follows to maximize both his in-app and real-world performance.

4 Conclusion

The field of Smart Sports Training is developing rapidly, and virtual trainers have the ability to enhance or replace human trainers in the future. This is particularly true for the individuals whose goals for exercise are of the non-professional athlete sports training nature. A common problem, as mentioned, is that over a quarter of the world population does not exercise enough. The main reason for their sedentary lifestyles is their lack of effort, which signifies deeper motivational issues.

Gamification as a tool is just the right tool to introduce into the field as its` main effects are increasing user motivation and engagement. We believe this is a vital component that has not yet been properly utilized in the field of Smart Sports Training.

The proposed approach was a demonstration of a Smart Sports Training system based on best practices of Gamification and the Theory of Gamification Effectiveness. The Fitness World application creates an immersive exercise world, which is implemented easily since exercise actions in the real world environment can be readily mapped to actions in the gamified system by the use of smartphones.

We believe it is also important that the only additional equipment the user needs is just a smartphone, which allows for the solution to be used by the widest range of users possible. The current application is developed in a way that can possibly be ported on other systems (e.g., iOS) and can be used by any modern mobile phone. The gamification techniques proposed during each of the four training phases will hopefully motivate the user to exercise more regularly and make exercising a daily routine.

The limitations of the current approach include training plans that will only be limited to training exercises but not nutrition, which is an equally important part of the training routine. No standardized ways on how to rank points in the users of different ages and genders have currently been determined. This is an issue that needs to be addressed so that the ranking (point awarding) system will be fair and allow competitiveness between all the persons exercising according to also their effort and not only fitness abilities.

In the future, the application in development will be tested by real users, and usability analysis will be performed so that the approach proposed approach can be used by the general population. Another possible direction of the research is data analysis of the collected exercise data to develop a system that can generate and propose personalized training plans suited for each individual's abilities and needs.

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Usage and Role of Open Government Data and Public Policies of 54+ Citizens e-Inclusion Issues

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Abstract. *The Digital Transformation era has forced upon some specific terms related to the digital data. Very popular buzzwords nowadays are Open Data (OD) and Big Data (BD). Considering that issue, this paper presents the importance of public policy documents openness and the role of open government data accessibility on the example of e-Inclusion issues of 54+ public policy documents. The authors consider the openness and accessibility of public policy documents at EU level, national level and regional level. Openness of public policies will be tested by measuring availability for anyone to access, possibility of digital search the content, alter and share. This research has been inspired by low rate of 54+ e-Inclusion in many EU counties. The authors shortly give the introduction of the organization and hierarchy of public institutions, the conceptual model of public policy documents considering multiannual period of 6 or 3 years. The research starts by analyse of the public policy documents of European Commission multiannual policy declaration, strategies, annual plans and annual reports. As the example of the national and regional level will be used Croatian case of national government public documents (strategies, plans, reports) and regional government documents. In accordance with the results of the analysis the authors recommended how to improve accessibility and ensure more efficient reuse open government public documents and data in public sector.*

Keywords. Active ageing, public policy, e-Inclusion, open data, big data

1 Introduction

Living surrounded by digital technologies necessarily leads to changing habits in social, business as well as in private life. Being able and ready to accept, use and exploit available digital services is a matter of multidisciplinary approaches solving the problem of e-Inclusion.

E-Inclusion refers to the situation where everyone in society can participate in the information society. This requires affordable access to technologies, the accessibility and usability of ICT tools and services, and the ability and skills of all individuals to use these tools (by EUROSTAT).

The public administration force and public policy are recognized as cause of digital inequalities on macro level as it is presented on the integrated model of digital divide (Yu, 2018, pg. 10). The Open Data (OD) concept, Big Data (BD) and the public policies are interdependent. Public policies cover the legality of making public policies open and legality of collecting social BD (smart city concepts), and on the other hand BD can make public policies much more directed to solving noted social problems. Regarding BD, OD and open government the overlaps of all three terms is Large public government datasets like Census, Healthcare. The overlap between BD and OD is large dataset for scientific research, social media or other non-government sources. The overlap between open government and OD is public data from state, local, federal government (eg budget data).

OD in Europe, is an indicator of Digital Economy and Society Index (DESI) and since 2018, is based on open data policy, open data portals, open data impact and open data quality. The score for 2019 is published on https://ec.europa.eu/digital-single-market/en/digital-public-services-scoreboard. Ireland, Spain and France performed well on this measure, scoring more than 80%. On the other hand, Hungary, Slovakia, Malta and Portugal underperformed, with scores below 50%.

The motivation for this research is based on gap between opportunities of living in Digital Transformation era, using e-services and being e-Included of 54+ and real rate of e-Inclusion presented by EUROSTATs e-society research. The example is selected because of disbalance between the Digital Transformation possibilities and personal ability to use the e-products and e-services or information published on Internet, and co-financed and supported by European Commission. Further, the question is what will happen with Digital Transformation

initiative if only 35% of those aged 55-74 and 30% of the retired and the inactive possess basic skills (in 2019) (European Commission, DESI – Human capital, 2020, p. 4).

There are many aspects of defining term "public policy". In this article for the term public policy authors use:

- As a noun public policy means the fundamental policy on which laws rest, especially policy not yet enunciated in specific rules. The public policy according the aspect of law means the principle that injury to the public good or public order constitutes a basis for setting aside, or denying effect to, acts or transactions.[1]
- Croatian law on strategic planning and development management system of the Republic of Croatia[2] defines the public policy as "the focus of action by public authorities on objectives that respond to public needs or problems over a given period".
- Public policy as a noun by Merriam Webster[3] defined as government policies that affect the whole population.
- Public policy means by which way a government maintains order or addresses the needs of its citizens through actions defined by its constitution. Public policy is generally not a tangible thing but rather is a term used to describe a collection.

Developing public policy begins with a set of guiding principles and by identifying issues, goals and objectives. In the analysis phase, the issues are carefully considered, and various possible courses of action are proposed. The list of recommendations is then discussed by the policy makers and a decision is made based on the available information. Technical openness, as of machine-readable format, and legally openness, as clearly licensed as open, is criteria for reuse and analysis of published documents for scientific, private and community purposes.

Nowadays, public administration faces challenges in modernising the process of policy analysis by using BD analytics. Shi (Shi et al., 2017, p. 559.) have studied the impact of BD on policy analysis. According to the mentioned research authors concluded that: (1) there is a broad consensus that BD will drive innovation in public policies; (2) BD analytics can provide accurate, proactive and participatory policy analysis but with a number of risks (data privacy, data misuse and bias, inequality), (3) BD analytics can provide information for problem prediction, condition analysis and thus help policy makers targeting the primary agenda.

[1] https://www.dictionary.com/browse/public-policy
[2] https://narodnenovine.nn.hr/clanci/sluzbeni/2017_12_123_2798.html
[3] https://www.merriam-webster.com/dictionary/public%20policy

Public policy tends to be an OD that could be available to stakeholders. On the other hand, public policy must be evidence-based in general, but nowadays the actual sources are BD platform. The authors tell more about two perspectives of data in the contexts of public policies in the next chapter.

To explore the above arguments, this paper is structured as follows. The next section present short review of open government data. This is followed by review of domains: e-Inclusion facts and numbers on EU, national and regional level and public policy system and hierarchy. In section four is presented research methodology. The findings of public policies on official web portals and Open data public government portals is presented in section five. The last section presents the conclusion and recommendation.

2 Open Government Data

Scientists, practitioners and foundations (Sunlight Foundation, 2014), (WWW Foundation, 2018) have been recently considered bidirectional relations between concepts OD and BD and public policies.

European Parliament and Council have accepted the Directive (eu) 2016/2102 of the European Parliament and of the Council of 26 October 2016 on the accessibility of the websites and mobile applications of public sector bodies.

In the Digital Agenda for Europe, the Commission announced that public sector websites should be fully accessible by 2015, thereby reflecting the Riga Ministerial Declaration of 11 June 2006 (EP and EC, 2016, p. 4, (17). (EP and EC, 2016). Additionally, the accessibility of public documents builds the rights of persons with disabilities and of the elderly to participate and be integrated in the social and cultural life of the Union. (EP and EC, 2016, p. 4, (23).

The European Parliament and the Council of the European Union (2019) accepted the Directive (EU) 2019/1024 of The European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information (recast)

Schrier (2014, p. 12-27) has presented USA experience of Open Government Data concept regarding benefits, strategies and use of OD.

The development of OD timeline in United Kingdom government has been presented by Halonen (Halonen, 2012., p. 4-5). The process starts 1966. Many authors have considered transformation process from old fashion buirocratic public government to modern, open, transparent government.

"Public sector information represents an extraordinary source of data that can contribute to improving the internal market and to the development of new applications for consumers and legal entities. Intelligent data usage, including their processing through artificial intelligence applications, can have a transformative effect on all sectors of the economy."

(The European Parliament and the Council of the European Union, 2019, p. 2).

Reale (2014) presents the opportunities and differences of open government data policies between EU countries.

Azzone (Azzone, 2018, p. 116 – 120) has reviewed the BD and public policies like opportunities and challenges. Regarding the opportunities some questions are opened, like: equality of all users, fake news and opportunistic behaviours, privacy rights and general interest, the role of competence of public management as well as accountability and responsibility of public managers.

Studinka (2018) have regarded the issues of paving the way for evidence-based governance by using BD in the Public Policy Process. The Public Policy Process consists of planning phase, design phase, delivery phase and continuous evaluation phase. The conclusion of research is "While the planning phases dominated by descriptions and examples of social media used for agenda-setting, the uses described in the design phase often have a predictive element. The focus of big data use in the delivery and evaluation phases was on real-time data, providing immediate feedback.".

Maciejewski (2017, p. 123) considered the big data methods that may be used in three approaches. Historical and Real-time models deliver real-world data, then Predictive model present the information about the future state with the relevant degree of certainty. The role of BD in public policy is systematized as: public supervision for identifying irregularities (legal incompliance and taking responsive action; public regulation for regulating social conduct and shaping social relations; public service delivery including infrastructure (Maciejewski, 2017, p. 124).

Giest has regarded the Data-based policymaking frameworks. In the context of evidence-based policymaking have been raised two aspect of looking at that issues; first is the integration of BD in an existing institutional context and the second is capacity of individuals or government entities to be able to find and utilize data-based information. (Giest, 2017, p. 369-370).

Zuiderwijk (2019) has presented an overview of the OD policy-making papers published in the period of 2014 – 2018. The researchers consider: 1) open data policy making and theory development; 2) open data policy making effects, and 3) open data policy-making from a multi-actor perspective.

E-Inclusion in general raises possibility of using e-services and e-goods and it has an influence on the collecting public open BD about any societal issues that has a digital solution for collecting digital data about behaviour. Especially, e-Inclusion of 54+ can give much more interesting information about behaviour of that part of population.

The European Commission, Directorate-General for Informatics has been taken the research about BD analytics in public policy making (Barbero, et.al., 2016).

3 Review of Domains

In this chapter authors shortly present the facts about e-Inclusion, public policy documents and public policy institutions, to describe the framework for discussion.

3.1 E-Inclusion Issues Facts and Numbers

3.1.1 EUROPEAN LEVEL

The Digital Economy and Society Index (DESI) is the composite index that summarises relevant indicators on Europe's digital performance and tracks the progress of EU Member States in digital competitiveness (https://ec.europa.eu/digital-single-market/en/desi, accessed on July 18th 2020). The DESI consists of five dimensions: 1) connectivity – fixed broadband, mobile broadband, fast and ultrafast broadband and prices; 2) human capital – Internet user skills and advanced skills; 3) Use of Internet – Citizens' use of internet services and online transactions; 4) Integration of digital technology – business digitalization and e-commerce; 5) Digital public services – e-Government and e-health.

According the Digital Economy and Society Index 2020 Human capital only 35% of those aged 55-74 and 30% of the retired and the inactive possess basic e-skills.

Regarding the DESI report – Usage of the Internet – "The share of people in the EU who have never gone online decreased again in 2019, although the current share of 9.5% warrants further action. Despite convergent trends, large differences remain across Member States. The share of people in the EU not using the internet fell in nearly all Member States in 2019. Sweden, Denmark, the Netherlands and Luxembourg are the countries where the share is the lowest (below 3%). The ratio is still large in Bulgaria (24%), Greece (22%), Portugal (22%) and Croatia (18%). The Member States reporting the largest reductions were Ireland with a drop of 7 percentage points, and Spain and Malta with drops of 4 percentage points. There is a high number of non-users among people with no or low education levels (24%), among those aged between 55 and 74 (23%), and the retired and the inactive (26%)."

As Active ageing measures that includes the encouraging the e-Inclusion as it is defined in Agenda 2030 about Sustainable Development – one of SD goals is „Provide inclusive and equal quality education and promote lifelong learning opportunities for all people" (United Nations (2015). - Goal 4).

Even the relevant institutions take care about e-society and Digital Transformation of economy and society the value of key indicators are still under the

politically planned level. To be classified as low skilled, an individual has to have carried out activities from only one of the four Digital Competence dimensions considered (information, communication, content-creation and problem-solving) (The EC, 2019). Basic skills mean that an individual has basic skills in at least one dimension, but no skills in none. To be classified as above basic, the individual must score above basic in all dimensions.

3.1.2 NATIONAL LEVEL – Croatian Case

The e-Croatia Strategy 2020 (Ministry of Public Administration, 2017) as national strategic document considers the term e-Inclusion as it stands "For the moment, the Croatian legislation does not define the need to ensure accessibility of websites in the public sector. The Website Development Guidelines for the Central Government Portal require that greater accessibility is ensured in line with the Web Content Accessibility Guidelines WCAG 2.0" (Ministry of Public Administration, 2017, p. 34).

Croatian Open government data policy has been accepted and published in Jully 2018 by the Government of the Republic of Croatia (2018).

3.1.3 REGIONAL LEVEL Koprivnica Krizevci County Case (NUTS3)

The Croatian counties have development strategy documents. As an example, in this research has been used the Development strategy for the period of 2014 – 2020 (Koprivnica Krizevci County, 2016). The e-Inclusion issues are not regarded in the mentioned county strategic document.

3.2 Public Policy System and Hierarchy

Public policy is the principled guide to action taken by the administrative executive branches of the state/region/county/local authority with regard to a class of issues, in a manner consistent with law and institutional customs. There has recently been a movement for greater use of evidence in guiding policy decisions, as it is mentioned in previous chapter. Proponents of evidence-based policy argue that high quality scientific evidence, rather than tradition, intuition, or political ideology, should guide policy decisions.

In this chapter will be presented public policy documents and creating procedure and public policy law regulation. The authors consider European practice of public policy law regulation. The European Council (EC) provides orientations and general political priorities. The operating period is five year and at the beginning the Commission sets out the priority areas to be focused on. The priority areas are derived from the Council's strategic agenda and from discussions with political groups of the European Parliament. For the five years' operating period of Commission the Priorities are set in President's political guidelines.

Actual Commission priorities have been set for the period 2015-2019 and they consist of 10 points as follows: 1) Job, growth and investment; 2) Digital single market; 3) Energy union and climate; 4) Internal market; 5) A deeper and fairer economic and monetary union; 6) A balanced and progressive trade policy to harness globalization; 7) Justice and fundamental rights; 8) Migration; 9) A stronger global actor; 10) Democratic change. Every year, the President of the Commission presents the achievements of the Commission during the previous year and the forthcoming priorities or initiatives for the year to come in the speech on the State of the Union.[4] The strategy is carried out by Commissions annual action plan. The annual action plan is based on declaration of the President of the Commission presented to European Parliament. The plan of action for the next 12 months is set out in the Commission work program, by which political priorities will be turned into concrete actions. The Programme is considered by other EU institutions and national parliaments.

For all major legislative and policy defining initiatives, Commission departments prepare an impact assessment to analyse the likely economic, environmental and social effects of the proposals. A list of planned Commission initiatives and a list of adopted Commission initiatives is updated regularly and sent to other EU institutions to help them organise their own activities[5].

Planning and reporting by departments mostly are conducted at the end of the year by presenting annual activity report on their performance in achieving their objectives. After the budget year ends, all departments produce an annual activity report on their performance in achieving their objectives. These reports are collated in a synthesis report communicated to the European Parliament and the Council. As of 2016, the synthesis report is included in the annual management and performance report for the EU budget.

[4] State of the Union speech 2018 - by Commission President Jean-Claude Juncker. Retrieved from https://ec.europa.eu/commission/sites/beta-political/files/soteu2018-brochure_en.pdf

[5] Work programme for 2019. Retrieved from https://ec.europa.eu/info/publications/2019-commission-work-programme-key-documents_en

Table 1. The terms and concepts of public policy law

Level	Attributes
EU	- EU's overall political strategy is developed jointly by its institutions: the European Parliament, European Council, Council of the European Union, and European Commission. (Priorities 2014 – 2019.) - The Commission's annual action plan → Commission work programme. It describes how the political priorities will be turned into concrete actions. Other EU institutions and national parliaments also comment on the programme. - Commission departments produce strategic and management plans showing how they will contribute to the Commission's priorities and setting clear objectives and indicators for monitoring and reporting – according to 10 priorities set in Overall political strategy.
National	Strategic plan multiannual, budget plan (3-year period), annual report
Regional/ County	Strategic plan multiannual, budget plan (3-year period), annual report

3.3 Public Government Institutions Organisational Review

The organisational parts on the observed governance level are:

- EU LEVEL (53) = Directorate general (31) + Service department (16) + Executive agency (6)
- CROATIAN NATIONAL LEVEL = Ministries (20) + Executive agency + Funds + State offices and others (6+5) [*On the July 15th 2020., after that was reorganization of public policy bodies in Croatia.]
- REGIONAL LEVEL (Koprivnica Krizevci County Croatian case) = Counties administrative units (8) + Agency (2) + Institutes (1)

The activities declared to the entities on EU level are policy making and implementation, managing programs, publications, archives, statistics on the governance level as a support to the publicity. Regarding the e-Inclusion in general and specifically the e-Inclusion of 54+ the key issues and topics delegated to the entities are related with human capital and digital issues, specified as: **Communications Networks, Content and Technology**; **Employment, Social Affairs and Inclusion**. Even the e-Inclusion is a matter of all Commission departments, directly or indirectly, it has influence to many indicators measured in DESI.

4 Research Methodology

The research methodology of this article consists of checking:

- *the accessibility of public policy documents about e-Inclusion of 54+ on the official national web portals (not open data) Croatian case,*
- *the accessibility of public policy documents about e-Inclusion of 54+ on the open data national web portals of member states of EU,*
- *the ability of using machine search of key words on the open data national web portals of member states of EU to find the public policy documents about e-Inclusion of 54+*
- *content analyse to check the occurrence of "e-Inclusion" (English and Croatian language) in the mentioned documents at different level of governance.*

The term **web accessibility** in the scientific and technical meaning is oriented to defining standards for different web components. Recently, the chronology of web accessibility standards developments and government directives have been researched and systematically reviewed by Moreno and Martinez (Moreno, Martinez, 2019).

According the phase 1 of testing, the authors conduct test of the public policy documents openness and accessibility about e-Inclusion issues.

The open government data portals support different kinds of file/data formats like PCAXIS, HTML, XML, KML, XLS, XLSX, GIS, DOC, WMS, WFS, PDF, CSV, ZIP, JSON, TIF, JPEG and so on. The structure of datasets can be defined or undefined (unstructured).

The maturity of openness is standardized marked from 5 stars to zero.

The variables that are considered according the research are: the availability of OD web portal, the number of accuracy of key word "e-Inclusion" as well as the local term for "e-Inclusion", checking manually the content of documents that machine search was detected to determine the matching case of key word, possibility of setting the search criteria, multilingually of OD web portals, possibility to accessibility setting for users with disabilities, licence information, the documents format information and marks of openness rank of open data portal.

Regarding the research settings, the authors get results as it is described in next section.

5 Public Policies on Official Web Portals and Open Data Public Government Portals

The authors have tested openness of government public policies documents by searching official government web sites (not exactly specified as open

data portal) and national open government data portals listed on the official web portal of European Commission.

5.1 The Accessibility

The digital accessibility government of public policy documents on EU level is assured according to the web portal of European Commission (one stop shop). The organization of the document mentioned in Table 1 related to the EU level has very simple structure, it is easy to search and use. There is one common model of publishing the documents of all institutions as executive bodies of European Commission and European Council.

The digital accessibility of public policy documents on national Croatian governance level is achievable but not organized to be clear the hierarchy of public bodies and documents as it is on EU administrative bodies level. Each ministry has its own web domain, so there is no possibility to search all of them in one cycle. The user must be familiar with public administration organizational structure (to find all national institutions) to be able to find relevant documents.

During the research of the accessibility of strategic multiannual documents on Croatian regional level (20 counties and City of Zagreb) the authors have found that those are not accessible on the web for all counties for the period of 2014-2020. Some counties put the information on the official web portal that development strategy document is in the process of preparation and acceptance, some strategic documents are published in draft version so they can't be used as official because they are not accepted. Even the acceptance of multiannual documents is defined by national law there still exist the exceptions of applying that rule in the practice. On the other hand, the accessibility and openness of those documents is the next level problem that can't be solved if the documents don't even exist.

Public administration on national and regional level in Croatia have no single web spot for publishing the documents specified in Table 1. as EC has. Relatively often the administrative officers do not think that it is even important to do so because the interest of publicity for such documents is not developed enough.

5.2 Accuracy of "e-Inclusion"

Searching the term of e-Inclusion was conducted on July 18th, 2020 by using search tool on https://ec.europa.eu/info/index_en. Except the main key word "e-Inclusion" the search criteria were: Date – it was set to "all"; Language – one cycle of search was used "English" and another "Hrvatski"; File format: "All formats" (Web, Word, Excel, PDF, Power Point".

As the e-Inclusion is interdisciplinary term it can be additionally matched as it is presented in the following table.

Table 2. The number of contents analyse results of searching EC official web sites for appearance of the term "e-Inclusion"

Topic	EN *	CRO*
Business & industry	53	
Economy, finance and investment	624	524
Environment, food & natural resources	112	
EU in the world	134	
Functioning of the EU	1063	45
Health, Wellbeing & Consumer Protection	303	1
Infrastructure, research & innovation	187	2
Life & Rights in the EU	309	
Media, culture & languages in the EU	417	1
Others	870	
Social	2	4
Work & Education	1355	10

*English/Croatian language; Source: made by authors

The official portal of national Croatian Government contains neither one case of accuracy term "e-Inclusion" or Croatian term "e-uključivost".

The official web page Koprivnica Krizevci County gives the same results.

The testing of the open government data national portals was conducted during the period from 1st till 6th of August 2020. All national open government data portals have been accessible at the moment of the test. As the key words for search have been used the term "e-Inclusion" and the translation to the national term for each member state as it is presented in the Table 3.

As it could be seen in the Table 3 the most of official national open data portals have no data about e-Inclusion. If the accuracy was over 10 the content was tested additionally, and the conclusion is that search algorithm gives the result that includes not just the exact key word than the other similar terms. The result of search is not satisfactory because there have been scored the documents that includes not just exactly the key word. Just Lithuania and Poland open government data portals have possibility of advanced

Table 3. The accuracy of keyword "e-Inclusion" on open data national portals of member states of EU

RB	OD portal	Accurancy of keyword on national language	Accurancy of "e-Inclusion"	Checking manualy the results in (4)	Possibility of setting the research options	Multilingual	Multilingual contenct	accessibility settings
1	2	3	4	5	6	7	8	9
1	data.gov.be	e-Inclusion = 0	No information to display		no	NL, EN, FR, DE	No, mostly structure of web	not found
2	data.egov.bg/	електронното включване = 2 results found	No information to display		no	EN	No, mostly structure of web	not found
3	data.gov.cz/english	elektronické inkluze = 0 datasets foundwith query	0 datasets foundwith query: "e-Inclusion"		no	CZ, EN	No, just structure of web	not found
4	portal.opendata.dk	e-integration = 311 fundne resultater	309 fundne resultater		no	DK	-	not found
5	govdata.de	e-Inclusion = 0	Ihre Suche ergab leider keine Treffer		no	DE	-	not found
6	opendata.riik.ee	e-kaasatus = 0	Andmehulkade arv: 0		no	EN, ET	yes	not found
7	data.gov.ie	e-Inclusion = 3210	3,210 datasets found for "e-Inclusion"		no	EN	-	not found
8	data.gov.gr	ηλεκτρονική ένταξη = 0	944 σύνολα δεδομένων βρέθηκαν για "e-Inclusion"	not passed	no	GR	-	not found
9	datos.gob.es	e-Inclusión = 10	7 conjuntos de datos encontrados para "e-Inclusion"		no	ES, EN	No, just structure of web	not found
10	data.gouv.fr	e-Inclusion = 314	314 jeux de données, 11 réutilisations, 45 organisations	not passed	no	EN, FR,ES	No, just structure of web	not found
11	data.gov.hr	e-Uključivost = 165 Rezultata	165 Rezultata		no	HR	-	not found
12	dati.gov.it	Inclusione elettronica = 0	32911 Dataset	not passed	no	IT	-	not found
13	data.gov.cy	Ηλεκτρονική ένταξη = No results were found.	No results were found. Please try another keyword.		no	CY, EN	No, just structure of web	not found
14	opendata.gov.lt	e-įtrauktis = 0	No results found for "e-Inclusion"		yes	LT	-	not found
15	data.gov.lv	e-iekļaušana = "105 datasets found for "e-iekļaušana""	92 datasets found for "e-Inclusion"		no	LV, EN	No, just structure of web	not found
16	data.public.lu	e-Inclusion = 25 datasets	25 datasets; 2 reuses; 7 organizations	not passed	no	EN, FR	No, mostly structure of web	not found
17	data.gov.mt	Inklużjoni elettronika = "Showing 0 to 0 of 0 entries"	No records to display according to the filtering criteria supplied and your authorised access permissions.		no	MT, EN	yes	-
18	data.overheid.nl	e-inclusie = 0 zoekresultaten	e-Inclusion=0 zoekresultaten		no	NL	-	-
19	data.gv.at	e-Inklusion=10	e-Inclusion =10		no	AT	-	-
20	danepubliczne.gov.pl	e-Integracja = No results found for "e-Integracja"	No results found for "e-Inclusion"		yes	PL, EN	No, just structure of web	letter, theme
21	dados.gov.pt	Inclusão eletrônica = Sem resultados. Tente novamente utilizando outros termos.	No results found, try to be less specific.		no	FE, EN, ES	No, just structure of web	not found
22	data.gov.ro	e-incluziune = "120 datasets found for "e-incluziune""	128 datasets found for "e-Inclusion"		no	RO, EN. IT, FR, ES, DE	No, just structure of web	not found
23	podatki.gov.si	e-vključenost = "2469 najdenih zbirk"	2469 najdenih zbirk		no	SI, BUT USE GOOGLE T	yes	letter, theme
24	data.gov.sk	e-Inclusion = No datasets found for "e-Inclusion"	No datasets found for "e-Inclusion"		no	SK, EN	No, mostly structure of web	not found
25	avoindata.fi	e-Inclusion = No datasets found for "e-Inclusion"	No datasets found for "e-Inclusion"		no	FI, SE, EN	Yes	not found
26	oppnadata.se	E-integration = "No matching results"	No datasets found for "e-Inclusion"		no	SE	-	not found

Source: made by authors during the period of 1st to 6th August 2020

search setting to search any word from the expression, all words, exactly these words or synonyms of mentioned words.

Multilingual open government data portal is available for 14 counties, so this is one of the possible reasons why the search score is not greater. Slovenia has a good solution of multilingual presentation of published content. Slovenian open government data portal includes Google translate module if the portal is open by Firefox or Google Chrome, so the content is usable globally.

The maturity rate of dataset openness is marked on Croatian open government data portals, Slovenian and Ireland. Slovenian and Poland open government data portal has the possibility to set the accessibility settings the font size or the contrast of colours for users with disabilities.

The results of analyse are presented in Table 3. The accuracy of keyword "e-Inclusion" on open data national portals of member states of EU.

6 Conclusion and Recommendation

As the presented results of research talks the conclusion is simple that the topic of e-Inclusion in general, and neither of 54+ is not enough highlighted on official public policy documents published on official web portals or on open data official portals.

The importance of openness as well as the ability to reuse of public policy documents and data is reflected on the increase transparency, economic benefits and social benefits.

The European Union institutions pay a lot of attention to e-Inclusion as an important issue of human rights, but there still is a lot of things "to do" to get much more progress of getting nations e-Included, especially citizens who are 54+.

Raising awareness of being open and the importance of openness in terms of increasing the transparency of actions and decision-making process of public authorities and public sector is still the challenge.

Regarding the issues of demographic ageing in EU countries the EU policy is directed to active ageing measures and to inclusions in society, so the e-Inclusion is also the key topic nowadays. As it was researched the public policy documents related with e-Inclusion of 54+ are not open according to the data accessible standards on open government data national portals.

At the end the authors feel free to give some recommendations as it follows:

1. The topic of e-Inclusion of 54+ has to be much more included in public policy documents because it is the only systemic way that the problem of low e-Inclusion rate of 54+ can be solved.
2. The openness of open government data has to be implemented faster in the practice, not just on the level of developing standards and creating the law regulation.
3. The multilingually solutions of open government data can improve their usability so the recommendation is to implement standardized modules for web content translation.
4. During the research of national official government portals, it has been noted that the searching process takes much more time than the searching of the EU level governance, because at the national level every public government body (ministry) use its own domain. So, it is impossible to search all sources in one cycle. Maybe it could be better to organize official web pages of all public institutions on common web domain.

The topic of e-Inclusion in general, and specifically of 54+, is still one of actual matter to research, as well as considering it from the point of public policies. The readiness of public policies for e-Inclusion of population 54+ and the awareness of policy makers will be considered in further research too. According the conclusion further research will be focused on using BD in creating public policies for e-Inclusion.

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Digital Maturity of Auditing Companies in the Republic of Croatia

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Abstract *The subject of the research is to determine the level of digital maturity of audit companies in the Republic of Croatia. Given the importance of monitoring and implementing digital trends in business, it is essential to determine the current position of companies on their digital transformation path. In assessing the current position of the company, digital maturity models with predefined dimensions are used. In connection with this, a research question arises: which phases of digital maturity can be identified in audit companies in the Republic of Croatia? A review of the literature defines the maturity model and methodology for assessing and determining the level of maturity. The impact of certain dimensions of the model is examined through an online questionnaire sent to audit firms' 206 e-mail addresses. A total of 45 correctly completed questionnaires were returned. The analysis of the collected data identified four dimensions of maturity, and it was found that most of the analyzed companies are at a high third level of digital maturity. This leads to the conclusion that audit firms' digital maturity in the Republic of Croatia is at a high level, which is contrary to previous research, which points out that despite the awareness of the need to digitize operations, audit firms do not take steps in this direction.*

Keywords: digital transformation, maturity model, auditing, audit, digital technologies

1 Introduction

The development of digital technologies has started the digital revolution and encouraged companies to use the technology in improving their business. Improving business through the use of digital technologies represents the digital transformation that has become necessary in order to maintain and gain market competitiveness. Digital transformation implies a fundamental transformation of the entire business using new technologies based on the Internet with the aim of influencing society as a whole. (Schallmo, Williams, & Boardman, 2017) It is a long journey that begins the moment a company starts thinking about introducing digital technologies into its business and lasts until the moment of their full integration. (europa.eu, 2020) Essentially encompasses various transformations within business systems that include changes in current ways of thinking and doing business and technical changes in the form of digitization and/or automation. Digital transformation requires a well-thought-out digital strategy with clearly set goals that require the involvement of all employees in the company. It is necessary to emphasize that an effective and high-quality digital strategy does not refer only to the application of new technologies, but also to the reconstruction of the entire business in order to use the information gathered by new technologies. For this reason, a coordinated reorganization is needed within the company that would enable digital transformation to create added value. (Henriette, Feki, & Boughzala, 2015) For successful digital transformation, it is necessary for managers to understand the current "as is" situation within the company in order to be able to develop a strategy to achieve the so-called "to be" conditions, i.e., to transform and improve business with the help of digital technology. To identify the current situation, digital maturity models are used, which estimate the phase of the digital maturity of a company according to predefined dimensions. (Kruljac & Knežević, 2019) (Berghaus & Back, 2016) Measuring and assessing a company's digital maturity is a frequent topic of scientific papers, which is evident from a large number of models developed for measuring the digital maturity of companies of all sizes and sectors.

A review of the literature revealed a lack of research into the digital maturity of audit firms. According to Dai and Vasarhelyia, improving business with the help of digital technologies is off the radar of audit firms. The authors state that audit firms consider the digital transformation to be promising but, at the same time, limiting due to

several factors. (Dai & Vasarhelyi, 2016) In order to identify the digital maturity of audit firms in the Republic of Croatia, a survey was conducted. "Which phases of digital maturity can be identified in audit companies in the Republic of Croatia?" was the formed research question.

To answer the formed research question, a model for assessing digital maturity was created using dimensions taken from several existing digital maturity models. (Gill, VanBoskirk, Evans, Nail, & Cause, 2016) (Kane, Palmer, Phillips, Kiron, & Buckley, Achieving Digital Maturity, 2017) (Shahiduzzaman, 2017) (Berghaus & Back, 2016) The method of determining maturity levels was taken from the research of the digitalization maturity model for small and medium enterprises by Blatz and others. (Blatz, Bulander, & Dietel, 2018)

After an overview of the relevant literature at the beginning of the paper, the methodology and the results are presented in the paper structure as followed. The conclusion appears in the last part of the article.

2 Literature Review

With the advancement of digital technologies, the process of digital transformation starts in numerous companies that begin to think about how to integrate new technologies into their business to improve business processes and increase companies' value. (Berghaus & Back, 2016) (Liu, , Chen, & Chou, 2011) Spremić defines digital business transformation as the application of digital technology and digital resources in order to generate new sources of income and / or create new ways of doing business, i.e., new business models. (Mario, Spremić, 2017)

The word "transformation" suggests that these are fundamental changes within the organization that are influenced by the digital age in which society currently finds itself. Shallmo explains how digital transformation implies a fundamental transformation of the entire business using new Internet-based technologies with the goal of influencing society in general. (Schallmo, Williams, & Boardman, 2017) In fact, the goal is to use digital technologies to transform business processes and improve interaction and collaboration with business partners. (Berman, 2012)

Digital transformation is far more than just integrating new technologies into business. For a successful digital transformation, it is necessary to use all the possibilities that this integration enables. (Kane, Palmer, Phillips, & Kiron, Is Your Business Ready for a Digital Future?, 2015) That means creating added value by improving business processes and thus improving the quality of service provided to customers while taking into account employees, processes that are improved, and the functions themselves to achieve appropriate competitive advantage. (Kane, Palmer, Phillips, & Kiron, 2015) (Teichert, 2019) Rothmann and Koch point out that digitalization can contribute to creating an entirely new business model or reshaping an existing one. (Rothmann & Koch , 2014)

It is evident that digital technologies will bring impressive changes in the next few years. It will be necessary for companies to adapt and improve their businesses not only to maintain a competitive position in the market but also to ensure their very survival. Adaptation in the form of digital transformation is already visible today, but the adjustment to digital trends and thus, the implementation of digital transformation is not going at the same speed in all sectors.

Dai and Vasarhelyi point out that despite the widespread use of digitalization, the acceptance of new technologies and their integration into business is finding it difficult to find its place in the audit profession. (Dai & Vasarhelyi, 2016) According to their research, ubiquitous digitalization and more advanced business, with the help of digital technologies, are off the radar of audit firms. They find it very promising but, at the same time, limiting due to several factors. One of the factors is the lack of standardization of accounting programs. As auditors audit the financial statements of a large number of companies, each of which uses different accounting programs, it is challenging to automate audit procedures. The lack of adequate skills of the auditors themselves is also cited as a limiting factor. Digital transformation involves people, and a successful one requires employees to have enough IT skills to support the transformation itself. The limiting factor for the digital transformation of audit processes is as well the so-called “problem of the black box," i.e., the problem of explaining how the algorithm makes decisions, and that would be problematic in the audit process, due to the need for the auditor to justify a particular decision. (Auditors, 2020)

Digital maturity describes the level of the digital transformation of a company and thus describes how much and what a company has done so far in terms of managing digital transformation. (Berghaus & Back, 2016) That is, it describes a company's progress in transforming its business using digital technology in a digital environment to achieve and maintain market competitiveness. (Teichert, 2019) (Chanias & Hess, 2016) Chanias and Hess emphasize that digital maturity goes beyond just improving business processes using various technological solutions and information technology, but it also includes monitoring progress in the digital transformation of enterprises by management. (Chanias & Hess, 2016) The level of digital maturity is not constant but is influenced by technological changes and therefore needs to be reassessed and measured. (Shahiduzzaman, 2017)

In measuring digital maturity, digital maturity models are used, which, in addition to assessing the state of the company itself, also observe its relationship with the competition and enable the management of progress towards higher stages of maturity. The main task of the maturity model is to describe the stage of maturation and to measure the current position on the maturation path. Digital maturity models are applied to the overall business of an enterprise or to a single function, and consist of several dimensions and criteria whose task is to describe the area of activity and stages of maturity that indicates the path of evolution towards enterprise maturity. (Berghaus & Back, 2016) (Kruljac & Knežević, 2019)

The digital maturity model is a descriptive type of model whose primary goal is to determine the current state of the enterprise, i.e., the existing digital transformation level, by describing what the enterprise has done so far in terms of transformation efforts. Using the maturity model, the company has the opportunity to assess its current position on the path of digital transformation according to predefined dimensions. Clearly defined dimensions and criteria describe the field of action and measures on the path to maturity, with each dimension being a specific, measurable and independent component that reflects the main, fundamental and different aspects of digital maturity and describes the field of action (Blatz, Bulander, & Dietel, 2018) (Teichert, 2019) (Berghous & Back, 2016)

3 Methodology

In order to answer the research question, a survey was conducted using a survey questionnaire using a modified maturity model. The dimensions of the model are taken from previous research and consist of culture, organization, information technology, strategy, and transformation management. (Table 1) (Gill, VanBoskirk, Evans, Nail, & Cause, 2016) (Kane, Palmer, Phillips, Kiron, & Buckley, Achieving Digital Maturity, 2017) (Shahiduzzaman, 2017) (Berghaus & Back, 2016)

The cultural dimension represents the company's attitude towards digital technologies and, thus, the digital transformation, which includes encouraging employees to use them. (Berghaus & Back, 2016) (Blatz, Bulander, & Dietel, 2018) The organization implies a clear structure of support within the company in the digital transformation of business. For digitalization to be successful, a clear division of roles and responsibilities within the company is needed. Information technology implies adequate infrastructure, while strategy means recognizing the importance and need for digitalization of business within the company. Transformation management implies the definition and division of roles for the management of the set digitization strategy. (Berghaus & Back, 2016) (Blatz, Bulander, & Dietel, 2018)

The dimensions of the maturity model are presented in the form of an online questionnaire created in the Google Forms application. The questionnaire was sent in April-May 2020 to the e-mail addresses of audit firms via the Mailchimp application. A total of 206 audit companies are registered in the Republic of Croatia, and their e-mail addresses are publicly available on the website of the Croatian Chamber of Auditors. (Chamber, 2020) Respondents were asked to express an attitude toward the presented statements using a 5-point Likert scale where 1 signified completely disagree and 5 agree completely. The questionnaire also contained questions related to the size of the company, the county, and the number of employees in the company. The questionnaire was sent on two occasions, and a total of 45 completed survey questionnaires were returned.

Table 1. below shows the dimensions of the digital maturity model, along with the corresponding claims. In order to confirm the homogeneity of the statements within each individual dimension, the internal reliability of the dimension was tested using the Cronbach's alpha coefficient. All factors are as seen in Table 1 within acceptable limits, i.e., above the recommended value of 0.7 (Field, 2013)

Table 1. Maturity level dimensions

Item	Source	α
CULTURE		
By using digital solutions (digitization), my company gains a competitive advantage.	(Gill, VanBoskirk, Evans, Nail, & Cause, 2016)	0,925
The management in my company supports the digital strategy of the company.	(Gill, VanBoskirk, Evans, Nail, & Cause, 2016) (Kane, Palmer, Phillips, Kiron, & Buckley, Achieving Digital Maturity, 2017)	
My company invests in the digital education of its employees.	(Shahiduzzaman, 2017)	
The digital vision of my company communicates clearly to employees and clients.	(Gill, VanBoskirk, Evans, Nail, & Cause, 2016)	
My company constantly implements innovations in business regardless of possible risks.	(Gill, VanBoskirk, Evans, Nail, & Cause, 2016)	
In my company, employees use available digital solutions to solve their tasks.	(Berghaus & Back, 2016)	
When hiring new employees, their digital skills are an important selection criterion.	(Berghaus & Back, 2016)	
Employees are familiar with the available digital solutions in the company and use them voluntarily.	(Berghaus & Back, 2016)	
To carry out the digital transformation of business, employees have adequate knowledge and competencies.	(Shahiduzzaman 2017)	
My company is ready to modify existing business processes (the way something is done) if the digital transformation requires it.	(Berghaus & Back, 2016)	
Employees are motivated to try new digital solutions despite a possible failure.	(Berghaus & Back, 2016) (Kane, Palmer, Phillips, Kiron, & Buckley, Achieving Digital Maturity, 2017)	
Errors and knowledge gained from failed projects related to the digitalization of business processes are communicated and discussed at meetings.	(Berghaus & Back, 2016)	
ORGANIZATION		
In my company, digital transformation (informatization) refers to the entire business, not just the digitization of individual business operations.	(Berghaus & Back, 2016) (Shahiduzzaman, 2017)	0,912
The business strategy of the company is to develop new skills that enable the management of digital transformation.	(Berghaus & Back, 2016)	
My company monitors the development of new technologies and business models that are relevant and applicable to our business.	(Berghaus & Back, 2016)	
In my company, adequate funds are provided for the digitalization of business processes.	(Gill, VanBoskirk, Evans, Nail, & Cause, 2016) (Shahiduzzaman, 2017)	
There are a sufficient number of employees in my company with appropriate digital / IT skills.	(Gill, VanBoskirk, Evans, Nail, & Cause, 2016) (Kane, Palmer, Phillips, Kiron, & Buckley, Achieving Digital Maturity, 2017)	
My company uses digital solutions to exchange information between employees and customers.	(Berghaus & Back, 2016)	
In my company, communication via video conferencing and screen sharing is common in internal and external communication (e.g., Lync, Skype, etc.).	(Berghaus & Back, 2016)	
In my company, innovative solutions and opportunities for their implementation in business are presented at meetings and conferences with the aim of spreading knowledge.	(Berghaus & Back, 2016)	
In my company, employees are allowed to work from home.	(Berghaus & Back, 2016)	
In my company, there are professionals who deal with digital topics that communicate with other employees.	(Berghaus & Back, 2016)	
My company has experience with mobile work (work from home, from the field, etc.).	(Berghaus & Back, 2016)	

INFORMATION TECHNOLOGY		
My company's IT infrastructure is regularly checked for digital requirements and updated as needed.	(Berghaus & Back, 2016)	0,945
My company has a clear strategy for the procurement and application of key digital technologies in business.	(Berghaus & Back, 2016)	
In my company, the budget for investing in new technologies is flexible and allows for adjustment and changing priorities.	(Gill, VanBoskirk, Evans, Nail, & Cause, 2016)	
Marketing and technological resources work together in the direction of the planned implementation of new technologies in business.	(Gill, VanBoskirk, Evans, Nail, & Cause, 2016)	
In my company, there is a flexible and collaborative approach to technology development.	(Gill, VanBoskirk, Evans, Nail, & Cause, 2016)	
We exchange data with clients digitally, e.g., interactions via Cloud APIs.	(Shahiduzzaman, 2017)	
My company uses various digital tools (e.g., communication tools, social media management, time and task management tools, etc.) to encourage employee innovation, mobility, and collaboration.	(Gill, VanBoskirk, Evans, Nail, & Cause, 2016)	
The implementation of new technologies in business is based on the suggestions and needs of clients.	(Gill, VanBoskirk, Evans, Nail, & Cause, 2016)	
Digital and mobile channels, as well as social media platforms, are consistently integrated into the business.	(Berghaus & Back, 2016)	
Digital and mobile channels, as well as social media platforms, are consistently integrated into our marketing communication.	(Berghaus & Back, 2016)	
In my company, there are appropriate defense mechanisms (applications, tools, etc.) against possible cyber attacks.	(Shahiduzzaman, 2017)	
STRATEGY		
The competition sees us as drivers of digital innovation.	(Berghaus & Back, 2016)	0,943
My company has a clearly set digital transformation strategy.	(Shahiduzzaman, 2017)	
Digital business is very important in our business strategy and is widely communicated.	(Berghaus & Back, 2016)	
Digital projects are frequent and are promoted with high priority within the company.	(Berghaus & Back, 2016)	
Digital transformation is an important project in my company.	(Berghaus & Back, 2016)	
All employees participate and support the digital vision of the company.	(Shahiduzzaman, 2017)	
TRANSFORMATION MANAGEMENT		
There is a developed plan for digital business transformation in my company	(Berghaus & Back, 2016)	0,933
In my company, roles, responsibilities, and decision-making processes for digital transformation are defined.	(Berghaus & Back, 2016)	
Management recognizes the importance of digital business and provides adequate resources.	(Shahiduzzaman, 2017)	
Operational management recognizes the importance of digital business and greatly encourages the implementation of digital projects.	(Berghaus & Back, 2016)	
Performance indicators related to the operational objectives of digital business are defined in decisions on management objectives.	(Berghaus & Back, 2016)	
The goals of digital transformation are measurably defined and periodically checked and revised.	(Berghaus & Back, 2016)	
Previously introduced digital initiatives in my company have created added value (revenue).	(Shahiduzzaman, 2017)	

3.1 Calculation of Maturity Levels

The method of determining the level of digital maturity is taken from the research of Blatz and others who, in their research, propose a model of digital maturity for small and medium enterprises. (Blatz, Bulander, & Dietel, 2018) According to data for 2018, out of the total number of registered audit companies in the Republic of Croatia, only two are medium-sized, while the rest are small companies.

Therefore, this method of determining maturity is suitable for this research. (Fina, 2020)

The statements within each dimension were evaluated on a Likert scale from 1 to 5, with 1 being 0 points and 5 being 4 points. After evaluating each statement within a dimension, the arithmetic means of each dimension shows which dimension is the most developed and which has the lowest rating in terms of the degree of digital maturity. Table 2 shows the calculated importance of each dimension relative to the other dimension.

Table 2. Weighing of the dimensions

Dimension	Weight
Culture	23%
Organization	21%
Information Technology	20%
Strategy	18%
Transformation Management	19%

After calculating each individual dimension's importance, the total maturity was determined by the weighted arithmetic mean. By summing the arithmetic mean of each individual dimension multiplied by the importance of the dimension itself. The obtained values identified three levels of maturity shown in Table 3. and started to determine each company's maturity.

4 Results

The research results showed that out of a total of 45 analyzed companies, 23 of them are at the 2nd level of digital maturity, 15 of them at the 3rd level, while seven companies are at the 1st level of digital maturity. (Figure 1.)

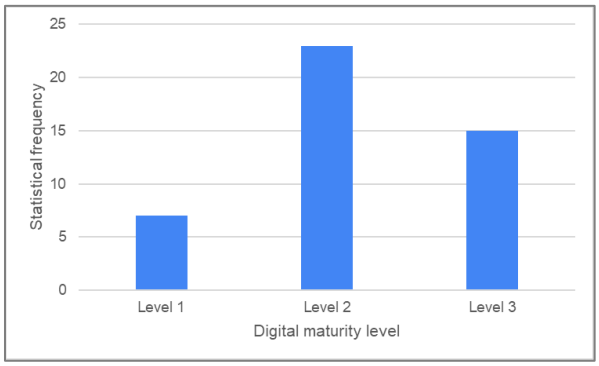


Figure 1. Results of maturity level, n =45

Table 3. Maturity Level *(Blatz, Bulander, & Dietel, 2018)*

Level	Description	Points/Digital Maturity (dM)
Level 1	The impact of digitization and digital technologies on the company itself and its business is minimal. The need for digitalization of business has been recognized, but no steps have been taken yet. There is a lack of management support and motivation for using new technologies and solutions.	> 0
Level 2	Certain steps have been formed towards the digitalization of business. The use of digital solutions is promoted. There are indications of a digital strategy, but the roles, goals, and models for measuring them are not clearly defined.	> 2
Level 3	The goals within the digital strategy are clearly set and are regularly checked and revised. The company has appropriate information infrastructure and proper management that takes care of the digitalization of business.	> 3

Observing the level of digital maturity in relation to the number of employees in the company, it is evident that the companies with the largest number of employees are at the highest level of maturity. (Figure 2.)

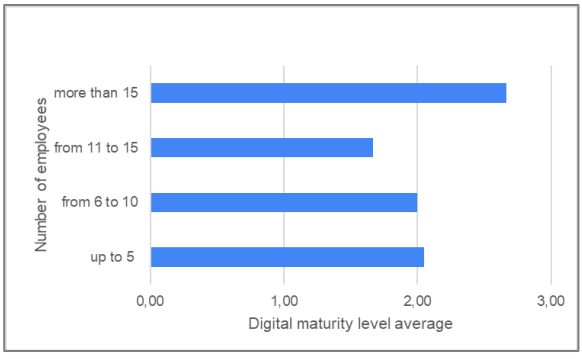


Figure 2. Level of digital maturity in relation to the number of employees, n=45

The average values obtained for each of the dimensions shown in Figure 3 indicate that the dimensions of culture and organization are mostly implemented in enterprises, while transformation management is in the last place. The same is confirmed by looking at the highest average value of each individual activity within the dimensions. (Tables 4. and 5.) Thus, the activities with the highest value refer to activities from the dimension of culture and organization. In contrast, those with the lowest average refer to activities related to digital transformation management and digital transformation strategy.

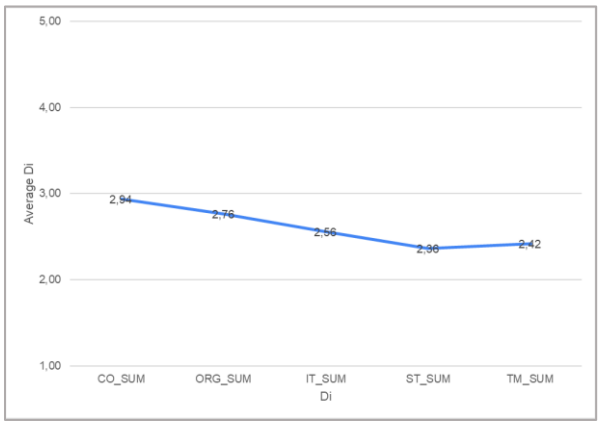


Figure 3. Average result from each dimension, n =45

Table 4. Activities with highest average, n=45

Activity		Average
2.11. ORG	My company has experience with mobile work (work from home, from the field, etc.).	3,4444
1.2. CO	The management in my company supports the digital strategy of the company.	3,4222
2.6. ORG	My company uses digital solutions to exchange information between employees and customers.	3,1778
1.8. CO	Employees are familiar with the available digital solutions in the company and use them voluntarily.	3,1556
1.3. CO	My company invests in the digital education of its employees.	3,1111
1.10. CO	My company is ready to modify existing business processes (the way something is done) if the digital transformation requires it.	3,1111
1.1.CO	By using digital solutions (digitization), my company gains a competitive advantage.	3,0444
2.9. ORG	In my company, employees are allowed to work from home.	3,0222

Table 5. Activities with the lowest average, n=45

Activity		Average
1.5. CO	My company constantly implements innovations in business regardless of possible risks.	2,2667
4.2. ST	My company has a clearly set digital transformation strategy.	2,2444
5.6. TM	The goals of digital transformation are measurably defined and periodically checked and revised.	2,2444
5.2. TM	In my company, roles, responsibilities, and decision-making processes for digital transformation are defined.	2,2222
5.1. TM	There is a developed plan for digital business transformation in my company.	2,1778
2.10. ORG	In my company, there are professionals who deal with digital topics that communicate with other employees.	1,8222
4.1. ST	The competition sees us as drivers of digital innovation	1,8222

For the purpose of describing each individual dimension, the samples obtained on the basis of the analyzed responses are presented, which are shown below (Figure 4.). The first level of digital maturity is characterized by inadequate development of all dimensions, especially strategy dimensions and transformation management. The most developed dimension at the first level is the cultural dimension. The second level of maturity is characterized by growth in all dimensions, but it is evident that the dimension of strategy and transformation management is not accompanied by the same growth as the dimension of culture, organization, and information infrastructure. At the 3rd level of digital maturity and at the last level, it is evident that all four dimensions are at the highest level, including the dimension of strategy and transformation management.

5 Conclusion

The paper aimed to conduct research in order to answer the formulated research question of which stages of digital maturity can be identified in audit companies in the Republic of Croatia. The dimensions and activities of the digital maturity model are taken from previous research. (Berghaus & Back, 2016) (Shahiduzzaman, 2017) (Gill, VanBoskirk, Evans, Nail, & Cause, 2016) (Kane, Palmer, Phillips, Kiron, & Buckley, Achieving Digital Maturity, 2017)

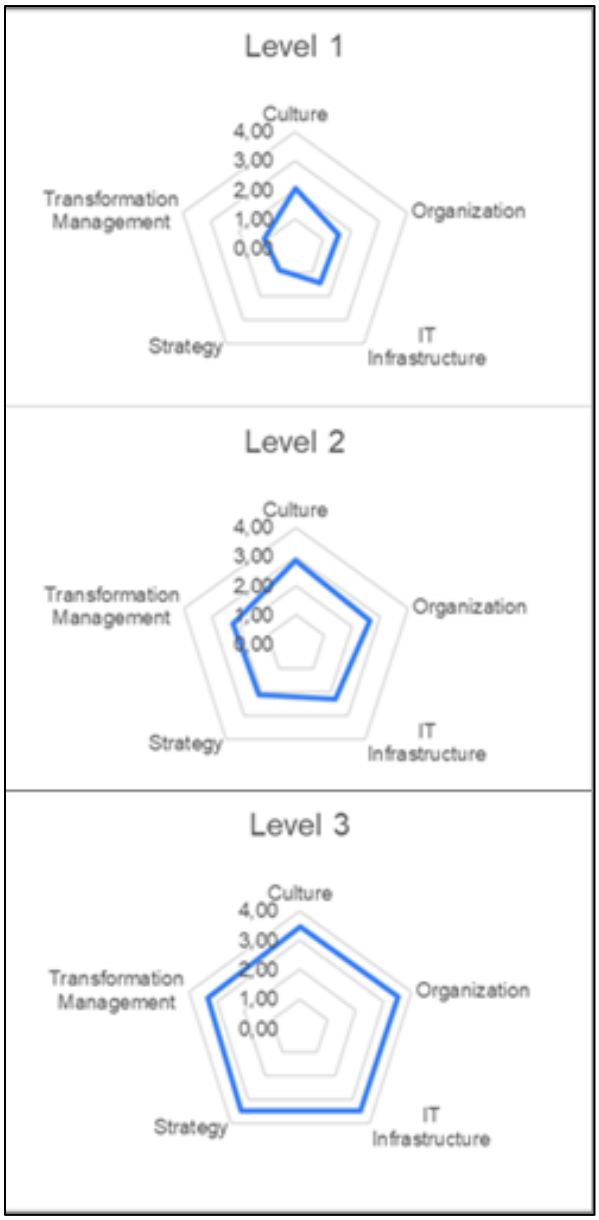


Figure 4. Answering pattern types

The model used includes five dimensions: the dimension of culture, organization, information technology, strategy, and transformation management. The methodology of Blatz et al. was used to determine levels of digital maturity. (Blatz, Bulander, & Dietel, 2018) Out of 206 registered in the Republic of Croatia, forty-five audit firms were surveyed, and three levels of digital maturity were identified by using a questionnaire.

The results of the research show that as many as 51% of the analyzed companies are at the 2nd level of digital maturity, while 16% of companies are at the first level. At level 3, there are 15 analyzed audit firms, i.e., 33.3%. The research also shows that companies with the largest number of employees are also at the highest level of maturity, so companies with 15 or more employees have reached the highest level of maturity. But it cannot be argued that the number of employees affects the level of maturity for the reason that firms with 11 to 15 employees have achieved a lower level of maturity than firms with fewer employees.

In order to determine the extent to which a particular dimension characterizes a particular level of maturity, response patterns are presented. It has been shown that what distinguishes Level 3 maturity from Levels 1 and 2 is the development of strategy and transformation management dimensions. These dimensions relate to the existence of a clear digital transformation management strategy with defined and measurable goals. The same can be seen from the activities that proved to be the least represented in the analyzed companies (Table 5), while the activities that are within the dimensions of culture and organization are highlighted as activities with the highest values (Table 4). In that sense, the activity that refers to the possibility of working from home, the so-called mobile work. It is important to emphasize that the research was conducted in March and May 2020 during the COVID 19 pandemic, which could have had an impact on the overall results of the research. Due to the pandemic, it has become necessary to use digital technology so that business can continue to some extent. Thus, for example, it was necessary to provide employees with conditions to work from home in order to prevent the infection and further spread the pandemic, mandatory training seminars were moved to webinars and the like. All of the above has certainly had an impact on raising the awareness of auditors themselves, as well as audit firms, about digital technologies and the opportunities they provide.

The results obtained from the research clearly indicate that audit firms are very aware of the digital transformation and that they have largely applied it in their business. The results contradict the claims of Dai & Vasarhelyi, who believe that audit firms lag behind other firms in the field of digital transformation. (Dai & Vasarhelyi, 2016)

The digital maturity of a company is not constant and changes over time under the influence of various factors. Therefore, research in the future should definitely be repeated to see if there are any changes. Also, the following research should apply the interview method in order to remove the questionability of the credibility of completing the survey questionnaire and expanding the sample.

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Conceptual Analysis of the Digital Innovation Hub as a Value Delivery System

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Abstract. *This paper explores the conformance of the concepts underlying the Digital Innovation Hub (DIH) with the concepts of value delivery systems. DIH literature was used as a DIH source of information and Object Management Group's (OMG) specifications were used for creating a metamodeling framework. The basis for the analysis is metamodeling, with the basic metamodel being Value Delivery metamodel of the Value Delivery Modeling Language (VDML). The research hypothesis is that DIH business model is delivery of value, which was tested by the conformity of the generic DIH metamodel (DIH RMM) with the VD metamodel. Further study is suggested.*

Keywords. Digital Transformation, Digital Innovation Hub, Value Delivery System, VDML, Metamodeling, Conceptual Mapping

1 Introduction

Digital transformation (DT) dramatically changes the way business was done in the past, introduces the whole new way of thinking and living, allows seamless work, and introduces new models and organizational structures. The technologies which are recognized as the ones having the highest impact on DT are High performance Computing, Internet of Things, Block-Chain, Robotics and Artificial Intelligence, but European Union (EU) Member States (MS) are not exploiting them enough, whilst the intensity of DT paints a very heterogeneous landscape within EU (European Commission, 2019a).

DIH is one of those organisational structures introduced in order to make the DT possible and more widely applicable. They were first introduced in 2016, as one of the priorities of utmost importance in Digitising European Industry Initiative, based on the notion that the level of digitalisation amongst EU MS should be more homogenous, that it is more than necessary for enhancing EU's competitiveness on international market, and that only one fifth of EU's small and medium-sized companies (SMEs) is highly digitalised (European Commission, 2019a). That ratio is very concerning, especially taking into account that SMEs carry out 99% of EU businesses (European Commission, n.d. a). In that regard, DIH is a policy instrument, making much needed DT support readily available (Rissola & Sorvik, 2018).

The aim of this article is to provide insight in DT related novel organizational structure called DIH and its added value, mapped onto a VDML metamodel, in order to explore its suitability for DIH reference metamodel (RMM DIH), which can in future be used as a benchmark for DIHs.

After the introduction, this article is structured in a way that it first explains the concept of DIH and refers to the relevant sources of information regarding it. Then it explains concepts regarding Value Delivery Systems and VDML with a special view of VDML metamodel. Following that, research methodology is explained and then conformance analysis is conducted through conceptual mapping of DIH concepts onto VDML classes. The conclusion also suggests further research.

2 DIH Concept and Reference Sources of Information

DIHs can help companies, regardless of their size, digitalise their businesses, providing a wide spectrum of one-stop-shop services, whilst heavily relying on knowledge and technology transfer provided by

technical universities or research establishments at their very core, which is illustrated on Fig. 1 below (European Commission, 2019a). They should be the very first regional points of contact when it comes to existing industries' demand-side endeavours regarding DT, which is what distinguishes them from clusters (Miörner, Kalpaka, Sorvik, & Wernberg, 2019a).

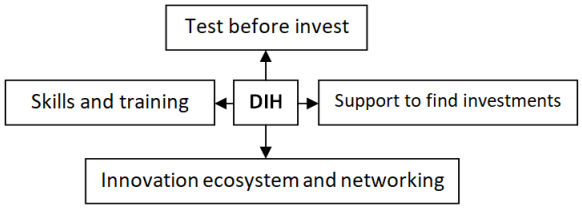


Figure 1. Digital Innovation Hub mission, Source: Adjusted from European Commission (European Commission, 2019a)

When it comes to being the first point of contact, it is worth mentioning that proximity also plays an important role. One study shows that geographically isolated locations with little population find it difficult to attract highly skilled and talented workforce (Lantz & Wu, 2017). The authors also mention possible solutions but they do however require additional investments, which often less isolated and more populated regions don't have to endure. It is also important to emphasize that DIH value proposition should be based on established needs of the industry, and then formed into a unique offer (WG1, 2017).

DIHELP guide for Applicants states that DIHs offer the following services to their users: "access to digital technologies and competences, infrastructure and training to test digital innovations, financing advice, market intelligence, networking opportunities, access to digital skills development and training" (European Commission, 2019b, pp. 2-3). That list is not exhaustive, but highlights the only the basic DIH offerings to its customers.

DIHs bring different stakeholders together, trying to create synergy through mutual engagement of different MS and regional policies created by state governing bodies and European Commission (EC), members of the industry (especially SMEs), academia and research entities. Already existing potential and needs of certain areas should be the starting point in order to support already existing EU industries in their DT endeavours (Rissola & Sorvik, 2018). MS created and adopted Smart Specialisation Strategies (S3) which define priority areas for research and investment taking into account the before mentioned potential, and based on European Cohesion Policy 2014-2020 (Miörner, Rissola, Sörvik, & Wernberg, 2019b). Most existing DIHs today are either existing actors which merely rebranded themselves, existing actors with new focus which involves DT, or entirely new actors (Miörner et al., 2019a). EC has not so far provided detailed criteria for DIHs, (Virkkunen, Still, & Rosso, 2019), which leaves space and an opportunity for further study.

DIH as an intermediary in this comprehensive multi-stakeholder policy aligned collaboration, amongst other things deals with matchmaking through the use of showrooms for local technologies, engaging events, exploiting websites as platforms with different tools, creating networks of suppliers or by promoting different organisations' complementarities (Rissola & Sorvik, 2018). This matchmaking or brokering is also achievable trough: roadshows, workshops, innovation camps, and hackathons (WG1, 2017, p. 12). Multi-sided platform (MSP) approach could also be one way of looking at DIH platform functionalities.

Regarding DIH funding; MS and regions are to invest in their respective DIHs, possibly through European Regional Development Funds (ERDF), and align them with their own digitalisation strategies, whereas EC has been providing 100 mil € every year from 2016 to 2020 to enable pan-European DIH network, in order to compensate for some DIH shortfalls with the resources available elsewhere, creating opportunities for knowledge transfer (European Commission, 2018). DIHs deal with financing challenges in different ways; whilst basic services provided should be free of charge, DIH sustainability is usually achieved through different means such as public funds, membership fees, and commercialising their own more specialised services (Rissola & Sorvik, 2018). One research showed that most DIHs are not financed directly by their S3s, in spite of the fact that they have been aligning their work endeavours with it, and some even helped create it (Miörner et al., 2019b).

DIH sources of information are rather scarce, especially in scientific literature. Therefore, the biggest sources of information regarding DIHs are EC's Joint Research Centre (JRC) technical reports and platforms. Comprehensive list and information on DIHs in Europe can be found in the Digital Innovation Hubs tool, a part of S3 Platform, created as a platform for DIH networking with one another (European Commission, n.d. b). DIH tool contains information on DIHs in EU MS and non-EU states in Europe, and can be used to search the catalogue taking into account also evolutionary stages (in preparation, fully operational or potential DIHs from Horizon 2020 Programme[1]), 25 different technical competences, 15 different services provided, with focus on 8 different Technology Readiness Levels (TRLs), 20 different market sectors, and whether they are involved in H2020 projects (European Commission, 2020). The tool also shows DIH information, on interactive map as well as listed, currently encompassing information on 618 DIHs (European Commission, 2020). DIHNET.EU project, JRC DIH catalogue interactive community, supports

[1] EU Research and Innovation programme, financial instrument

DIH network collaboration across Europe, in order to create added value through sustainable, cooperable and coordinated pan-European network of networks, whilst offering tools and services to DIHs, organising DIH Champions Challenge, and focusing on regional DIHs (TNO, n.d.).

The proposed Digital Europe Programme (DEP) for the upcoming six year period, will focus on creation of EU strategic digital capacities, provision of funds for supercomputing, artificial intelligence, cyber security and advanced digital skills, whilst allowing deployment of digital technologies throughout EU's economy and society, in order to further enhance DT (Commission, 2019c). EC will continue to invest in DIHs, and DEP will provide grants to one DIH per EU region, which will be called European Digital Innovation Hubs (EDIHs) (Virkkunen et al., 2019).

3 Value Delivery Systems, VDML, VDML Metamodel

Conformance of the concepts underlying the DIH is confirmed through the concepts of value delivery systems. The research hypothesis is that DIH business model is delivery of value. This research aims to map DIH, as a value delivery system, onto a VDML metamodel, in order to explore its suitability for RMM DIH.

According to Lanning & Michaels (as cited in Ballantyne, Frow, Varey, & Payne, 2011, p. 203), Value Delivery System (VDS) was first mentioned in scientific literature 1988, and it was comprised of three steps: choose the value, provide the value and communicate the value. VDS aims to deliver as much value as possible to its customers whilst simultaneously creating profit for the participants in the process (Ji, 2008). Some authors also describe projects as VDS and seek for their optimisation (Drevland, 2019).

OMG creates specifications for applications, which implement Model Driven Architecture (MDA), and amongst which also Unified Modeling Language (UML) specification (OMG, 2018). It also provides a specification for VDML for managerial staff, and whose purpose is creation of business design models connecting strategic and operational level of corporate business, in order to enhance common understanding of business transformation (OMG, n.d.). VDML focuses on the value chain, complex collaborations, business networks, activities, roles and capabilities (OMG, 2018). Value modeling can be used to depict both creation and exchange of values (Roelens & Poels, 2013). Meta Object Facility (MOF) is OMG's modeling and metadata specification, part of MDA family of languages, which provides framework for open and platform-independent management, in order to allow creation and interoperability of systems handling models and metadata (OMG, 2019). MOF allows models to be transported from one application to another, stored, retrieved, transformed into different formats, and used for the creation of application code (OMG, n.d.). Metamodel is a model of the model, used for modeling models and arbitrary metadata, with the minimal number of two layers (metalevels) (OMG, 2019).

For the purpose of this research, the methodology displayed at Fig. 2 below is the following: UML Model represents Object of Modeling, and conforms to UML Metamodel (for additional specification); UML Metamodel conforms to MOF (a meta-metamodel setting rules for metamodeling); object of modeling is a DIH system; DIH model representing DIH System is created as an UML model, and it conforms to DIH RMM.

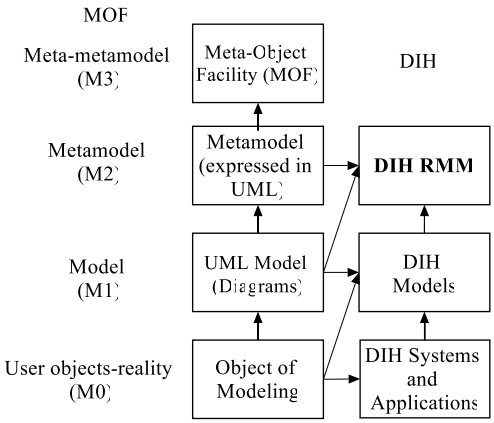


Figure 2: UML, MOF and DIH, Source: Authors' own creation

The next step in this methodology, displayed in Fig. 3 below, is extending the metamodeling by using VDML profile, a UML profile for value delivery (VD) systems. As shown in the figure: VD System (VDS) is an Object of Modeling; VDS Model (VDSM) is an UML profiled model, which conforms to VDML - a Metamodel of VDSM which represents a VDS.

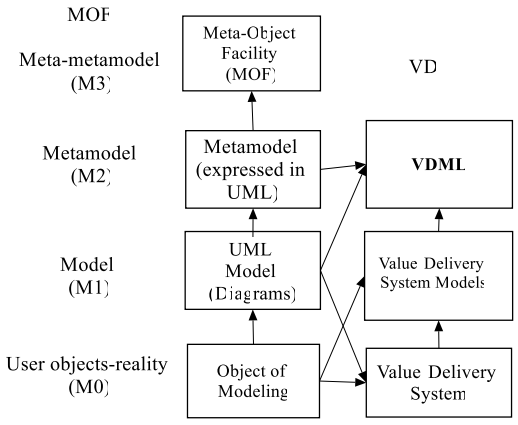


Figure 3: Extending the metamodeling by using VDML profile, Source: Authors' own creation

The complete methodology concepts are depicted in the Fig. 4 below. DIH RMM is what the authors are trying to create and that is, besides the methodology, the scientific contribution of this research. DIH RMM is important because it can be used for DIH benchmarking, comparison of DIHs, and it can also be used as a reference point providing guidance for what a DIH should be comprised of. Also, DIH RMM design can be useful for structuring DIH catalogue.

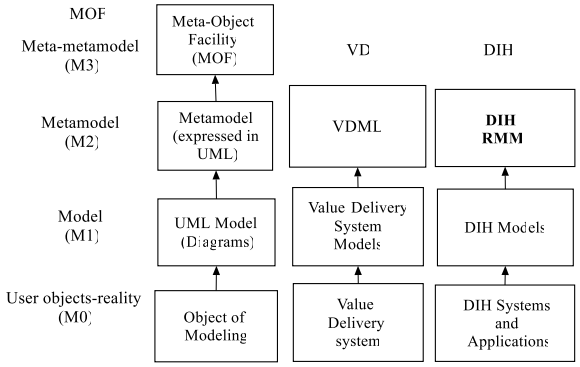


Figure 4: Research methodology concept, Source: Authors' own creation

4 Conformance Analysis

The research is based on the hypothesis that DIH's business model is essentially a delivery of value. We will prove this by proving the conformity of the generic DIH model (DIH RMM) with the VD metamodel (part of the VDML specification), as displayed on Fig. 5 and Fig. 6 below.

Conformance Analysis will be implemented at the level of VDML Collaboration Modeling Conformance; the VDML metamodel subset can be used for structures and relationships in organisation, and it conforms if XMI can be imported and exported consistently with Structured Metrics Metamodel (SMM) and VDML Metamodel Conformance (Subclause 2.2) whilst implementing the following classes: ValueDeliveryModel, VdmlElement, MeasurableElement, Attributes, Annotation, MeasuredCharacteristic, PortContainer, Collaboration, Role, RoleDefinition, RoleLibrary, RoleCategory, Participant, Actor, Person, Assignment, OrgUnit, Position, Community, Member, BusinessNetwork, and Party (OMG, 2018, pp. 3-4). The same source further states that before mentioned conformance level is a subset of VDML Metamodel Conformance (Sub-clause 2.2), but that it does not conform to VDML notation (Sub-clause 8) (OMG, Value Delivery Modeling Language (VDML, 2018).

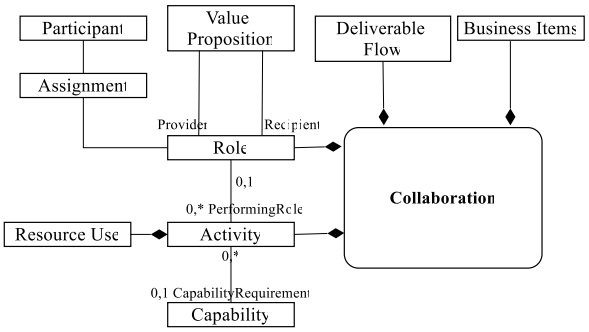


Figure 5: Collaboration sub-model, part of the VDML metamodel, Source: Author's own creation based on OMG VDML Specification (OMG, 2018)

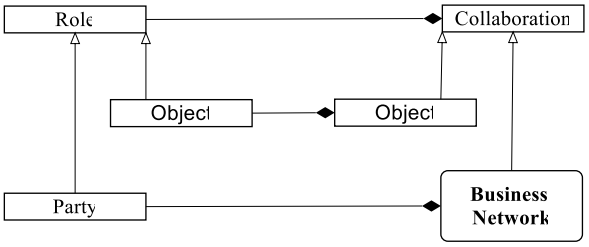


Figure 6: Business Network sub-model, part of the VDML metamodel, Source: Author's own creation based on OMG VDML Specification (OMG, 2018)

VDMbee is a Value Management Platform which monitors business trends and tries to improve them by, amongst other things, maping ideas into perspective of Value Delivery, and describing business models in OMG's Value Management Language (VDMbee, n.d. a). The platform allows insight regarding value creation and delivery, and prototyping business transformation in accordance with Value Objectives (VDMbee, n.d. b). It also uses Value Stream Maps for specification of Value Streams; artefacts which allow specification of value proposition and which are depicted as streams of activities (VDMbee, n.d. c). Value Proposition is also an integral part of Business Model Canvas for which VDMbee can create simulations (VDMbee, n.d. d). Taken into account the usefuleness of the methods offered by VDMbee platform, Value and Value Propostion class is also an important concept for this research.

In order to carry out the analysis, each of these before mentioned concepts should be identified in the selected DIH documents (conceptual mapping). Concept maps graphically represent knowledge in form of concepts and relationships between them, represented hierarchically, with the most general concept at the top, in order to allow meaningful learning (Canas et al., 2003).

In this research, each mapped concept was displayed in a table; the first column of the table is composed of before mentioned VDML classes important for the conformance analysis, and each literature source has one column for the examples of concepts and also a column for comments. Classes

'Value and Value Proposition', 'Activity', as well as 'Resources and Stores' of OMG Specification (OMG, 2018) were also added because they can be used later on for some other methods. Due to extensiveness of the table, only some classes and mapped concepts will be listed in this article. The first row of the table is reserved for ValueDeliveryModel class, which is DIH RMM, and the second row is reserved for VdmlElement class, which is DIH Model.

Following the illustration on Fig. 5, those classes and mapped concepts will be shown first. Collaboration class examples of the mapped concepts are the following: Micro- and small enterprises, Medium-sized enterprises, Mid-caps, Large companies (DIH customers) (Miörner et al., 2019b, p. 21); Regional cluster organisations, Cluster organisations from other regions, Regional government, Chambers of commerce, Trade associations, Enterprise Europé Network (EEN) local..., Innovation support organisations, Incubators, Vocational training organisations, Funding organisations, National government, Investors (Miörner et al.,, 2019b, p. 31); Internal human capital: Internal skills (employed/affiliated), Universities within DIH consortium, Business actors within the DIH, Public actors within the DIH consortium, Business actors within the DIH consortium; External human capital: Other DIHs outside the region, Universities within the region (not part of DIH), Universities outside the region, Business actors within the region (not part of DIH), Business actors outside the region, Business actors within the region (not part of DIH, Public actors outside the region, Public actors within the region (not part of DIH), Other DIHs within the region, and other DIHs outside the region (Miörner et al., 2019b, p. 28).

Role class inherent examples of concepts are the following: Knowledge provider, Technology provider, Knowledge recipient, Technology recipient; Policy creator, Funding recipient; and Infrastructure provider (DIH tangible role) (Miörner et al., 2019b).

After providing the examples of Role class concepts, examples of Community and Member class concepts will be provided, even though they are not shown on the Fig. 5. Examples of Community mapped concepts are the following: Micro- and small enterprises, Medium-sized enterprises, Mid-caps, Large companies (Miörner et al., 2019b, p. 21); Internal human capital: Internal skills (employed/affiliated), Universities within DIH consortium, Business actors within the DIH, Public actors within the DIH consortium, and Business actors within the DIH consortium (Miörner et al., 2019b, p. 28). By researching DIH literature, the inherent conclusion regarding concepts to be mapped in Member class would be for example: Individual employees within DIH enterprise and companies-especially the ones on executive positions making business decisions; Individuals at universities within DIH, and individuals in public bodies within DIH (Miörner et al., 2019b).

The examples of mapped concepts regarding Activity class are the following: educating, internationalisation (Miörner et al., 2019b); training, skill developing, business advising, helping with business plans, supporting scale-up and internationalisation, matching new firms with customers, testing and validating, and attracting funding for financing DIH activities, (Miörner et al.,2019b, p. 18).

For the reasons of brevity, only BusinessNetwork, Collaboration, Role, and Party classes from Fig. 6 concept examples will be listed next.

Examples of BusinessNetwork are the following: Regional cluster organisations, Cluster organisations from other regions, Regional government, Chambers of commerce, Trade associations, Enterprise Europé Network (EEN) local..., Innovation support organisations, Incubators, Vocational training organisations, Funding organisations, National government, Investors (Miörner et al., 2019b, p. 31); External human capital: Other DIHs outside the region, Universities within the region (not part of DIH) Universities outside the region, Business actors within the region (not part of DIH), Business actors outside the region, Business actors within the region (not part of DIH, Public actors outside the region, Public actors within the region (not part of DIH), and Other DIHs within the region, Other DIHs outside the region (Miörner et al., 2019b, p. 28).

Next, examples of mapped concepts of Collaboration are the following: Micro- and small enterprises, Medium-sized enterprises, Mid-caps, Large companies (DIH customers) (Miörner et al., 2019b, p. 21); Regional cluster organisations, Cluster organisations from other regions, Regional government, Chambers of commerce, Trade associations, Enterprise Europé Network (EEN) local..., Innovation support organisations, Incubators, Vocational training organisations, Funding organisations, National government, Investors (Miörner et al., 2019b, p. 31); Internal human capital- Internal skills (employed/affiliated), Universities within DIH consortium, Business actors within the DIH, Public actors within the DIH consortium, Business actors within the DIH consortium; External human capital- Other DIHs outside the region, Universities within the region (not part of DIH) Universities outside the region, Business actors within the region (not part of DIH), Business actors outside the region, Business actors within the region (not part of DIH, Public actors outside the region, Public actors within the region (not part of DIH), Other DIHs within the region, and Other DIHs outside the region (Miörner et al., 2019b, p. 28).

Role class mapped concepts inherent examples are the following: Knowledge/technology provider, Knowledge/technology recipient; Policy creator, Funding recipient, and Infrastructure provider (DIH tangible role) (Miörner et al., 2019b).

By researching DIH literature, the inherent conclusion regarding concepts to be mapped in Party class are the following: Regional Clusters, Governments, Chambers of Commerce, Trade Associations, Members of Enterprise Europé Network (EEN), Innovation support organisations, Incubators, Vocational training organisations, Funding organisations, Investors; other DIHs, Universities not in DIH, Business actors not in DIH, and Public actors not in DIH (Miörner et al., 2019b).

Last but not least, example of mapped concepts of Value and Value Proposition class is Technology transfer (Miörner et al., 2019b). Due to the extensiveness of the table created for conceptual mapping, only a part of it is shown in the Table 1 below.

Table 1: Conceptual mapping of DIH concepts onto VDML classes, Source: Authors' own creation

VDML concepts	Lit source 1	Lit source 1 comments
Participant	For example in a DIH or project: SMEs from region, Regional Incubators, Partners	- *whatever fills a role in collaboration (OMG, 2018)*
Actor	For example in a DIH or project: E-elarning platform, Project Manager, Communication Officer, Partners' points of contact, Library (database)	- *human or non-human participant (OMG, 2018)*
Person	For example in a DIH or project: Project Manager (specific person), Communication Officer (specific person), all the partners' points of contact (specific persons)	
Assignment	For example in a DIH or project: Meeting participation, Webinar participation	- *participant performs Activity through Assignment, which specifies how a Role is filled in collaboration (OMG, 2018)*
Value and Value Proposition	TT (Miörner et al., 2019)	

5 Conclusion

This article provided some insight in DT related novel organizational structure called DIH and its added value, mapped onto a VDML metamodel, in order to explore its suitability for RMM DIH, which can later on be used as a DIH benchmark, for DIH comparison, but also as a blueprint for information system architecture design.

Researchers used UML Model to represent Object of Modeling, which conforms to UML Metamodel; UML Metamodel conforms to MOF; object of modeling was a DIH system; DIH model representing DIH System was created as an UML model, and it conforms to DIH RMM; metamodeling was then extended by using VDML profile; VDS was an Object of Modeling; and VDSM is an UML profiled model, which conforms to VDML.

Conformance Analysis was implemented at the level of VDML Collaboration Modeling Conformance. In order to carry out the analysis, each of these concepts was identified in the selected DIH documents by performing conceptual mapping. Each mapped concept was displayed in a table; the first column of the table is composed of before mentioned VDML classes, and each literature source has one column for the examples of concepts and also a column for comments. Classes Value and Value Proposition, Activity, as well as Resources and Stores of OMG Specification (OMG, 2018) were also added because they can be used later on for some other methods. Degree of conformance is important for interoperability and systematisation of DIH catalogue.

The researches have established that it is possible to design DIH RMM, as a referent model of a value delivery system. The scientific contribution of this research is the methodology and increased knowledge about DIH, proposed design of VDML DIH metamodel as a value-producing system, and the proposal design of RMM DIH. The societal contribution is the possibility of practical use of the proposed VDML DIH metamodel as a conceptual framework for DIH modeling, and RMM DIH use was already explained. The research is valuable for enhancing synergy between different sectors, in order to contribute to the strengthening of national and also European economy.

Further research should be performed to add more detail to DIH RMM through additional DIH literature research and in-depth interview with DIH expert. The incompatibilities of concepts trough DIH literature review should be noted and the conclusion weather the incompatibilities' analysis provides foundation for the extension of the model should be made. Methodology for validating the model should also be established.

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The Role of Symbolic Capital Among Entrepreneurs in the Croatian Software Industry

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Abstract. *Drawing on Bourdieu's theory of capital, we present the results of research on the forms of symbolic capital of entrepreneurs and their conversions into economic, social and cultural capital. The research is industrially and spatially positioned within the software industry in the Republic of Croatia and is based on a qualitative methodology. Face-to-face in-depth interviews were held supplemented by observations. Empirical data were analyzed using the techniques of grounded theory. The results show that the software entrepreneurship is characterized by a wide range of symbolic resources that are valuable in the context of acquiring economic capital and cultural capital.*

Keywords. symbolic capital, Bourdieu's theory of capital, software entrepreneurship

1 Introduction

The *illusio* of market rhetoric (Pret, Shaw & Dodd Drakopoulou, 2016) favoring economic capital in the field of entrepreneurship has been gradually weakening. Consequently, entrepreneurial researchers have been refocusing to study the forms and relationships of different, tangible, and intangible resources in the entrepreneurial process. Among them, symbolic capital (Bourdieu, 1985) is certainly the most subtle and obscure resource manifestation with a still fragmented and poor empirical base in the area of entrepreneurship.

In this paper, we adopt Bourdieu's (1977; 1985; 1986) theory of capital to investigate the role of symbolic forms of capital among Croatian entrepreneurs in the software industry. More precisely, the paper presents the results of qualitative research on the forms of symbolic capital among entrepreneurs and their conversions into other resource manifestations (economic, social and cultural capital). After the conceptual definition of symbolic capital from the perspective of Bourdieu's theory, in the first part of the paper, the current knowledge about the role of symbolic capital in entrepreneurship is presented and research questions are formulated. The second part of the paper presents the methodology and results of the research and the conclusions and implications for practice.

2 Symbolic Capital in the Context of the Entrepreneurship Process

Bourdieu (1986) tends to dispel collective beliefs about capital as something purely economic and stresses that labor can be materialized in multiple forms. In this sense, in addition to economic capital (money and tangible assets), he conceptualises cultural capital (cultural goods and services, including formal education), social capital (acquaintances and networks) and symbolic capital (social recognition, prestige, reputation) (Bourdieu, 1986; Swartz, 1997; Fanuko, 2008; Desan, 2013). He also notes that it is possible to account for the structure and functioning of the social world only if capital is considered in all its forms and if one tries to understand the laws by which different forms of capital are changed into one another. Thus, Bourdieu (1986) holds that any form of capital can be converted into some other resource manifestation (Bourdieu, 1986, p. 84). For example, a high level of cultural capital (in terms of formal education and professional experience) can be transformed into symbolic capital manifested through social recognition and prestige, as well as economic capital (through financial investment in education) can be converted into cultural capital (Lam, Shaw & Carter, 2007; Shaw, Lam & Carter, 2008; De Clercq & Voronov, 2011). Such conversions are more or less overlapped and take place in all directions. They represent the struggle to improve or maintain positions of power within the social system and as such illustrate the fundamental mechanism of social reproduction (Bourdieu, 1986; Fanuko, 2008).

Symbolic capital is something that is "…another name for distinction - is nothing other than capital, in whatever form, when perceived by an agent endowed

with categories of perception arising from the internalization (embodiment) of the structure of its distribution, i.e., when it is known and recognized as self-evident" (Bourdieu, 1985, p. 731). It is not a special kind of capital, but it is the form in which the other forms of capital (economic, social, cultural) are perceived and recognized as legitimate (Bourdieu, 1985, p. 724; Fanuko, 2008, p. 17; Desan, 2013, p. 329).

Symbolic capital represents everything *what counts* within a specific social structure (or as Bourdieu (1977) calls it - field). In this sense, it essentially coincides with the concepts of status, respect, prestige, reputation, credibility, power, and honor (Gergs, 2003; Fuller & Tian, 2006; Stringfellow & Shaw, 2009; Townley, Beech & McKinlay, 2009). In this context, Bourdieu (1998) mentions an example of the concept of honor in Mediterranean societies. Such honor (i.e., symbolic capital) exists on the basis of common representations of members of the society derived from a common set of beliefs and collective labeling of certain patterns of behavior as honorable or dishonorable (Bourdieu, 1998, p. 47).

The specificity of symbolic capital is that it exists in the eyes of others. Unlike economic or cultural capital, it has no material, institutionalized, or embodied existence (Bourdieu, 1985; Siisiäinen, 2000). However, just like any other form of capital, symbolic capital can be accumulated and freely converted into other forms of capital. Its accumulation is as rational as the accumulation of economic capital and it takes time. Once symbolic capital is accumulated, it can reproduce itself, grow or decrease to a certain degree (Fuller & Tian, 2006, p. 291).

De Clercq and Voronov (2009a, 2009b, 2009c, 2011) consider symbolic capital in the context of conceptualizing the process of acquiring the legitimacy of newcomers entering a field of entrepreneurship. According to their conclusions, this form of capital acts as a mechanism that allows the entrepreneur to establish control over the perceptions of *self* in the environment. It implies a kind of capacity to create an image of *self* that is congruent with the essential characteristics of entrepreneurship such as risk-taking, disruption of existing harmony and "the heroic capability of wealth creation though novel commercial activity" (De Clercq & Voronov, 2009b, pp. 809-810). Access to symbolic resources enables agents to meet the expectation to *stand-out* from current field arrangements, which is achieved by imposing new business standards, innovating and other practices of disrupting the *status quo*. Such practices unknowingly or intentionally disrupt the existing structure of the field. They are a precondition for building entrepreneurial legitimacy in the social structure. Therefore, symbolic capital, along with cultural capital, is the best indicator of power in the field of entrepreneurship.

The role of symbolic capital in entrepreneurship is also addressed by Fuller and Tian (2006) who use the concept within the study of the nature of corporate social responsibility. Based on narrative analysis, the authors develop a classification of socially responsible business strategies ("taking", "sharing", "giving"). According to their findings, the accumulation of symbolic resources is directly based on the strategy of "giving". The mentioned strategy refers to rewarding employees, investing in the development of the local community and related socially responsible activities. The authors conclude that small businesses, which do not have significant economic and political power compared to large corporations, draw their source of strength from social relationships with their stakeholders. Such relationships, among other things, require the accumulation of a sufficient level of symbolic capital, especially in the later stages of the business life cycle.

Pret, Shaw & Dodd Drakopoulou (2016) examine the conversion nature of different forms of entrepreneurial capital in the creative industries. As they state, the symbolic resources are related to entrepreneurs' prestige, status and positive reputation. They are more powerful than other forms of capital because they create confidence in the quality of products and services and act as a base for social recognition of entrepreneurial action. Although obscure, they can be objectified in the form of formal awards and recognitions. The authors conclude that among all forms of entrepreneurial capital, symbolic resources are most susceptible to conversion into other forms of capital. Therefore, they are a particularly valuable resource form in the field of entrepreneurship.

Based on the previous theorizing about symbolic capital in the entrepreneurial process, in this paper we present research focused on understanding the role of symbolic capital among Croatian entrepreneurs in the software industry. Taking into account the conversion nature of capital, from the perspective of entrepreneurs, we examined the following research questions:

1. What forms of symbolic capital are used by Croatian entrepreneurs in the software industry?

2. What conversions of symbolic capital are carried out by Croatian entrepreneurs in the software industry in order to acquire economic, social and cultural capital?

3 Methodology

In order to reach a deeper understanding of the examined phenomenon, the research is methodologically based on a qualitative approach. Primary data were collected through observations and in-depth interviews with 77 participants from 70 companies. The final sample included entrepreneurs from 11 counties in different parts of the Republic of Croatia. The selection of interview participants was based on the theoretical sampling principle (Patton 2002; Charmez, 2006). The interviews were conducted in-person at the business location of the company (39 interviews), in a nearby cafe (15 interviews), via Skype

(14 interviews) or at the researcher's workplace (2 interviews). In order to protect the anonymity of the participants and the confidentiality of the data, each participant was given ethics declarations about using the data collected in the field research. The average duration of the interview was 66 minutes. Every interview had been recorded by audio recorder and credible transcripts were produced.

Among other things, the research examined the component of symbolic capital related to the entrepreneur's media exposure. Therefore, in addition to the primary data, secondary qualitative data were collected. They include information on the appearance, timeliness, coverage and content of the company's website and the appearance and content of news about the company and the entrepreneur in online media, information on the activities of entrepreneurs on social networks, participation and/or organization of conferences and other gatherings in industry and business, data on receiving awards and recognitions of the company and other. The Internet was used as a source of secondary data. All found qualitative content for each entrepreneur was stored and read and a report on available qualitative secondary data was compiled. Based on the report, the intensity of media exposure of entrepreneurs and companies was estimated.

Data analysis was based on analytical procedures of grounded theory (Charmaz, 2006; Glaser & Strauss, 2012; Corbin & Strauss, 2015). Accordingly, initial, focused, and axial coding were performed (Charmaz, 2006). In the initial coding phase, *raw* empirical data were grouped into segments and each segment was marked with a code or label that presents the meaning of the data set. In the process of focused coding, the most significant and common codes were identified and they were synthesized into particles of a higher level of abstraction (so-called categories) (Charmaz, 2006). Finally, axial coding was applied to reconnect the data by identifying the links between the categories and the links between the data within each category (Corbin & Strauss, 2015; Šmaguc & Vuković, 2016). The entire process of data collection and analysis was guided by constant comparison (Charmaz, 2006). It is a technique that involves an iterative "circular comparison of previously and re-collected empirical material" with the aim of finding similarities and differences in the data (Šmaguc & Vuković, 2016, p. 6). Table 1 illustrates an excerpt from initial and focused coding.

4 Results

4.1 Forms of Symbolic Capital

According to the results of the data analysis, Croatian entrepreneurs in the software industry employ several different forms of symbolic capital (Table 2).

Market reputation, reputation in the local community and the media exposure associated with these reputations are manifestations of symbolic capital that are characteristic of the largest and financially strongest companies. These are resources accumulated on the basis of the company's expertise, top quality products and services, and the strength and visibility of the company's customers (Zimmerman & Zeitz, 2002). Accumulation of these resources is also contributed by the size of the company, attractive location, luxurious office space (Zimmerman & Zeitz, 2002; Clarke, 2011) and the active involvement of entrepreneurs in local community events (Zimmerman & Zeitz, 2002). Examples of such engagement are the proclamation of philanthropy by sponsoring local activism in industry (Suchman, 1995; Zimmerman & Zeitz, 2002), participation in media-covered social events, and collaboration with the political and academic fields. These practices contribute to the positive media reputation created by the publication of inspiring entrepreneurial stories. This in turn further strengthens the market reputation by shaping the legitimacy of the company in the eyes of potential customers, business partners and future employees (Deeds, Mang & Frandsen, 2004).

In relation to the market reputation are symbolic resources in the form of **trust of banks, investors and business partners**. Trust most often stems from a built market reputation, the growth of business revenues and the "financial health" of the company. As Ivan (40-50, Varazdin) points out, stakeholder trust facilitates new acquisitions of financial and other resources, stimulating further expansion of the company:

Now the situation is that we are negotiating with the banks in the way we say… we have a need for so much and so much, four banks are looking for an offer and put together an offer in 2-3 weeks… If creditworthiness is maintained then in principle the price of capital is corrected and reduced ... and be so affordable. Then what people are saying about some percentages, fortunately for us, is no longer so crucial…. And then we built that kind of relationship with the bank… our business is a sufficient guarantee for you and don't ask for any other collateral outside the company itself. (Ivan, 40-50, Varazdin)[1]

Market reputation subtly overlaps and intertwines with the recognition of entrepreneurs in the industry. **Reputation in the industry** is the result of entrepreneurial practices used to engage industry specific cultural and social resources in order to produce symbolic capital. Examples of such practices are innovating, highlighting the captivating and rare expertise of key employees, sharing specific knowledge through articles, blogs and lectures, and activism within the industry associations.

[1] The names of the interviewees were replaced by pseudonyms.

Table 1. Excerpt from initial and focused coding

Symbolic capital (Alen, 34, Zagreb)		
Interview excerpt	**Code**	**Category**
We are trying to do some things like writing blogs, case studies and columns for external portals. We cooperate with various media houses so that our knowledge that we create on these projects can be seen outwards.	blogs and columns	reputation in the industry based on cultural resources
…So, if I could say one marketing pillar we have is knowledge sharing… through lectures, seminars…	knowledge sharing	reputation in the industry based on cultural resources
We have somewhere around a dozen awards, international. So ... for the portals and mobile apps we've been working on.	awards	other forms of symbolic resources

Own research.

Table 2. Forms of symbolic capital with frequencies of associated codes

Forms of symbolic capital	**Number of firms (N=70)**	**Code frequency**
Market reputation and local recognition		
- prestigious clients	10	14
- recognizability in the local field	14	27
- materialized cultural capital*	14	-
- media appearance (market) **	24	-
Stakeholder trust		
- trust of banks	1	2
- trust of investors	5	6
- trust of partners and clients	28	39
Reputation based on cultural resources and active engagement in the industry		
- knowledge sharing	35	50
- expertise	27	44
- innovations	7	11
- organization of events	18	26
- activity in associations and competitions	14	23
- media appearance (industry) **	36	-
Other forms of symbolic capital		
- awards and recognitions	31	42
- media appearance (other) **	68	-

** Identified through observations.*

*** Identified through secondary data sources.*

Own research.

Table 3. Conversions of symbolic capital with frequencies of associated codes

Conversions of symbolic capital		
Symbolic capital	Economic capital (f=51)	* Visibility as a source of customers * Finding more profitable customers based on reputation
	Cultural capital (f=16)	* Reputation as a foothold of access to new quality employees
	Social capital (f=8)	* Customer trust and reputation in the function of strengthening networks

Own research.

Whether ideological or strategic in nature (Suchman, 1995; Drori, Honig & Sheaffer, 2009) these practices create media visibility of entrepreneurs, not only in electronic publications thematically related to the industry, but also in the wider media. In this way, the social recognition gained within the professional community spills over into the field of markets and other fields.

Finally, symbolic capital can also be manifested in **awards and recognitions**. Yet this symbolic form contributes the least to the acquisition of other forms of capital. Moreover, as Andrija (30, Virovitica) testifies, the significance of the awards can be reduced by their devaluation by the constituents who award them:

…We were nominated last year that we didn't even know, which was shocking to me ... for the best micro-entrepreneur in the Republic of Croatia by the Ministry of Entrepreneurship… So, it was… at the national level. We were in the top three at the end of the election, that no one even informed us… So, it was that some event, all the ministers were there,…,some kind of entrepreneurship promotion, this, that… So much about what those awards [mean]*… what is the level at which they are awarded and what is the mode of communication of the value of that recognition.* (Andrija, 30, Virovitica)

4.2 Conversions of Symbolic Capital

According to the results of the analysis, the entrepreneur's symbolic capital is easily converted into other forms of capital (Table 3). Conversions of symbolic capital into economic capital are the most common, and are reflected in exploiting the market reputation and reputation in the industry in appropriating new customers, finding more profitable jobs and penetrating more attractive markets. This is an advantage in which, as Mladen (42, Split) says, *you don't have to look for a client, the client finds you*, and adds Vedran (37, Zagreb), *price is no longer a subject of negotiation* - a symbolic advantage that can be easily converted into economic capital i.e. financial growth of a cognitively recognized firm.

In addition to providing new business opportunities, a company's reputation is related to the process of finding new employees. In fact, it gives this quest a symbolic stretch since an established player is usually perceived as an attractive employer. It is about the conversion of symbolic capital (industry reputation) into cultural capital (attracting quality employees) (Zott & Huy, 2007) - a practice that emerges in the perception of a company as an attractive employer. Such a company finds new talents more easily and, as Branka (43, Zagreb) says, *it can act more selectively in this process*, which is important in the context of the labor shortage issues in the industry.

Although symbolic capital is easily transformed into economic and cultural resources, there is not much evidence of its conversion into social capital. Specifically, the practice of converting symbolic capital into social capital has been identified in only a few cases, and it relates to the contribution of customer trust and market reputation to creating and strengthening informal entrepreneurial networks (Deephouse & Carter, 2005; Pret, Shaw & Dodd Drakopoulou, 2016). As Bruno (34, Pula) suggests, such networks can be significant in the context of gaining financial benefits for a company, which is in fact a form of (indirect) transformation of symbolic capital into economic capital:

I am currently working as the organizer of the European Wordpress Conference, which will be held in Vienna this year. So this is my time that I donate .... And now… I don't do it for the sake of interest, but people have to understand that such things eventually bring…contacts and then they later result in new recommendations. (Bruno, 34, Pula)

5 Conclusion and Implications

Croatian entrepreneurs in the software industry are characterized by a tendency to accumulate a wide range of intangible, symbolic resources that are valuable in the context of acquiring economic capital and human capital. These resources are idiosyncratic (Barney, 1991), and they are the product of economic (financial strength), social (community networking), cultural (expertise, elite business space), and symbolic resources that build the firm's existing bundles of capital. In this sense, the results imply recommendations for new entrepreneurs in the industry. The practices of early accumulation of symbolic capital by engaging cultural capital create the outlines of the visibility of (potential or new) entrepreneurs in industry. Such visibility replaces the financial resources needed to invest in traditional marketing and is a foothold of further accumulation of valuable forms of capital. Therefore, new entrepreneurs in the industry need to be encouraged to get involved in sharing knowledge by writing blogs and lecturing at conferences, and to participate in the organization of events and in the activities of industry associations. As stated, such practices contribute to building the firm's initial resource base. However, they also potentially stimulate the acquisition of entrepreneurial and managerial knowledge and skills by the technological ethos, helping him to cope with the world of entrepreneurship.[2]

[2] This paper is based on the research conducted as part of the doctoral thesis.

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Good Practices and Tools for Digitalization of SMEs in the Natural Fiber-based Value Chains

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Abstract. *Digitalization has become an important part of our daily lives. The benefits of its introduction into business are reflected in many success stories. On the other hand, it is increasingly recognized that small and medium-sized enterprises (SMEs) play a major role in contributing to the economy. However, there are various challenges that these companies face in their digitalization process. In our research, we have identified these existing challenges and good practices and analyzed them with SWOT analysis. The results showed that many different funding schemes and assistance are available for SMEs. The main disadvantages of this assistance are the lack of support during the application process, the large number of conditions and the unadjusted funding.*

Keywords. digitalization, SME, good practices, tools, SWOT analysis, natural fiber-based value chain

1 Introduction

Nowadays, the term digitalization is mentioned and used in a large number of areas. At the same time, the economic and innovational potential of small and medium-sized enterprises (SMEs) operating in different industry sectors is recognized increasingly by several European projects and initiatives. Various reports show that they can influence and contribute to a country's economy significantly in terms of innovations, employments, and economic growth (Organisation for Economic Co-operation and Development (OECD), 2017). One of the possibilities to enable these companies to develop further, grow, and operate successfully is the introduction of digitalization in their business process.

The establishment and usage of digitalization tools may accompany some issues and barriers, especially in less digitalized companies. Different indicators and measures are used to assess the digitalization level of countries. One of the most used is the Digital Economy and Society Index (DESI), which measures the level of digitalization in six different areas (connectivity, digital skills, use of Internet services by citizens, integration of digital technology by business, digital public services, and research and development of ICT) (European Commission, 2019). Existing measures do not provide an insight into the digitalization level, good practices and tools used within SMEs in the natural fibers' domain, so we focused on this area as part of this research. The study, which was conducted within the EU-project Smart SME's, includes four regions/countries from the Alpine region - Baden-Württemberg region (Germany), Lower Austria, Trentino (Italy) and Slovenia, from which we obtained existing tools and good practices and included them in the SWOT analysis. A SWOT analysis consists of four areas that describe the strengths, weaknesses, opportunities, and threats of a possible introduction of good practice into wider use among SMEs in the natural fiber value chain (VC). This value chain represents a list of activities performed within SMEs in the selected natural fiber domain (e.g. the wood value chain includes activities such as sawing, milling and production of wooden products).

In the following section, the related research from the area of digitalization in SMEs is presented, followed by a section on the methodology used in the implemented research. Section 4 includes examples of good practices of integrating digitalization into companies, and the final section describes the SWOT analysis of the presented good practices in the conclusion of the paper.

2 Related Work

Several studies have already been published analyzing the challenges and opportunities that the Industry 4.0 revolution can bring to SMEs in different sectors (Matt, Modrák, and Zsifkovits, 2020; Autio, 2017).

Ezzel and Atkinson performed a benchmarking study of countries' policies and programs aimed at supporting manufacturing SMEs in their business growth, as well as research and development activities (Ezell and Atkinson, 2011). Their results provide a detailed overview of mechanisms implemented in different countries, such as technology acceleration funding or programs and practices, connections to and for SMEs, and involvement of support agencies.

Several examples of SWOT analyses from similar fields can be identified. For example, Falcone et al. performed a SWOT analysis of the strategies employed in the Italian forest sector to transition towards a circular bioeconomy (Falcone et al., 2020). The results indicate the importance of investments in forest planning tools, supporting entrepreneurship programs and innovations within the value chain. As the biggest weaknesses and threats, the authors identified inconsistent policy frameworks, lack of skilled professionals, excessive bureaucracy, and lack of long-term planning by government bodies.

Different ideas and approaches behind the Industry 4.0 paradigm and their impact on Bulgarian SMEs are presented by (Moraliyska, Antonova, et al., 2018). A SWOT analysis was performed on Bulgaria's readiness for Industry 4.0 focusing on the manufacturing industry. According to the analysis, the lack of research and development funds or dedicated programs for job training, as well as the high competitiveness of the sector, are the most significant weaknesses, while national and European Union policy initiatives and the growing international market present the most important advantages for Bulgarian manufacturing SMEs.

On the other hand, Issa, Lucke and Bauernhansl studied the effectiveness of approaches introduced in Germany to connect their manufacturing SMEs with specialized research institutions called "I4.0 test environments" (Issa, Lucke, and Bauernhansl, 2017), which highlighted the information deficit between SMEs and test environments as the biggest issue. Based on this finding, the authors proposed an approach to facilitate their collaboration. Their approach includes a competence-based matching mechanism between SMEs and test environments, funding schemes initiated by the government, and developing mechanisms for evaluating the success of funded SME projects.

3 Methodology

Our research methodology consisted of two steps:

1. Identification and analysis of existing examples of knowledge transfer on digitalization to SMEs, as well as identification of good knowledge transfer practices and tools, and

2. Performance of "bottom-up" SWOT analysis on the identified knowledge transfer practices and tools identified in the first step.

In the first step, existing examples of knowledge transfer on digitalization to SMEs were analyzed with regard to the four dimensions in which knowledge transfer is mostly required:

- **Skills of the staff** - refers to activities, such as workshops or training for employees, which aim at improving the employees' skill set in working with digital technologies,

- **Methods** - refers to different mechanisms and endeavors for sharing the "know-how" about the digitalization process to SMEs,

- **Technologies and tools** - refers to various Information Technology solutions, such as platforms or websites, used to share knowledge on digitalization, and

- **New value generation** - which refers to innovative approaches, such as using Machine Learning or Blockchain technologies, which generate new value and knowledge for participants.

Based on these four dimensions, existing good practices and tools were also identified for implementing digitalization in SMEs by region/country.

The collected practices and tools for the digitalization of SMEs bring various benefits or impose limitations when implemented in different countries in the Alpine region. To further study the results of their implementation in a given country/region included in our research, and identify both their benefits and drawbacks, an individual SWOT analysis has been performed on each practice/tool presented in Section 4. The aim of our approach was to use the insights on the strengths and weaknesses of the country/region-specific practices/tools to draw more general conclusions about their characteristics necessary to perform a cross-border SWOT analysis of digitalization practices and tools.

4 Good Practices, Tools and Examples of Knowledge Transfer Within a Region/Country for the Digitalization of SMEs

A good example of knowledge transfer which we identified in the Baden-Württemberg region (Germany) is The Digitalization Premium Support Project, funded by the Ministry of Economic Affairs, Labour, and Housing of Baden-Württemberg, which supports SMEs with subsidized loans in introducing new digital solutions and improving information security. It has the potential for knowledge transfer in all four dimensions. It can be used to promote training for employees (help them acquire ICT software and hardware knowledge), to help introduce new digital solutions in production processes, products, and services, and bring knowledge for renewal of strategies and organization, as well as bringing added value to bio-based and other value chains. In addition to this example of knowledge transfer in the Baden-Württemberg region, we identified three other examples shown in Fig. 1. Good practice of successfully digitalized business processes in Baden-Württemberg comes from a carpentry company

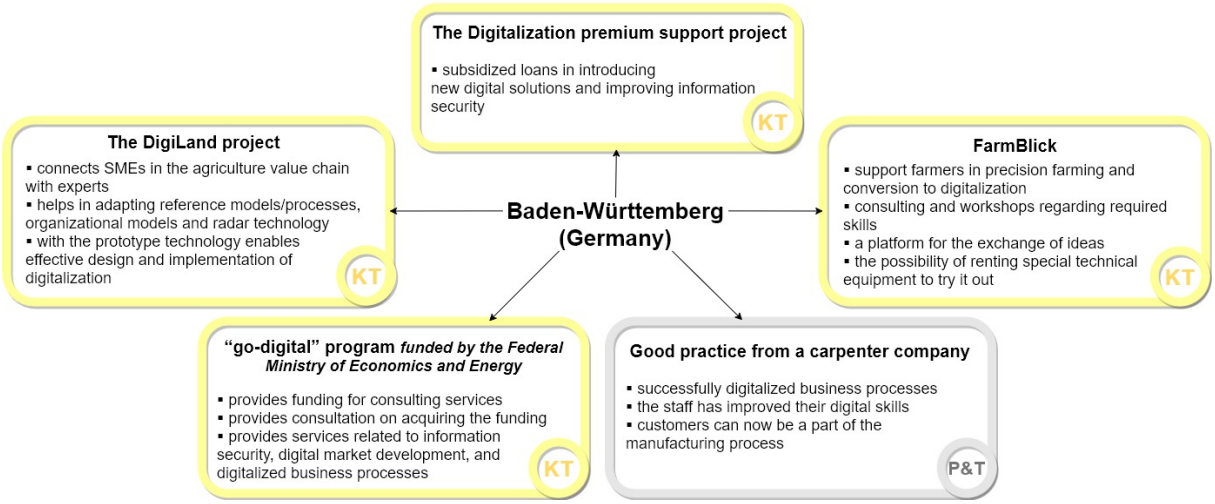


Figure 1. Identified good practices, tools (P&T) and examples of knowledge transfer (KT) within the Baden-Württemberg region.

that has largely digitalized its business processes. The staff has improved their digital skills and the customers can now be a part of the manufacturing process. Customers can choose preferable materials through video, and employees can track their working time through a mobile app. Due to the digitalization of all customer and production data, the data can now be accessed at any time.

Fig. 2 shows the identified good practices and knowledge transfer in the Trentino region. There, we find The Chamber of Commerce, which provides the "Punto Impresa Digitale" service to SMEs. This service helps to promote the digitalization culture and dissemination through the creation of a network of organizations, and assists enterprises in the digitalization process through educational events, workshops, and mentoring support. In the same region, several hubs participate to assess the level of digitalization of participating SMEs and evaluate possible strategies to optimize their internal processes. They organize web-conference training, provide advice on the implementation of technologies to increase digitalization, and provide SMEs with vouchers to improve and implement innovative ideas. A good example from this region is a medium-sized enterprise in the energy sector. The enterprise has implemented advanced Building Information Modeling (BIM) using Digital Twins technology, with the support of the national and local funding opportunities. After implementing this, the enterprise was able to avoid project and mounting mistakes during the implementation of the product, and furthermore, to decrease the time between the design and the delivery of the product, increase precision in the offer phase, as well as reduce waste.

In Lower Austria, one of the good examples of knowledge transfer is the KMU Digital program from the Austrian Digitalization Initiative, which helps SMEs to analyze digital trends, opportunities, and risks, helps them to determine the status quo in e-commerce and information security, and assists them in obtaining subsidized consulting and assistance in implanting the digitalization strategy. Another example from Lower Austria is The House of Digitalization, which connects SMEs with main IT knowledge providers in the region through specific IT seminars, and offers assistance in finding partners. It also offers the option of crowdsourcing in order to contribute to ideas for potential solutions.

An example of good knowledge transfer in Slovenia, also seen in Fig. 3, are the so-called Digital Vouchers provided by the Slovenian Enterprise Fund. Vouchers are designed to increase the level of digital competences and skills of staff through education and training vouchers. They contribute to the development and implementation of new technologies and tools, and improve innovative project ideas. A detailed description of the vouchers can be found in Section 5.4. A Slovenian company operating in the wood value chain can be considered as a good practice of using existing financing, as it received funding from SPIRIT Slovenia for two of their projects. The first project focuses on digital modernization of the company, with the goals of developing and upgrading e-business elements through improved electronic exchange between partners, website, and web-shop upgrade, as well as staff training. The second project focuses on the optimization and improvement of business processes related to business aspects of wood processing (administration, HR and finances, manufacturing, commerce).

5 SWOT Analysis of Collected Good Practices

The identified good practices and examples presented in Section 4 share some common characteristics, even

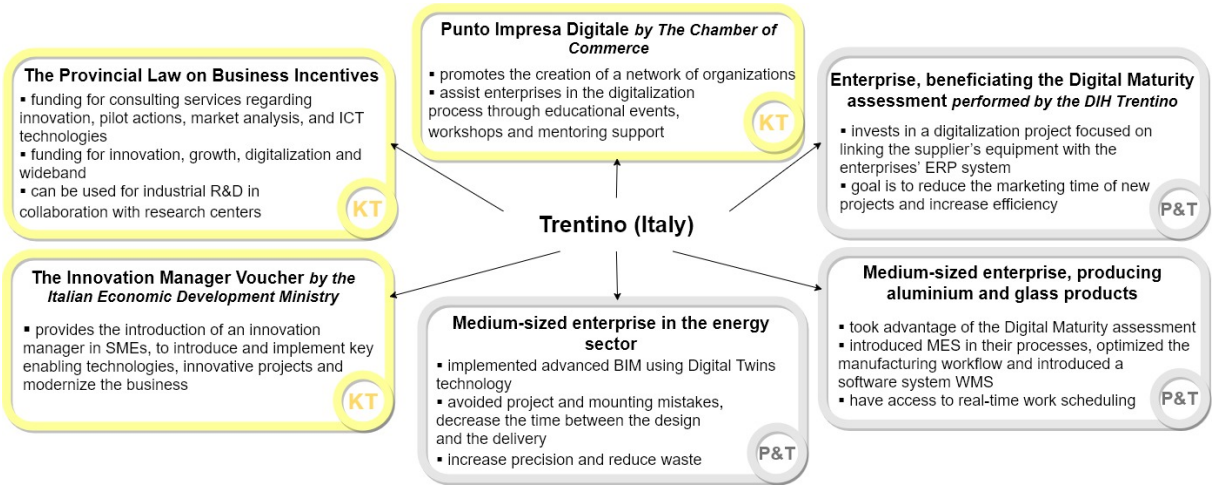


Figure 2. Identified good practices, tools (P&T) and examples of knowledge transfer (KT) within the Trentino region.

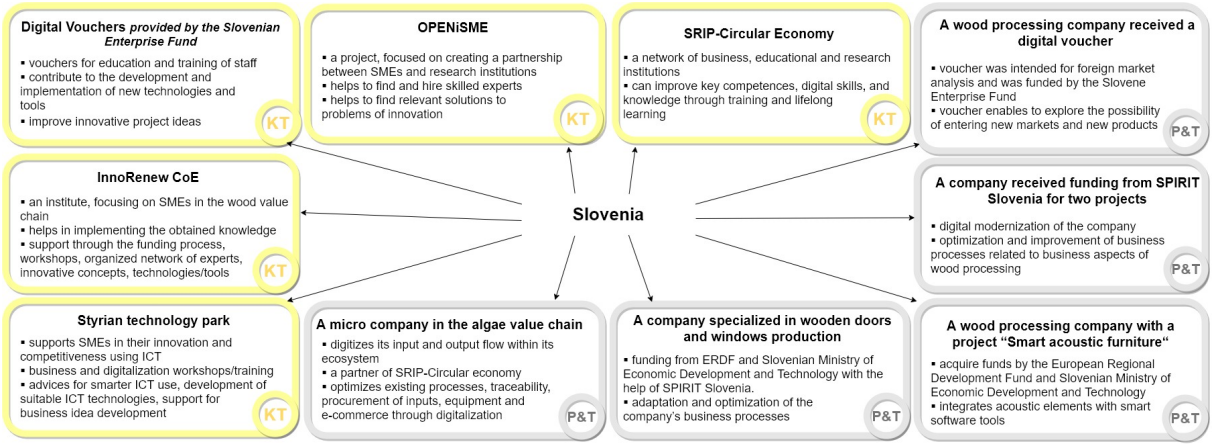


Figure 3. Identified good practices, tools (P&T) and examples of knowledge (KT) transfer within Slovenia.

though they are found in different countries/regions. Furthermore, varying benefits and drawbacks can be observed in their implementation in SMEs. An initial general analysis of all collected practices and tools indicates that their positive and negative effects are highly influenced by their origin. Therefore, before further studying the characteristics of the collected practices and tools, we grouped them according to their type of origin into three categories with the following characteristics:

1. **Government-level practices and tools** - national and/or local government initiatives focusing on developing a support framework for the digitalization of SMEs through regulations and public funding schemes,

2. **Research center-level practices and tools** - incentives and programs offered by research institutions, focusing on providing support to SMEs throughout their digitalization process through workshops, consulting services and active project partnerships, and

3. **Private sector-level practices and tools** - projects and activities carried out by the private sector, with a focus on networking and the dissemination of the "know-how" regarding the digitalization of SMEs.

It is important to note that the relationship between the government, research centers and private sector SMEs is not necessarily mutually exclusive. This means, for instance, that some strengths of the government-level practices (and the government itself) can help in resolving weaknesses and threats, which appear with practices on the private sector or research & development levels, and vice-versa.

5.1 Government-level Practices and Tools

Usually, within every country, the national and local governments are those who have the widest range of possibilities to create a favorable environment for SMEs. In generating success and added value, SMEs depend on the availability of resources necessary for their business, which can be in the form of finances,

investments, knowledge networks, or similar resources (Organisation for Economic Co-operation and Development (OECD), 2017).

Our research on the included Alpine region countries/regions indicates that the national and local governments are highly supportive of initiatives related to the digitalization of SMEs operating in the natural fiber-based value chain. Specifically, in each analyzed country/region, there is at least one agency initiated either by the national or local government, dedicated as the "go-to-place" for SMEs included in the digitalization process. The baseline for each government-level digitalization practice and tool is the official national digitalization strategy (Mărcuț, 2017), which is, nowadays, established in most European countries. Based on this strategy, national and local governments are able to introduce support mechanisms and develop specialized frameworks to help SMEs throughout their digitalization efforts.

Besides funding schemes and dedicated policies, governments and their agencies can also develop mechanisms and organize events for informing SMEs and raising their awareness about the resources and options available to help them carry out the digitalization process since the lack of such information is often one of the strongest inhibitors of SMEs' digitalization. Some common examples of such government-level practices and tools identified in general, as well as through our research, are:

- Dedicated agencies that offer access to direct funding schemes and projects financed exclusively by national/local public funds (e.g. Digitalization Premium in Baden-Württemberg),
- Digitalization-oriented projects (co-)financed by the European Structural and Investments Fund (or any other European dedicated agency),
- Vouchers for helping SMEs in their digitalization undertakings (e.g. digital vouchers in Slovenia).

Fig. 4 presents the results of the SWOT analysis performed on the identified government-level practices and tools from all four involved countries. The analysis shows that government-level practices and tools create a number of digitalization possibilities for SMEs, especially regarding the funding of their digitalization-oriented projects. By using government funding opportunities, SMEs can enjoy different benefits, such as increased market share/recognition, income, innovative products, and so on. Government-issued policies can help SMEs as a guideline to accessing available resources and steps necessary in their digitalization efforts (Autio, 2017). They can also present a hurdle if they require too much administrative effort from SMEs. It is often the case that SMEs perceive government policies as inattentive to the actual market developments and their business needs, which results in SMEs not taking advantage of the potential opportunities offered by government initiatives (Minh and Hjortsø, 2015).

One of the strongest backbones of the government-level practices is the higher transparency and precise definition of terms and conditions for all participants, required since they are based mostly on public funding. However, it is important to be careful when specifying these conditions, as they are sometimes too restrictive for smaller SMEs, which is especially the case for the natural fiber-based SMEs. In these cases, the exhaustive preparation of documents necessary to apply for government-funded projects often generates additional administrative costs with questionable cost-efficiency, and without any assurance that, in the end, a given SME will receive the funding.

In general, one of the biggest threats to government-level practices and tools is the insufficient knowledge support for SMEs, as government agencies often invest limited efforts into informing SMEs about the funding opportunities and precise conditions, how to apply for funding, which is a possible pitfall, and this can result in a number of incorrect applications caused simply by their misunderstanding of the procedural steps. In addition, public funds are available to a wider range of national/local SMEs with the same goals. This creates an increased competition between SMEs but also decreases the chances of receiving the funds, which might discourage some SMEs from applying or indulging in their digitalization projects in the first place.

5.2 Research Center-level Practices and Tools

Research centers represent an environment in which the knowledge and interests of universities and SMEs are brought together to generate new value for both parties. In recent years, an increasing number of countries have recognized the potential of research centers in overcoming challenges arising in both academia and industry. A number of research centers and innovation hubs can be found in the countries and regions of the Alpine region included in this research, such as the Kompetenzzentrum Stuttgart Mittelsland in Germany, House of Digitalization in Lower Austria, or the InnoRenew CoE in Slovenia. As a mediator, research centers enable SMEs to access the knowledge and research practices of universities, while enabling universities to bring their research ideas to the market and implement them in practice through partnerships with SMEs. Such organizations support SMEs in their digitalization efforts free-of-charge by providing financial, marketing, and operational information through discussion platforms, workshops, consulting services, partnerships in applying for funds, and similar. Various events organized and carried out by research centers bring the most opportunities for SMEs to improve their employees' digital skills, which is an important

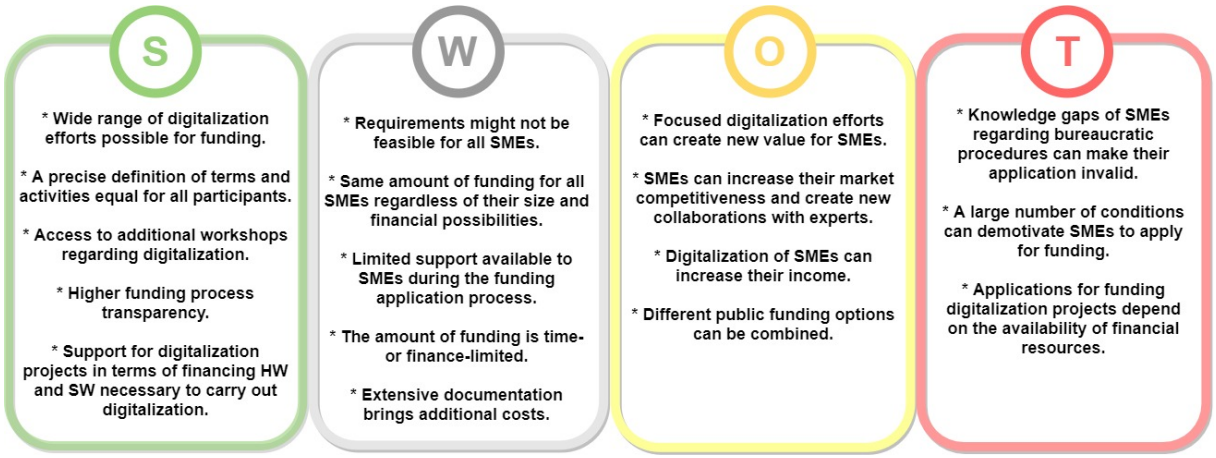


Figure 4. SWOT analysis of government-level practices and tools for Alpine region countries.

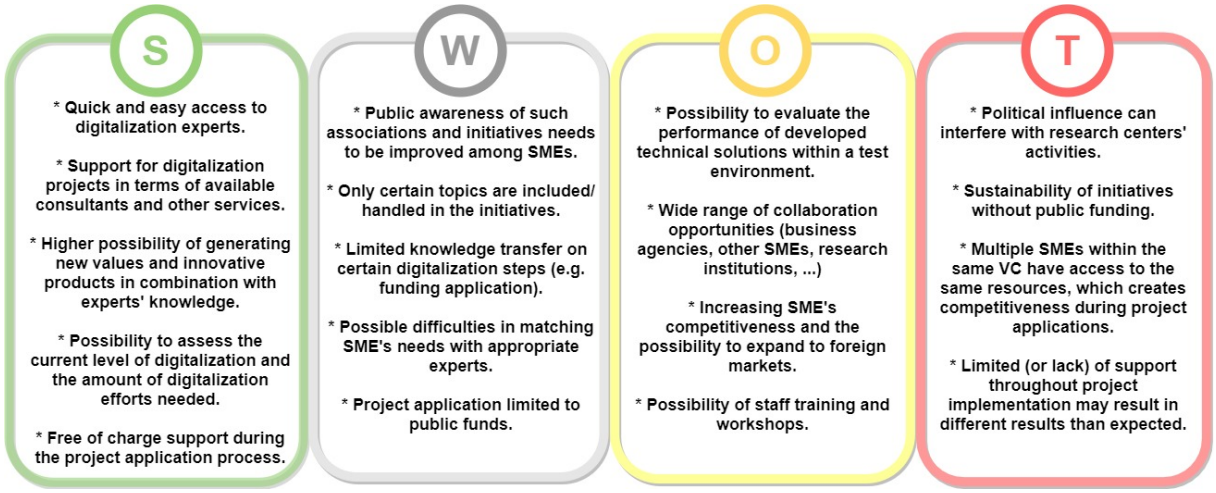


Figure 5. SWOT analysis of research center-level practices and tools for Alpine region countries.

starting point in successful digitalization projects.

As shown in Fig. 5, research centers achieve their greatest advantage in creating networking opportunities for SMEs (especially those in the rural areas), which can then lead to new innovations (Minh and Hjortsø, 2015). By building networks of contacts with the necessary domain expertise, SMEs can reduce the risks and costs (administrative or any other) of their digitalization process greatly. The intermediary role of research centers helps SMEs to build their knowledge networks, as well as provide them with the necessary information related to available funding schemes and market information. In this way, research centers disseminate the knowledge necessary to SMEs, thus reducing their costs for researching the required information on their own (Kirkels and Duysters, 2010). Through such direct interaction with researchers and experts, SMEs can receive the valuable knowledge necessary for innovations and further improvements enabled through the digitalization (Collier, Gray, and Ahn, 2011).

The result of bringing SMEs and universities together may not always be as successful as expected, mainly because of the differences in their interests and "cultures". Being research-oriented, the universities are more focused on performing scientific research for their own purposes, which can take years and/or require many adaptations before it can be implemented in practice by SMEs because it does not meet SMEs' needs (Cannarella and Piccioni, 2005). Also, the practices identified in our research show that some national/local government policies and strategies may inevitably affect the activities of research centers and innovation hubs (for example, national digitalization strategies focusing on only certain industries and areas in a given time period). Being co-financed (or entirely financed) by national or local governments can also present a significant risk to the operations of research centers.

5.3 Private Sector-level Practices and Tools

Lastly, within the analysis, we identified one example of good practices and tools provided to SMEs by a private enterprise. This was a start-up company FarmBlick from Baden-Württemberg, presented in Section 4. In addition to providing SMEs with direct access

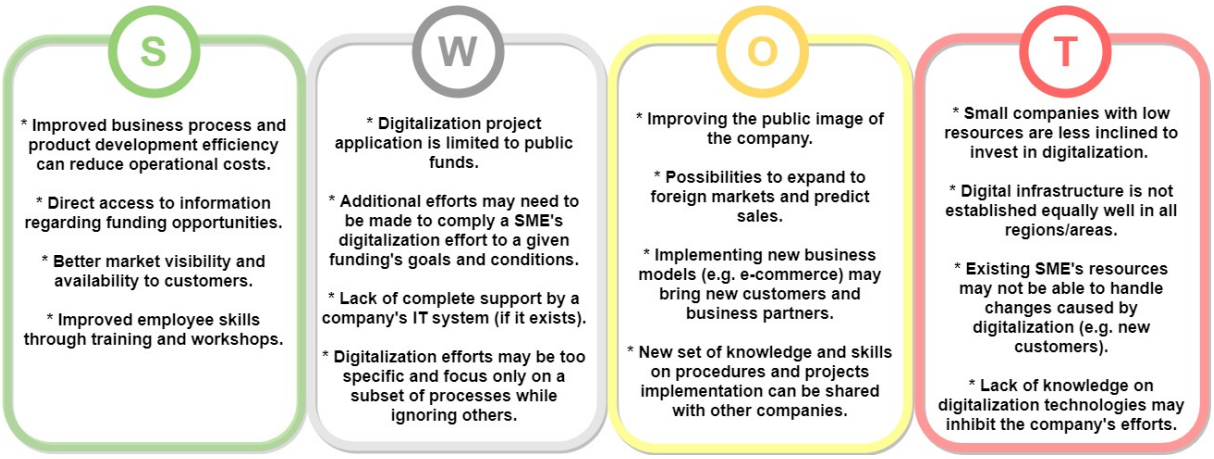


Figure 6. SWOT analysis of private sector-level practices and tools for Alpine region countries.

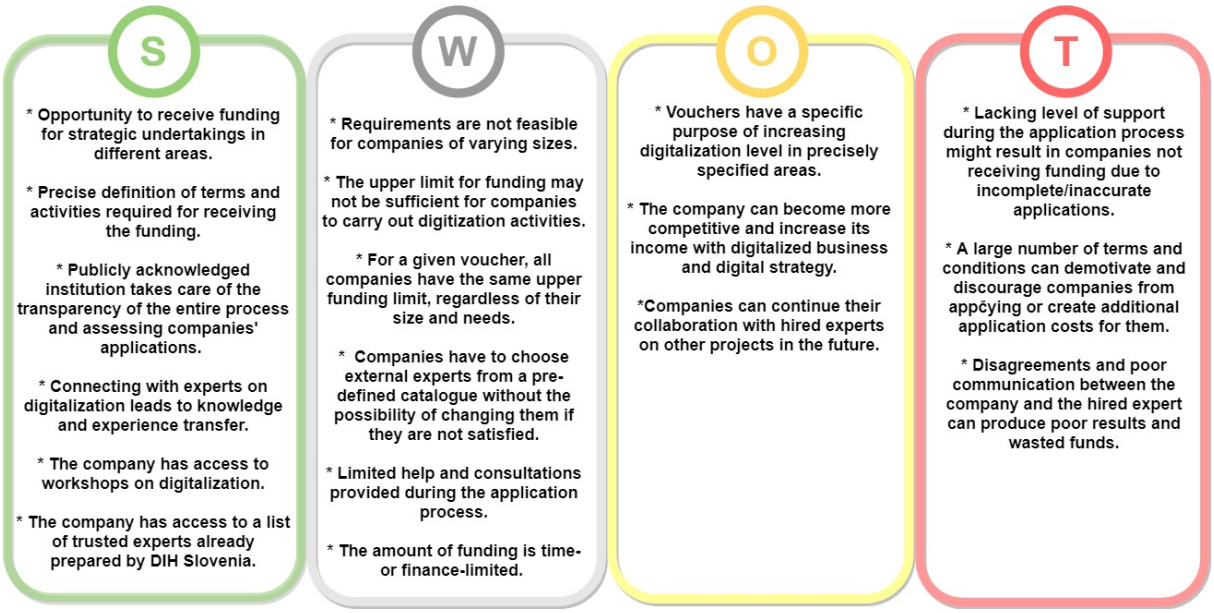


Figure 7. SWOT analysis of Digital vouchers in Slovenia.

to targeted solutions, such collaborations could lead to other opportunities, such as better market visibility, and implementing modern business models. Furthermore, they provide an opportunity for formalized cooperation between SMEs, although such formal cooperation was not identified in our analysis. Other strengths, weaknesses, opportunities, and threats posed by such a form of cooperation are presented in Fig. 6.

Despite the potential for cooperation between SMEs and private companies, our research reveals that such solutions are not common among the analyzed SMEs in the Alpine region. Most SMEs operate with limited resources, investing mainly into day-to-day business, and are often dependent on public funding, revealing the major downside of private sector-level practices and tools. Furthermore, the efforts for digitalization might be too specific and focused on a subset of processes, weakening the digitalization efforts of SMEs.

5.4 An Example of SWOT Analysis

An example of knowledge transfer in Slovenia, digital vouchers were analyzed using SWOT analysis, as shown in Fig. 7. The analysis shows that their strengths are in the field of the possibility of obtaining funding, in the detailed requirements for their acquisition, in the possibility of connecting with experts and professionals, and so on. They also show opportunities in the field of exact goals, and are aimed at enabling companies to be more competent and have larger incoming in the future. One of their weaknesses is that they are not achievable for companies of all dimensions. Especially small companies may have a problem, for example, in complying with the requirement that 20 % of workers must be included in the training, and, as a threat, there is a possibility that funding will not be obtained due to incomplete or inaccurate applications.

6 Conclusion

As part of the research, we analyzed existing good practices and tools used for the process of digitalization of SMEs in the Alpine region and performed a SWOT analysis. We found that in all involved countries/regions (Baden-Württemberg, Trentino, Lower Austria, and Slovenia) are examples of knowledge transfer in the form of support projects, programs, initiatives, vouchers, institutes, and hubs. We further identified small and medium-sized enterprises in these areas, which represent good practices for the introduction of digitalization and have already benefited from the offered support from the before mentioned sources. We divided these collected good practices and tools into three levels (Government-level, research center-level, and private sector-level), depending on the field from which the practice originates. The results of the survey suggest that the national and local governments are highly supportive of initiatives related to the digitalization of SMEs operating in the natural fiber-based value chain. One of the most important advantages is the possibility for SMEs to obtain various funding and advice from different institutions and experts, while a major drawback is their inadequacy to different sizes and areas of operation of companies and complex procedures/conditions for obtaining assistance. During the research, we identified one example of good practices and tools provided to SMEs by a private enterprise. That suggests that such solutions are not common among the analyzed SMEs. Most of them operate with limited resources, investing mainly in day-to-day business, and use mostly only public funding. Nevertheless, the strong relationship between these levels can help resolve some barriers in the digitalization process.

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Change Management as a Support to the Organizations' Digital Transformation – State of the Art

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Abstract. *This paper studies the linkage between the change management and digital transformation (DT), a contemporary change management approach to the DT, "living labs" (LL's), as a promising and challenging paradigm for DT integration into the organization. The growing number of research and papers in this area note the multidisciplinarity, due to complexity and mutual interdependence. During the past few decades, innovations, information and communication technology (ICT), artificial intelligence (AI), and internet of things (IoT), provided significant impact to almost each aspect of human activity, adapting to the changing environment. The aim of this paper is to stress the linkage between the change management, contemporary management approaches, such as "LLs", their impact and contribution to the agriculture sector DT. A global trend of DT incorporated each industry and sector, leading practitioners to the challenge of the most convenient approach choice.*

Keywords. digital transformation (DT), "living labs", change management, information and communication technologies (ICT), artificial intelligence (AI), Internet of Things (IoT)

1 Introduction

This paper aims to stress the linkage between the new approaches to change management, such as "living labs" and their impact to DT. (Antle et al., 2017)
Recently, the IoT expansion to contemporary business each domain, agriculture as well, lead us to development of the Internet of Everything. IoE (Internet of Everything) as well. (Langley et al., 2019)
The "smart cities and smart villages" as a developing concept, indicating holistic and agile multidisciplinary approach to the challenging area such as agriculture sector.

Recent trends in smart communities, either urban and rural, and sustainable DT development, stresses the impact and importance of the infrastructure. Håkansson, (2018) in Ipsum - An Approach to Smart ICT Infrastructures for Smart Cities and Communities, demonstrates the importance of systematic and tailored approach to smart cities and structures, through the sustainable and systematic ICT application and development tailored to stakeholders' needs.

Considering the change management and the complexity of the topic, this paper is focused onto the DT in business environment. Accordingly, there is a need to take into consideration recent trends, businesses and their specifics, in order to ensure the most convenient approach to DT and change management interconnections. (Spremić, 2017)

2 Change Management and the Digital Transformation

DT is defined as "the profound transformation of business and organizational activities, processes, competencies and models to fully leverage the changes and opportunities of a digital technologies mix and their accelerating impact across society in a strategic and prioritized way, with present and future shifts in mind." [i-SCOOP.eu, 2016]

Tomičić Furjan, Tomičić-Pupek and Pihir, (2020) presented background, business, and technology-related concepts or factors relevant to DT initiatives as well as the transformation drivers and expectations, considering the fact that there is no single one right combination of technological concepts that could be explicitly determined. DT changes all – organization, models, processes, relationships, products (Schallmo et al., 2017), incorporating cultural and organizational changes needed for new digital technologies usage, in order to enable significant improvements - such as

better user experience, rationalization of business operations and innovation of products or services and business models (Brown et al., 2014), as well as to improve business performance (Čorejova et al., 2016).

DT deals with technological and non-technological aspect and change management operative level changes through the improved products, organisational structures or processes automation (Clohessy et al., 2017), it shows their impact across society in a prioritised way through the transformation of business activities, processes, competencies and whole business models (Betchoo, 2016). Enterprises need DT so to provide new or enhanced products and services to the customers, where technologies are the means, key enablers or even part of the offering (Nandico, 2016). Recent papers are indicating DT industries impact, a systematic approach upon the real-life case studies, considering the context. (Kutnjak, Pihir, Furjan, 2019).

In an overview of DT perspectives Westerman et al. categorized all digital initiatives into three main groups: Substitution (digital technologies replace an existing process), Extension (digital technologies improve the functionality of an existing process) and Transformation (digital technologies fundamentally redefine or create a new process). (Westerman et al. 2014) DT maturity determinants have to be considered also. In order to improve the DT maturity there are necessary focuses: a) Strategy orientation, b) Customer centricity, c) ICT and process infrastructure, d) Talent, capability and capacity strengthening, e) Innovation culture and organizational commitment. (Pihir, Tomičić-Pupek, Furjan-Tomičić, 2018).

Not only the benefits, but also challenges are related to DT and its impact to the change in almost each aspect. (Tabrizi, 2019) They are recognized and described as "potential problems" and could be classified into the challenges, issues, barriers or just problems depending on weight and time dimension, what was made in further steps. (Kutnjak, Pihir, 2019) Amongst the various influences on DT drivers, considering the business model creation, there is a need for the consideration of change management drivers (Hrustek, Tomičić Furjan and Pihir, 2019)

Cameron and Green (2019) described the key points and making sense of change management connecting it to the DT. McKinsey Global Survey on DT (2018), has shown the issues and new opportunities in DT, from various aspects. According to AlManei et al. (2018) change can be distinguished by following components: Scale, Scope, Time and Outcome. They defined change management as the "area of study that aims to facilitate the transition of individuals, teams or the whole organization by managing them. Actually, the purpose is to lead and guide the process from the current state to the intended future state by managing and controlling the different difficulties in order to overcome resistance." (AlManei et al. 2018)

One of the critical issues of DT is the ICT adoption, presented in study "The contribution of ICT adoption to a sustainable information society". (Ziemba, 2017)

The Social Living Labs were presented as a paradigm for Digital Participation through Social Living Labs, from the tech perspective high speed internet access and associated ICT, expected to bring connectivity, economic development, innovation, etc. Recent research has established that access by itself is necessary but not sufficient to foster digital participation for the broadest possible range of individuals. (Dezuanni, Foth, Mallan, Hughes, 2017)

3 The Digital Transformation Framework

Sustainability of technological development with human resources is the basis of sustainable development, needed to be seen through the impact of the organization cultural dimensions. (Hofstede 2011)

DT is also tied to the Unified Communications (UC) paradigm, a concept that describes the services integration, messaging, mobile communications, voice, web and video conferencing, fixed and mobile telephony (FMC), desktop sharing, data sharing, call and speech control, unified messaging (integrated voicemail, email, SMS and fax). Johansson et al. (2019), presented 6 areas of communication maturity: 1) understanding, 2) functioning, 3) organization, 4) prerequisites, 5) competencies and 6) practices, including communication assessments. A study of communication conducted by Johansson et al. (2019) described how the communication managers and practitioners vary between organizations and how they cope with organization change. (Johansson et al., 2019) Welch (2012) explores media attitudes and preferences and employee preferences, defining internal communication as "communication between strategic managers and internal stakeholders designed to promote commitment and a sense of belonging to an organization, to develop awareness of a changing environment and understanding of its evolving goals". The constitutive perspective of communication is advocated by Gregory and Halff (2017), pointing out that all members accept communication and should be equipped, trained, and encouraged to participate in conversations that contribute to value creation.

Designing organizations stresses the importance of change management, organizational design, improvement and development of organization by finding the optimal combination of approaches to DT challenges. (Fabac, 2017) Research on personality traits (McCrae, Costa 1999) and their contribution to the development of the organization are increasingly represented, as well as research on cultural dimensions (Hofstede, 2011), given the globalization and influence of individual characteristics and growing cultural influence (Vidaček- Hainš, 2016).

DT is mainly related to the growing need for ICT use so to remain competitive in the age of the Internet of Everything (IoE) (Langley et al., 2019).

Dunleavy et al. (2006) in "Digital Era Governance" state that technology in itself does not change organizations, but the way organizations work and their use of technology changes work practices. Ismail et al. (2017), described DT as "The process through which companies converge multiple new digital technologies, enhanced with ubiquitous connectivity, with the intention of reaching superior performance and sustained competitive advantage, by transforming multiple business dimensions, including the business model, the customer experience (comprising digitally enabled products and services) and operations (comprising processes and decision-making), and simultaneously impacting people (including skills talent and culture) and networks (including the entire value system)". (Ismail et al., 2017)

Recent COVID-19 pandemic shown organizations and individuals change, facing issues in each phase of such a complex process are dedicated and focused onto DT practical solutions. Abraham (2019) described the DT during the change initiative, structure, work processes, people, tech and tools, culture and shared values, tasks, procedures, strategy and strategic plans, leadership style, and policies. (Abraham, 2019) McKinsey's 7 S model stresses the use of 7 s' within the context of undertaking a change model and incorporating 7 change model critical elements.

3.1 Lewin's Change Management Model

Lewin (1951) conceptualized and documented a specific change management model and presented it in 1951. Regardless of the 7-decade history, this model passed the test of time and various applications with regard to different business settings (Abraham, 2019; Galli, 2019).



Figure 1: The McKinsey 7-S framework, Source: Hayes, J. (2014). The Theory and Practice of Change Management.

Lewin proposed a three-stage change model, also referred to as "the force field change management model". (Galli, 2019) Lewin's implementation theory consists of three phases:

- Unfreeze
- Change / Moving
- Re-freeze

This model has a people-centered focus (Galli, 2019) and is considered to be one of the most suitable for a change management initiative, but it has been undervalued due to evaluation of being too simplistic and mechanistic. (Galli, 2019)

3.2 Kotter's Model of Organizational Change

Kotter (2007), developed 8-stage model aiming to help the issue arising from the change implementation. His model includes accelerators as the key steps that could be implemented so to ensure the change process fulfilment, featuring 8 change accelerators as follows:

1) a sense of urgency establishing
2) a guiding coalition creating
3) a vision and strategy developing
4) the change vision communicating
5) a broad-based action empowering
6) the short-term wins generating
7) more gains and change consolidating
8) the new approaches in the culture anchoring (By, 2005)

3.3 ADKAR Change Management Model

Hiatt (2016) developed the ADKAR change model, supporting an effort to enhance change in individuals, as they are organizations' change objects, considered as an individual-target change framework. Hiatt (2016) described five factors that influence successful awareness building in individuals:

- A person's view of the current state;
- How a person perceives problems;
- Sender awareness messages credibility and the organization's history with change;
- The presence of misinformation or propaganda in the background conversation;
- Contestability of the reasons for change
- External / observable drivers' presence (Hiatt, 2016)

The model, with its advantages and disadvantages, aimed for government change integration, and the society with the individual level in focus. The model is evidence-based, supported by clear and simple change language, covering all levels and incorporating the change strategies into everyone's everyday work life, but also provides the ability to scale across large and diverse organizations as it provides an understanding of how people change. (Wong et al., 2019)

4 Living Labs – An Innovative and Adaptive Approach

Innovation designed "with users", brings products/ services co-designed with both designers and active users. The European Network of Living Labs (ENoLL) defines Living Labs as "user-centered, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings. Innovation is designed "by users".

It leads users to the innovators' role, from the idea, inspiring others, prototypes creating, till the solutions

and content developing, so designers got facilitators' role. Nesti, (2018) described LL's connection to the innovation, and their contribution to the stakeholders' contribution development. (Nesti, 2018)

The concept of Living Laboratories (Living Labs – LLs) is created by MIT's Prof. William Mitchell, who provided the idea and its development, by connecting the computing capacities and benefits, sensing and ICT, in order to move the innovation research from in vitro to in vivo settings (Dutilleul et al., 2010). The term Living Lab was used to describe the process for conducting user research in the context of smart homes or homes of the future (Bergvall-Kåreborn et al., 2009; Dutilleul et al., 2010). LLs can be observed, recorded and experimentally manipulated with volunteer research participants individually living in the lab, treating it as a temporary home (Rogel, 2013). LLs are related to the Open Innovation concept (Chesbrough, 2006), that is, on the benefit of opening up innovation processes to the users (Colobrans, 2019). No matter the fact the concept was developed in the North America, it was particularly successful in Europe. (Zavratnik et al., 2019) Schuurman (2014) presented the "LL anatomy", to describe the relations and model itself.

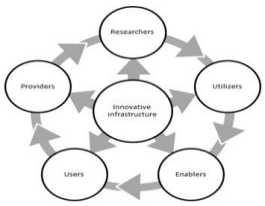


Figure 2: The anatomy of a living lab, Source; Schuurman, D. (2014). Knowledge exchange for innovation development in open innovation systems: LLs as innovation intermediaries & knowledge brokers aligning user & stakeholder input.

European and global LLs community was established in 2006, forming the European Network of Living Labs (ENoLL) (EC, 2009) a month after the Helsinki Manifesto (2006). ENoLL's definition describes LLs as a new research area in which human ideas and needs, from multi-actor and participatory perspective (a public-private partnerships), established as a starting point in innovation and transition towards new productive, governance, consuming and living models. Westerlund and Leminen (2014) defined LLs as: "physical regions or virtual realities, or interaction spaces, in which stakeholders form public-private-people partnerships (4Ps) of companies, public agencies, universities, users, and other stakeholders, all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts". (Westerlund and Leminen, 2011) Lane (2017) approach to multiple perspectives and reflecting on boundary judgements, recognized as Systems thinking represent an approach, a viewpoint, thinking and acting in an environment that takes into account particular relations, connections, impacts and circumstances, creating a whole new world.

Aversano et al. (2016) pointed to a general defining element of Living Labs is the ability to study users in a natural setting (Schuurman et al., 2011). Zavratnik et al. (2019) defined the common points that contribute to understanding the LL concept:

a) openness to inviting different collaborators, addressing different themes, and including the public;

b) innovation, as one of the main ingredients, the aim and the principle of LLs;

c) co-creation, as the involvement of users and stakeholders at all stages of the products development; d) real-life setting, through real life or work settings. (Leminem et al., 2012)

Leminem et al. (2012) conducted 103 semi-structured interviews with representatives of 26 living labs in four countries between 2007 and 2011, and distinguished 4 types of living labs. Their differentiation is based on which actor drives their activities: utilizer-driven, enabler-driven, provider-driven and user-driven. Bergvall-Kåreborn et al. (2009) identified five LLs' principles: 1) Openness, 2) Influence, 3) Realism, 4) Value and 5) Sustainability. These Principles provide the foundation for LLs operations' design. (Bergvall-Kåreborn et al., 2009) LL common methodology is called harmonization cube, as they include, harmonize and exchange best practices developed by Mulder et al. (2007). Helsinki manifesto (2006) stated that, "This approach should ensure that common methodologies and tools are developed across Europe that support, stimulate and accelerate the innovation process It can be said that harmonization of LL methods and tools is key." (Mulder et al., 2008). Veeckman et al. (2013) developed the LL Triangle framework so to guide empirical research into the implementation and the related outcomes of LLs. Leminen et al. (2012) found that LL depends on: i) strategic intention; ii) passion; iii) knowledge and skills; iv) other resources; and v) partners in the living lab network.

5 Conclusion

Rural and urban areas, industry and other sectors, are facing the turbulence of global changes, meeting new opportunities and challenges. Recent ICT and tech innovations in general are leading to the various outcomes and benefits.

All those opportunities and challenges were given to each stakeholder, particularly the researchers dealing with the DT in any aspect. Recent studies and papers have shown that the most of the approaches and issues were related to the change management. Managing changes in organizations, as well as individually, depends on the stakeholders' support, either the political, economic, legal and social aspect. Managing change need to be a component of the social, economic, political and cultural development, considering the critical issues, developed according to its specifics.

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The Contribution of Women on Corporate Boards - Board's Effectiveness

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Abstract. *The composition of supervisory and board of directors in companies is extremely important for the successful operation of companies. Nowadays, women in the workplace, and especially in management positions, encounter a form of discrimination that has its own professional name - the phenomenon of "glass ceiling". Therefore, it is very important to analyze the representation of women and men on the company's supervisory board and board of directors. This paper will explain women's leadership style, differences between men's and women's leadership style, and the problems that women in employment, and especially in promotion. The aim off these paper is to determine whether the "glass ceiling" phenomenon is prominent in Croatian companies and to what extent. In addition, women's representation in senior positions will be related to business performance criteria.*

Keywords: „glass ceiling", female executives, discrimination, supervisory board, board of directors, promotion

1 Introduction

According to the statistics provided by the European Institute for Gender Equality in 2019, the percentage share of women on the supervisory boards or boards of directors in the largest quoted companies in the EU was 25%, with men comprising a significantly larger proportion – as much as 70% – of corporate board members. Moreover, a research conducted in 2015 covering the 400 largest Croatian companies by revenue in 2014 has shown a similar distribution of data. The boards of directors of the companies covered by the research comprised of 15% of women and 85% of men, while the supervisory boards consisted of 21% of women and 79% of men (Dreven and Kokot, 2015). Furthermore, based on their 2017 research, the Network of Executive Women estimates that women will account for only 15% of executive ranks if their status does not start to improve. This proportion is significantly lower in comparison with the current percentage of women executives, which is 35% (The Female Leadership Crisis, 2018).

The principal indicator of discrimination against women in the workplace is precisely their position in management. Discrimination is reflected in the fact that the number of female executives is inversely proportional to the level of management (Bahtijarević-Šiber, 2014, pp. 400). In many companies, there is a great deal of unequal distribution of women and men on different hierarchical levels within the same occupation – a type of discrimination better known as vertical segregation or the "glass ceiling" phenomenon (Legal Clinic, 2013). Reasons contributing to women's underrepresentation in senior positions are multiple. The main reasons for discrimination against women in employment, and especially in promotion, are various stereotypes and prejudices. According to one of those stereotypes in management, "women's place is in the house and they do not devote themselves to work or a career" (Bahtijarević-Šiber, 2014, pp. 406). Such a deep-rooted belief cannot be shattered at once. However, as years bring about positive changes in society, this stereotype is gradually wearing off.

One extremely important factor which had an impact on women's advancement in the past was their education. Today, the situation has improved in this respect, as numerous analyses have shown (Bahtijarević-Šiber, Sikavica and Pološki Vokić, 2008, pp. 608). In fact, according to the Croatian Bureau of Statistics, in the Republic of Croatia in 2017 women outnumbered men in higher education with 34.7% against 23.2% (Women and Men in Croatia, 2019, 2019). Moreover, women have fewer opportunities to build networks, which is a significant obstacle hindering their professional advancement (Bahtijarević-Šiber, 2014, pp. 409). A study conducted in 2018 in Germany involving 37 female executives deals with the reasons why women are less successful at professional networking than men. The findings of the study reveal that women underestimate their self-worth in professional networking, and restrain from exploiting the opportunities which may come from

social ties, leading them to engage less in networking activities (Greguletz, Diehl and Kreutzer, 2018).

The introduction of this paper will be followed by an overview of literature dealing with the types of discrimination women face in the workplace as well as the importance of the "glass ceiling" phenomenon. Afterwards, the methodology used for the analysis will be described. The fourth chapter will deal with the results of the analysis, the aim of which is to get an insight into women's representation on boards of directors, supervisory boards, and recruitment committees. More precisely, the aim is to determine whether the "glass ceiling" phenomenon is prominent in Croatian companies and to what extent. In addition, women's representation in senior positions will be related to business performance criteria. The conclusion of this paper will be provided in the final chapter.

2 Literature Overviews

2.1 Types of Discrimination Women Face in the Workplace

According to research conducted on the global as well as national level, women differ from men in the workplace in several key aspects. The most prominent difference is evident in the fact that, on average, women earn less than men with the same level of education (Bahtijarević-Šiber, 2014, pp. 404). Gascoigne lists several reasons for the gender pay gap. The first reason is related to the fact that, unlike women, a greater number of older men occupy positions which have existed for a long period of time. Naturally, older, and more experienced employees with longer seniority are paid more than their younger counterparts. Moreover, women are paid less than men due to the imbalance between different positions and flexible working hours. In other words, women tend to opt for low-paid jobs in order to be able to take care of their families, while men are more flexible, and therefore have more opportunities to work in managerial positions, which are high-paying (Gascoigne).

According to the data available from the Croatian Bureau of Statistics, in the Republic of Croatia in 2017, the average monthly income of men was higher than women by 1,126.00 kn. On the other hand, the average monthly net income of women was 5, 552.00 kn, which was lower than men's average monthly net income by 794.00 kn, which was 6,346.00 kn (Croatia in Figures 2019, 2019). However, the European Commission's data suggest the Republic of Croatia fares significantly better than the rest of the EU and their average. Specifically, in the Republic of Croatia in 2014, the gender pay gap was almost half the average of the European Union, i.e. women were paid for their work 8.7% less than men (The Gender Pay Gap in Croatia, 2018). It is important to note that in 2011 in the European Union, women earned on average 16.8% less than men. Nevertheless, five years later, in 2016, the situation had somewhat improved. To be more precise, women earned 16.2% less than men (Women in the EU earned on average 16% less than men in 2016, 2018).

Another reason stated as important for the gender pay gap is that higher paying jobs are in fact less flexible and require employees to devote a great deal of their time to work. Consequently, it is maintained that women taking care of their children, families, households, etc. cannot completely dedicate themselves to such obligations, which predetermines their inclination towards lower paying jobs with fewer responsibilities (Bertrand, 2018). An analysis of the data from the Croatian Bureau of Statistics reveals that in 2017 in the Republic of Croatia, most of the women was employed in education and human health and social work activities, accounting for 78,7% of employees. The other two leading sectors dominated by women include the financial and insurance activities, where female representation amounts to 69.5% (Women and Men in Croatia, 2019, 2019). Additionally, in 2017, women had lower earnings than men in the activities dominated by women. More precisely, in financial and insurance activates, women had the average monthly net income of 7,580.00 kn, in contrast to 10,156.00 kn man had, which represents a pay gap of 2,576.00 kn (Women and Men in Croatia, 2019, 2019).

A similar distribution of data is found in other activities where women's representation exceeds 50%. To illustrate, in wholesale and retail trade in 2017, women had the average monthly net income of 4,884.00 kn, while men had 6,116.00 kn. In addition, in 2017, men's net income in education was 6,599.00 kn, while women were 5,551.00 kn Similarly, the data from human health and social work activities showed discrimination against women regarding net income in 2017. To be specific, women earned a 6,024.00 kn salary for their work, while men were paid on average 2,025.00 kn more for their work in the same activity (Women and Men in Croatia, 2019, 2019).

The main very important and salient difference between men and women is the fact that women occupy managerial positions more rarely than men and that women with the same level of knowledge and skills advance more slowly than men (Obradović, Samardžija and Jandrić, 2015, pp. 164). Researchers Möllerström and Wrohlich state in their research paper that, unlike men, women feel less inclined to compete against others. In fact, women are less willing to compete against men, which accounts for their underrepresentation in managerial positions. On the other hand, women are apt to compete against themselves, rather than other people from their company.

A study conducted in 2019 by the Credit Suisse Research Institute involving 3,000 companies

from 56 countries yielded the following findings: the US, Canada, Scandinavia, the UK, France, Germany, South Africa, Australia and New Zealand are the countries with the highest share of women in managerial positions. Precisely, the proportion of women in managerial positions in companies operating in these countries ranges from 20% up to 43%. With not more than 4%, Japan stands out as the country with the smallest share of women in managerial positions in the covered companies. Mexico and Brazil have a somewhat higher percentage of women in managerial position – 8% to be more precise, while the rest of Latin America has only 9% of women in senior management (Credit Suisse Research Institute, 2019).

Moreover, the study by the Credit Suisse Research Institute clearly shows the difference between financial indicators when a company is run by a woman. When the female representation in senior management exceeds 20%, the data representing EBITDA margins, CFROIs and P/E ratios are higher than in the case when there is less than 15% of women in senior management of a company. When female representation on boards is more than 20%, the EBITDA margin is higher by 2%, the Cash Flow Return on Investment (CFROI) is higher than 2.04, and the Price-to-Earnings ratio is higher by 16% (Credit Suisse Research Institute, 2019).

According to data from 2019, there was 28.1% female and 71.9% male ministers in the European Union. Moreover, a similar distribution of men and women is found in the Parliament and regional assemblies. There is 29.3% female and 70.7% male members of Parliament. Similarly, 28.5% of members of regional assemblies are female, while 71.5% are male. However, in financial institutions or, to be more accurate, on the Central Bank board, the ratio of women is 20.3%, while the ratio of men is 79.7%. A share of 39.9% of female and 60.1% of male board members participate in the organization of financing research in the member states of the EU. Data provided by the European Institute for Gender Equality in 2019 suggest that the smallest proportion of women can be found on executive boards of national Olympic organizations. The share of women in such executive bodies is 14.8%, while male representation in the same bodies is 85.2% and more (European Institute for Gender Equality).

2.2 "Glass Ceiling" Phenomenon

The discrimination of qualified and competent women in their promotion within a company is known as the "glass ceiling" phenomenon (Jergovski, 2016). As the term itself suggests, it is transparent that this phenomenon assumes the existence of barrier within a company preventing women from rising beyond it and advancing in their careers. (Obradović, Samardžija and Jandrić, 2015, pp. 164). The glass ceiling hinders women's advancement regardless of the type of sector: private, public, or business (Klepić, Šunjić and Klepić, 2019). The first woman to identify this type of discrimination was the editor of the Working Woman magazine, Gay Bryant. However, it was not until 1986 and the publication of an article by two journalists from the Wall Street Journal that the term "glass ceiling" entered common usage (Jergovski, 2016).

Additionally, the term can be explained as favoring men, rather than women, for leadership positions (Yukl, 2008, pp. 423). Therefore, the glass ceiling phenomenon refers to vertical discrimination preventing women from reaching management positions. Women who succeed in reaching a managerial position tend to remain in it. In fact, they most commonly manage business functions such as procurement, sales, marketing, finance, etc., seldom accessing higher managerial positions or becoming executive managers (Bahtijarević-Šiber, 2014, pp. 400). Research has shown that women tend to give up more easily than men once they have reached management positions, i.e. women in managerial positions leave their jobs at three times the rate of their male colleagues (Elting, 2019). Although the glass ceiling phenomenon refers primarily to women, it is increasingly used to denote discrimination against other minorities (C. Certo and T. Certo, 2009, pp. 87).

In most of the cases, this type of discrimination is not perceived neither by the woman facing it nor other people in the workplace. Consequently, women only perceive it when they "hit" their heads against this glass ceiling. Over the years, the glass ceiling phenomenon has worn off, but is still substantially salient in companies. This phenomenon can be shattered, but only over a longer period. Furthermore, to tackle the glass ceiling phenomenon, a personal plan should be created. This includes a continuous knowledge and competence development, efforts aimed at building relationships and communication with colleagues at work, as well as a proactive attitude towards task completion (Obradović, Samardžija and Jandrić, 2015, pp. 163).

3 Methodology Description

The data on board members and authorized company representatives, as well as the data on total incomes, profits/losses of accounting periods, and credit ratings of the covered companies were gathered by using the info.BIZ service launched by the Financial Agency. The collected data were analyzed in Microsoft Excel. The 500 leading companies by consolidated 2018 revenue were supposed to be included in the analysis. However, 17 companies were excluded from the analysis, including those categorized as institutions, other companies, limited partnerships, as well as companies in the insolvency and pre-insolvency proceedings or companies which have been erased from the register. The final sample comprises 483

companies whose legal forms are either joint-stock companies or limited liability companies. The largest portion of the sample comprises limited liability companies – 76.40%, while joint-stock companies represent 23.60% of the sample. In other words, the analysis includes 114 joint-stock companies and 369 limited liability companies.

4 Analysis

The findings of the analysis of the data on the number and gender of board members and authorized representatives show that, out of the total of 2,654 members of the bodies of the joint-stock and limited liability companies, 618 are females, and the remaining 2,036 are males. From Figure 1, it can be unequivocally concluded that there is still an unequal distribution of men and women in management positions, at least in the 483 joint-stock companies and limited liability companies covered by this research. Furthermore, in all analyzed companies there is 76.71% of men on the boards of directors, supervisory boards or working as authorized representatives, while women account for a significantly smaller portion of executives with the representation of only 23.29%.

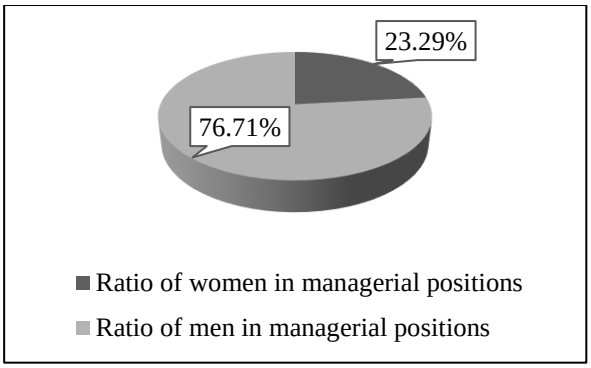


Figure 1. Share of women and men in managerial positions in the analyzed companies
(Created by the authors according to the data provided by the info.BIZ service)

There is no equal distribution of men and women on the management boards, supervisory boards or among authorized company representatives. Considering all members, the total female representation on the management boards of all analyzed companies is 11.57%, while male is 40.66%. This translates into only 307 women and 1,079 men on the management boards of all analyzed companies.

In all companies covered by the research, there are 297 women and 864 men on the supervisory boards. In percentages, women's share is 11.19%, while men's is three times higher, resulting in a 32.55% male representation. The authorized company representatives from all analyzed companies are mostly male. More precisely, 93 authorized company representatives or a share of 3.50% are male, while 14 or a share of 0.53% are female.

In order to be able to draw a conclusion whether companies with women on management and supervisory boards or working as authorized representatives are more successful than those with no female executives, a set of criteria needs to be compared. Business performance is determined based on the following criteria: revenue, profit and loss over in the accounting period and credit rating. It should be noted that all analyzed joint-stock companies generate more total average revenue than all the other companies included in the analysis. This is not the case with the limited liability companies covered by the research. Therefore, the analyzed limited liability companies generate less total average revenue than all the other analyzed companies (Table 1).

It follows that average revenues of the joint-stock companies with one woman on the management board are somewhat lower than those of all the analyzed joint-stock companies, while average revenues of the joint-stock companies with one woman on the supervisory board are higher than those of all the analyzed joint-stock companies. However, average revenues of the joint-stock companies with one woman designated as the authorized company representative are significantly lower than average revenues of all the analyzed joint stock companies. As for the joint-stock companies with two or more women designated as the authorized company representatives, a similar situation can be found as in the case of the joint-stock companies with one woman on the management board. Therefore, average revenues are lower in this case than those of all the analyzed joint-stock companies. Average revenues of the analyzed joint-stock companies with two or more women on the supervisory board are higher than average revenues of all the analyzed joint-stock companies (Table 1).

When it comes to average revenues of the analyzed limited liability companies with one woman on the management, supervisory board, or as the designated company representative, they are lower than average revenues of all the analyzed limited liability companies. In contrast, the analysis shows that average revenues of the analyzed limited liability companies with two or more women on the supervisory board are higher than average revenues of all the limited liability companies included in the analysis. Total average revenues of the analyzed limited liability companies with two or more women acting as authorized company representatives cannot be compared with the revenues of the other companies. This is because only one limited liability Company with two or more women acting as authorized company representatives was included in the calculation of total revenues.

Table 1. Average revenues of the analyzed joint-stock companies and limited liability companies according to the representation women on management and supervisory boards, and among authorized company representatives.

	Joint-stock companies (HRK)	**Limited liability companies (HRK)**
Average revenues of JSCs with 1 woman on the management board	1,088,672,927	504,588,911
Average revenues of JSCs with 1 woman on the supervisory board	1,616,429,490	600,033,988
Average revenues of JSCs with 1 woman as the authorized company representative	426,016,549	558,209,876
Average revenues of JSCs with 2 or more women on the management board	752,124,826	900,752,708
Average revenues of JSCs with 2 or more women on the supervisory board	1,160,995,763	695,450,886
Average revenues of JSCs with 2 or more women as the authorized company representatives	0	1,594,891,524
Total average revenues	1,103,907,418	601,474,950
Total average revenues of the JSCs and LLCs	720,307,525	

(Created by the authors according to the data provided by the info.BIZ service)

Joint-stock companies with at least one woman on the management or supervisory board earn higher profits in comparison to the average profit of all the analyzed joint-stock companies. Similarly, the average profits earned by the joint-stock companies with two or more women on the supervisory board are higher, though not significantly so, in comparison to the average profit of all the analyzed joint-stock companies. By and large, the joint-stock companies with one woman designated as the authorized company representative, and those with two or more women on the management board earn lower average profits when compared to the average profits of all the analyzed companies.

The average profits earned by the companies with one or more women on the supervisory board, as well as those with two or more women on the management board, are higher than the total average profits of all the companies included in the analysis. Nevertheless, the companies earning lower profits in comparison to the total average profits of all the analyzed limited liability companies include those with one woman on the management board, with one woman designated as the authorized company representative, and those with two or more women among authorized company representatives.

Table 2. Average profit of the analyzed joint-stock companies and limited liability companies according to the representation women on management and supervisory boards, and among authorized company representatives.

	Joint-stock companies (HRK)	**Limited liability companies (HRK)**
Average profit of JSCs with 1 woman on the management board	100,585,589	29,463,838
Average profit of JSCs with 1 woman on the supervisory board	103,240,323	46,252,175
Average profit of JSCs with 1 woman as the authorized company representative	4,922,554	27,189,842
Average profit of JSCs with 2 or more women on the management board	59,188,338	33,729,600
Average profit of JSCs with 2 or more women on the supervisory board	87,663,662	50,718,169
Average profit of JSCs with 2 or more women as the authorized company representatives	0	32,808,684
Total average profit	86,466,374	33,401,837

(Created by the authors according to the data provided by the info.BIZ service)

The analysis of the data on average losses reveals that nearly all of the analyzed joint-stock companies suffering losses and with at least one woman on the management board, supervisory board or among authorized company representatives have lower losses than the average loss of all the analyzed joint-stock companies. According to the data from 2018, the analyzed joint-stock companies have over 50% lesser losses when there is one woman on the management board or among authorized company representatives. However, with one or more women on the supervisory board, the average losses are somewhat greater than the average losses of all the analyzed joint-stock companies (Table 3).

Out of all analyzed limited liability companies suffering losses, the companies with one woman on the management board and supervisory board suffer greater losses in comparison with the total average losses in comparison to total losses of all the analyzed limited liability companies. The companies with significantly lower losses are those with two or more women on the supervisory board, as well as those with at least one woman among authorized company representatives (Table 3).

Table 3. Average loss of the analyzed joint-stock companies and limited liability companies according to the representation of women on the management board, supervisory board, and among authorized company representatives.

	Joint-stock companies (HRK)	**Limited liability companies (HRK)**
Average loss of JSCs with at least 1 woman on the management board	-40,057,943	-35,454,395
Average loss of JSCs with at least 1 woman on the supervisory board	-92,990,012	-53,626,564
Average loss of JSCs with at least 1 woman among authorized company representatives	-42,377,713	-4,281,155
Average loss of JSCs with 2 or more women on the management board	0	-14,735,550
Average loss of JSCs with 2 or more women on the supervisory board	-66,414,220	-25,560,091
Average loss of JSCs with 2 or more women among authorized company representatives	0	0
Total average loss	-100,906,594	-32,353,084

(Created by the authors according to the data provided by the info.BIZ service)

The assessed credit rating of the majority of the analyzed joint-stock companies with one woman in executive positions ranges from negligible expectations of default risk to very low expectations of default risk. Such are the assessed credit ratings of 44 joint-stock companies. On the other hand, the assessed credit rating of the remaining 23 analyzed joint-stock companies with 1 woman on the management, supervisory board and among authorized company representatives ranges from B1 to B6.

The results of the analysis show that the analyzed joint-stock companies which have two or more women on their management boards, supervisory boards or among the authorized company representatives fare worse than the companies with only one woman in executive positions. Furthermore, 19 of the analyzed joint-stock companies are assigned the A rating and are grouped into classes from 1 to 3. which means that the expectations of default risk are very low or negligible in the case of these 19 joint-stock companies. As already mentioned, the assessed credit rating for the majority of joint-stock companies with two or more women in managerial positions is worse. The expectations of default risks vary from low to very high in the case of 26 such companies.

The data obtained by the analysis suggest that in the majority of the analyzed limited liability companies a very good credit rating coincides with the fact that there is one woman on the management board, supervisory board and among authorized company representatives. To be more precise, 103 analyzed limited liability companies with one woman in managerial position are assigned the ratings from A1 to A3, meaning that default risks are negligible or very unlikely. There are 64 limited liability companies assigned the B rating and these are the companies with a low to average likelihood of default risks in payment. Moreover, one limited liability company with one woman on the supervisory board is assigned the C3 rating, meaning that there is a strong likelihood of default risks in payment.

5 Conclusion

The status of women in companies has changed over the years and is still incessantly changing. Although women started fighting for their rights decades ago, i.e. at the end of the 19th century, this fight is still going strong today. Nonetheless, women are fighting for a different type of rights today, including equal employment opportunities, equal status in companies, as well as equal pay for equal work. Despite their advanced competences and better education than men, women are still underrepresented in senior positions within companies. What accounts for this situation is the so-called glass ceiling phenomenon? Namely, there is an invisible barrier in a company hierarchy beyond which women simply cannot raise, often not even being conscious of its existence. Apart from this phenomenon, women are discriminated against with respect to their pay, which is evident from the data provided by the Croatian Bureau of Statistics, the European Commission, and the European Institute for Gender Equality. Previous research reveals that the glass ceiling phenomenon is still present both in the Republic of Croatian and abroad.

The analysis presented in this paper leads to the conclusion that in 2018 in the Republic of Croatia there was an unequal distribution of men and women in executive positions in the companies covered by the analysis. In all the analyzed joint-stock companies and limited liability companies the percentage share of men on management boards, supervisory boards and among authorized company representatives is 76.71%. In the same executive position, the share of women is significantly lower, i.e. they account for only 23.29% of executives. Additionally, the most radical unequal distribution of men and women is evident in the position of authorized company representative, where the ratio of women is six times lower than that of men. Similarly, the share of women on management boards and supervisory boards is about the same. More precisely, the ratio of women on management boards and supervisory boards is three to four times lower than that of men. From all this, it can be concluded that the glass ceiling phenomenon exists and is present to a very high degree.

Company performance is tightly connected with the representation of women in executive positions. According to the total revenue criterion, the more successful joint-stock companies are those with at least one woman on the supervisory board, while the less successful ones are the joint-stock companies with one or more women on the management board. In the case of limited liability companies, according to the criterion of total revenue, the significantly more successful companies are those with two or more women on the management board and supervisory board. Furthermore, considering the profit in the accounting period, the more successful joint-stock companies are those with one woman on the management board, and with two or more women on the supervisory board. According to the same criterion, the more successful limited-liability companies are those with one or more women on the management board, and with one woman on the supervisory board. The analysis conducted for the purposes of this paper leads to the conclusion that joint-stock companies with one woman on the management board, supervisory board and among authorized company representatives suffer lesser losses. Similarly, the limited liability companies that suffer lesser losses are those with two or more women on the management board and supervisory board. What is more, there is connection between credit ratings and the representation of women in executive positions. The majority of the analyzed joint-stock companies and limited liability companies with better credit ratings are those with one or more women in managerial positions. In conclusion, considering the criteria of average profits, revenues and losses in the accounting period and credit ratings, the more lucrative companies are those with one or more women in managerial positions.

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Agile vs. Traditional Methods for Managing IT Projects - A Case Study*

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Abstract: *Agile methods of project management have been a relevant topic for several years and are especially relevant in IT fields. One of the assumptions is that agile methods in IT projects are a better choice than traditional ones; therefore, this paper compares traditional and agile approaches with the aim of research on real case studies. Based on assumptions and a literature analysis, a survey was conducted on a realistic sample of 16 IT experts from project managers or members of project teams with experience in projects guided by both approaches. The results respond to the assumptions and give a picture of the advantages and disadvantages of both approaches, and the paper summarizes recommendations for their implementation in IT projects.*

Keywords: project, project management, agile methods, traditional methods, comparison of methods

1 Introduction

With all its achievements, inventions, and the knowledge that people possess, today's world is constantly accelerating and improving. Business strives for greater work efficiency and process efficiency. Modern products are designed and manufactured by increasingly complex processes, and the time from idea / design, to development, sales and application is getting shorter. All of the more complex products, services, or generally non-standard processes that are carried out to achieve the specific goals of the organization, have a dose of innovation and risk for organizations, and they are not routine are called projects. The discipline that deals with the improvement of the way of working and methods for leading/implementing projects is called project management, and the methods and techniques used are continuously improved. According to Kerzner (Kerzner, 2009, p. 6), project management is actually about time, cost, performance and resources, i.e. how to choose the best mix to achieve the project goal.

Projects and project management are used in various industries such as construction, the development of new products, technologies, and materials; and the production of complex products such as aircraft or ships. In particular, the discipline of project management is important in the information technology (IT) industry where the development and advancement of technologies, the requirements of new users and the adaptation of existing solutions change very quickly. Such conditions set challenging goals for IT project management. The products made by IT companies and teams of IT experts are unique such that they are specialized and fully tailored to the client. In order to achieve such goals through projects, as well as to make them feasible and as efficient as possible in a certain period of time with available resources and within a certain budget, it is necessary to manage projects in the right way. This is helped significantly by the selection of appropriate methods and techniques that can be categorized as traditional and agile, where the choice of methods and techniques depends on the characteristics of a specific project.

Based on the above, this paper seeks to explore the application of agile and traditional methods in IT project management and it compares their advantages and disadvantages on a realistic sample of project participants. The research is focused on the employees of an IT company - the case study. It was identified that only a few years ago this company switched to using project management according to the agile approach as opposed to the previously used traditional approach. This situation makes its employees (project managers and project team members) ideal candidates to test and compare both approaches.

The paper is organized as follows. The introduction to the topic is followed by a chapter on the methodology where the sample, methods, implementation of research and the case study itself are described. Following that, a theoretical framework is presented, which describes the validity of concepts and methodologies according to traditional and agile approaches. The theoretical framework and existing

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research are followed by results and discussions. The paper ends with the conclusion and references.

2 Methodology

This paper is based on research conducted as part of the final work and practical work in the company case study. Research on project management methods was conducted at Emil Frey Digital, which deals with: the development of innovative software solutions, web development, image processing, artificial intelligence and machine learning, the Internet of Things, and data integration and business intelligence (Emil Frey Digital, 2020).

The research was conducted in 2020 in two steps. A structured interview was conducted with two employees (project managers) which ensured that the questions were calibrated and that the final questionnaire for the main research was defined for the second step. This second step was carried out with 52 of the 57 employees. The sample involved experienced project managers and project team members who were mostly IT professionals with a university degree working in the case study company. Based on the theoretical framework of agile and traditional methods, and the assumptions that those agile are more efficient and by that a better choice when it comes to IT projects, this research aims to investigate and compare the two approaches and make recommendations for their implementation in IT projects. According to the above assumptions as well as the well-known theory related to concepts such as projects, project management, agile and traditional methods, etc., a set of questions was compiled that served as a structured survey for interviewing two employees of the selected company. Through interviews, it was checked whether the case study company was the ideal choice of company in which research on traditional and agile methods could be conducted. This was based on the company's project management policy and the knowledge of individuals on the chosen topic. As these employees within the case study company are in positions that are closely related to Scrum as an agile method, and that they have experience in working with traditional methods, it was possible to compile a new survey based on their answers relating to the main survey. Survey was conducted online and send to a selected sample of employees included in the main research.

The online survey for the main research consisted of 33 questions of different types (open-ended questions, closed-ended questions, and questions of agreement with a statement according to the Likert scale). Surveys for research purposes were sent to two groups of respondents within a sample of 52 employees, i.e. to project managers and members of project teams. The number of surveys sent to project managers was 8, while the number of surveys sent to team members was 44. The number of employees who responded was 4 project managers, which is 50% of the total number of managers within Emil Frey Digital. When it comes to project team members, the percentage of respondents is 27% or 12 out of 44 project team members to whom the survey was sent. After collecting answers from both groups of respondents, an analysis of the results was performed. Based on this, this paper presents the findings and explains how they are connected with the original assumptions. It also compares these two approaches and gives recommendations for their application in IT projects.

3 Theoretical Framework

Traditionally, project management is the application of tools, skills, techniques and knowledge in project activities in order to meet the objectives of the project or the requirements of the client and their set scope. Traditional project management includes 5 phases: project initiation, planning, execution, monitoring and control, and closure. All five phases are carried out under the guidance and support of the project manager as well as the project team. (Project Management Institute, 2013, p. 5)

The features of traditional methods are visible in the fact that they are implemented by organizations in which projects are implemented that are fully defined and their changes are predictable. Management itself is based on commands and controls, communication is formal, and the development model is based on a life-cycle model. It is a matter of complete planning and the examination of the results that comes at the end. When it comes to the result itself, whether it is a product or a service, the requirements related to it are stable and pre-specified. Traditional methods as such are mostly used in large teams (Engelhardt, 2019, p. 15-16)

In addition to the above, traditional project management is based on a definite, stable, predictable and linear model. In other words, projects that are traditionally run are focused on a plan prepared in advance with the aim of meeting the time limits, budget and performance objectives of the project. One of the biggest features of such a plan, as well as the traditional methods themselves, is that it is largely isolated from the environment in which the project is implemented and which changes during the project (Shenhar & Dvir, 2007, p. 19).

The best known and most common traditional method is the traditional waterfall method or waterfall approach. The main phases are gathering specifications/ requirements, design, implementation/ development, testing and maintenance. In some versions, there are additional stages of the observed traditional method, but the five listed are a mandatory set in each of the existing versions (McCormick, 2012, p. 3, 5, 6). From the point of view of IT projects, the project team spends a lot of time on the specifications/ requirements phase in terms of planning and design. As well, when the implementation / development phase

starts, there are no additional requirements, doubts or undefined parts of the project related to the final result. For this reason, projects that have a long duration are suitable for the waterfall approach/method (McCormick, 2012, p. 4-6).

Another traditional method considered in this paper is PRINCE, an abbreviation for Projects IN Controlled Environments. PRINCE2 is a traditional method that is considered a "process driven" method. It answers the questions 'what' and 'why', and partially the question 'how'. PRINCE2 was developed by the UK government, and recently the rights to use the methodology have been granted to the public-private company Axelos (Axelos, 2020)

The Project Management Institute (PMI, 2020) is an organization that has developed and maintains the PMBOK Guide. It is a methodology for classical project management, which is one of the strongest classical methodologies globally aimed at transferring good practices. This is also the case with the PRINCE2 methodology. PMBOK is considered a set standard or project management tool, and it is a set of knowledge and good practices when it comes to project management.

The PMBOK Guide and PRINCE2 are the most common classical project methodologies in projects globally and in Croatia. A Croatian survey (Fabac, Pihir & Radšević, 2009, p. 5). showed that only 16% of Croatian companies use the PMBOK or PMI standards, and they mostly combine approaches. Both methods have recently received an agile variant and a corresponding certificate (PMI, 2020 and Axelos, 2020).

Another well-known method that permeates all of the above is the Critical Path Method (CPM). It is based on a logical and mathematical model for projects. It is centred on determining the optimal time required for a particular process in a project and the simultaneous use of the most economical available resources, regardless of it being human labour, equipment, finances, etc. (Antill & Woodhead, 1991, p. 1,2,4,5, 8-10). The main advantage of CPM is that it determines the sequences that do not have adequate time/timing (critical path), and it recognizes the sequences of activities that have them.

The combined features of traditional methods are presented in Table 1 (according to Engelhardt, 2019, p. 15,16)

Table 1. Features of traditional methods

User requirements	Clearly defined at the beginning, during the first phases of the project
Size of the team	Larger teams
Inclusion of the client during the project	Very small (at the very beginning when the user gives his requests and finally, when delivering the final result / product / service)
Duration of the project	Long
Management	Based on command and control
Communications	Formal
Development model	Life-cycle model
The amount of risk and change	Minimum amount of risk and change

Agile methods are believed to have first appeared in IBM in 1957, but were developed in the mid-1990s as an alternative to traditional or standard methods. The agile approach or methods have several explanations. In terms of IT projects, they are interactive and incremental methods through which project requirements together with solutions are developed through the cooperation of multifunctional self-organizing teams (Islam, 2013).

The greatest emphasis in agile methods is placed on flexibility and a quick response to change. Likewise, agile methods are considered adaptive, saying that a project can move based on one idea but in the end, the result turns out to be something different from the original idea. When there is a change within the project itself, agile methods are the ones that adapt to them very quickly and that is one of the main reasons for their existence. When it comes to the course of developing the end result, teams working on agile principles are allowed to develop part by part the final product/service as they see fit. They decide for themselves which functionalities they take as a priority for the project. According to that prioritization, they take the features, either one by one or a smaller set of several of them, and develop them in iterations. For this reason, the team is considered to be self-organizing in agile methods (Islam, 2013). According to the authors (Merzouk et al., 2018, p. 3, 4) and their comparison of agile methods, it is necessary to observe team size, the project and repetitions (or iteration length) when choosing the correct agile method for a project.

Regarding the representation of agile approaches, the most common one is Scrum. Its representation can mostly be attributed to its simplicity in functioning. It is applicable to any type of project. Regarding the level of the entire company, it can be applied to the company's business policy and its global operations (Stellman, Greene, 2017, p. xii, 12). For example, a project manager can take on the role of scrum master or product owner, and then redefine his/her role and take on the responsibilities of the previous job (project manager) along with the responsibilities of the role he/she currently takes on. (Kothari, 2019).

In addition to the listed roles as well as the ceremony, the term “backlog” is an indispensable part of Scrum. There are product backlogs and sprint backlogs. A product backlog is a list of all the features of the end result that the team must develop in order for the result to be satisfactory. A sprint backlog is a set of

all the features that the product owner and his team decide to develop in the sprint that follows. The features themselves are taken from the product backlog, from which the features are taken in order of priority (Stellman & Greene, 2017, p. 4, 74).

Kanban is the second most famous agile method. It was created in the 1940s by Taiichi Ohno in Toyota. Kanban had its beginnings in Toyota's manufacturing process. Kanban is a method based on term 'just-in-time' production (Moondnen, 2011).

The visualization of work within the project and its activities is done using Kanban boards (Stellman & Greene, 2017, p. 280-281). A task board or a board that can be used in Scrum is used in Kanban to limit the work in progress in relation to a set of parallel activities per unit of time. It gives an overview of the entire work as a means to see the whole picture (Kniberg & Skarin, 2010, p. 15,16).

Scrumban is a method that combines Scrum and Kanban into one method. It takes the parts of Scrum and the parts of Kanban that are most applicable in practice and combines them to come up with a generally accepted method of project management. Scrumban is a very adaptable method that many IT teams opt for because it provides the advantages of sprint in Scrum and the visibility and necessary control from Kanban (Slović & Stojanović, 2019, p. 41).

Extreme programming (XP) was developed by Kent Beck and Ward Cunningham in the mid-1980s. This development followed as a part of their work in the Tektronix research group. After starting the idea, Beck embarked on the further development of Extreme Programming and added new principles and ways to apply the observed method to projects using the most important items: a) communication, b) simplicity, c) feedback and d) courage (Pap, 2008, p. 25-26, 31).

The way in which program code is created and regulated is achieved with many of the principles that XP explains as a part of its method. Some of them are: pair programming, feedback, joint code ownership, frequent and thorough testing, reliance on metaphors, 40-hour work week, and continuous integration (Tadić, 2005, p. 237, 242).

According to the author's work (Malik, Ahmad & Hussain, 2019, p. 656), the flexibility of agile methods is the most significant feature; whether it refers to Scrum, XP or other methods. In addition, they state that one of the problems of agile methods is that in more complex projects, parts of agile methods, such as meetings or phone calls, are necessary and can be difficult to implement in international teams that have different time zones.

XP as a project management method in fact puts more of its focus on software development or best practices for its development, while leaving aside, or assigning less priority to, best practices in how to achieve the entire project within a given budget and within defined deadlines. (Javanmard & Alian, 2015, p. 1391). To facilitate this application in projects of greater complexity, it is recommended to use project management software where according to the authors (Fabac, Radošević & Pihir, 2010, p. 466), it is possible to divide it into three categories: project management software, process management software and time tracking software.

The combined features of agile methods (according to Engelhardt, 2019, p. 15, 16) are found in Table 2.

Table 2. Features of agile methods

User requirements	They are not clearly defined. The end result is determined without the detailed features or complete vision
Size of the team	Smaller teams
Inclusion of the client during the project	Large (involvement is present throughout the project)
Duration of the project	All project lengths
Management	Based on leadership and cooperation
Communications	Informal
Development model	Evolutionary, iterative

Based on the characteristics listed below, the results of the case study are presented.

4 Results

The results of the main research were divided into two surveyed groups (project managers and team members), and demographic and general data on them were presented separately. The main results related to the methods were presented together for both groups of collected respondents. When it comes to general information on the respondents, the first observed characteristics are gender, years of experience and the highest level of education achieved. Figure 1 shows that within the case study company, regardless of whether or not the person is a project manager or team member, men predominate. Of the total number of respondents, 75% of the project managers are men, while 67% of the team members are also men.



Figure 1. Gender of respondents (left side – project managers, right side – team members)

Figure 2 presents the years of work experience of the respondents. It is evident, when it comes to project managers, that these respondents' work experience range evenly. 50% of them have 10 to 15 years of work experience and 50% have ≥15 years of work experience. On the other hand, looking at the respondents in the group of team members, it is evident that there is very diverse work experience. 33% of them have up to 5 years of experience. Likewise, 33% of them have 5 to 10 years of work experience, 25% have 10 to 15 years of experience, while only 9% have more than 15 years of work experience. From the comparison of these two graphs, the respondents in the group of project managers have more work experience than the respondents in the group of team members. This is expected considering the roles.

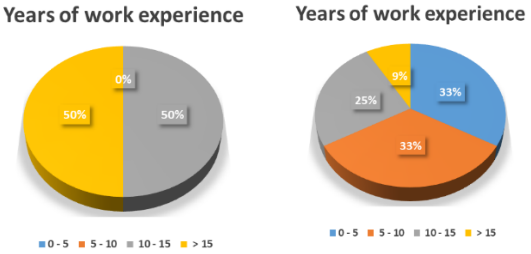


Figure 2. Years of work experience (left side – project managers, right side – team members)

Traditional and agile methods have great differences in their main features. Apart from the fact that their differences are visible in terms of the theory, the respondents confirmed that there are differences through their answers to the questions within the survey. Knowledge of the methods and answers given related to their features are considered credible given the number of projects they have completed or managed. The respondents' answers show that on average they worked on a large number of projects guided by agile methods. The average number of projects the respondents worked on with traditional methods is 4.4 projects, while the average number of projects completed with any of the agile methods is 7.9. Thus, respondents worked on almost twice as many projects with agile methods as opposed to those guided by traditional methods.

When it comes to the reasons for choosing a certain group of methods, the main three reasons given by the respondents are provided in Table 3.

Table 3. Reasons for choosing project management methods

Reasons for choosing traditional methods	Reasons for choosing agile methods
When it is known exactly what needs to be done during the project	When only the rough requirements and goals are known.
When a project cannot be split into smaller parts	When flexibility is needed
When the client does not have technical people to check individual parts, and is only interested in the final product	When it is expected that changes will occur during the project and it will be often

Although it was found that some respondents did not understand the reason for choosing certain types of project management methods, it was shown that they still understand the features of them. Most of the respondents answered the set questions correctly (according to theory) Once again, there is a case where the characteristics of traditional methods are the opposite of those of agile ones, which is shown in Table 4.

Table 4. Features of traditional and agile methods

Features of traditional methods	Features of agile methods
Size of teams	Teams of 4 to 7 persons
It is very hard to makes changes after the project starts	High level of flexibility
The phases are analysis, documentation, development/coding, testing, implementation and maintenance	The phases are initiative, iteration and the release of a portion of the product

Most of the research conducted on agile methods has obtained similar results. However, there are a few findings whose results have stood out. One finding is in the research conducted by Livermore (2008, p. 35). He found that when it comes to team sizes, there was no significant correlation between team size and the success of a method's implementation. He states that this is an unexpected result, considering that a large amount of research on the mentioned topic concludes that agile methods are less successful in larger teams.

Results like these support the fact that methods, especially agile ones, are adaptable to different teams and situations. Their flexibility is not only applicable in terms of responding quickly to additional requests, but they are themselves flexible in their adaptation over a team or project – in terms of team size, team role, and sprint length. The advantages and disadvantages of the observed types of methods, stated by team members (open-ended questions), are largely in line with the researched literature and generally coincide with the theoretical assumptions of other authors. This means that respondents in this case study are familiar with working on projects according to both approaches, and that the theoretical descriptions of the methods are accurate in relation to the practical application. The results regarding the comparison of advantages and disadvantages are shown in Table 5.

Table 5. Advantages and disadvantages regarding traditional and agile methods

Traditional methods		Agile methods	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Not a lot of time lost at meetings	Difficult to adapt to potential problems, less flexibility	Flexibility, quick adaption on changes	Fewer specifications and documentation
The requirements are known at the beginning	Slowness, sluggishness	Greater team involvement, members contribute with their own ideas	Potentially higher costs
Detailed specifications and documentation	Less expressiveness concerning the individuals ideas	Cooperation with the client	Difficult to hold deadlines due to frequent changes
Easy to predict problems	Rare deliveries	Frequent deliveries	Daily meetings can take up too much time

In the conducted research, four already mentioned characteristics of project management methods were observed and their evaluation was carried out on a scale from 1 to 5, where 1 represents the characteristic happens "very rarely" and 5 means the characteristic is "very often." In this part of the research, different approaches in traditional and agile methods are especially seen. The graphs in Figure 3 show the difference in team involvement, i.e. their contribution with their own ideas in different types of methods during a project. When it comes to traditional methods, most respondents said that team involvement with their own ideas is rare or happens only sometimes. Meanwhile, most of the same respondents agreed that team involvement is often or very often in agile methods. In observing the average response of the respondents, it is seen that the involvement of the team with their own ideas in traditional methods is rated at 2.2, while with agile methods it is rated at 4.2 (on a scale from 1 to 5).

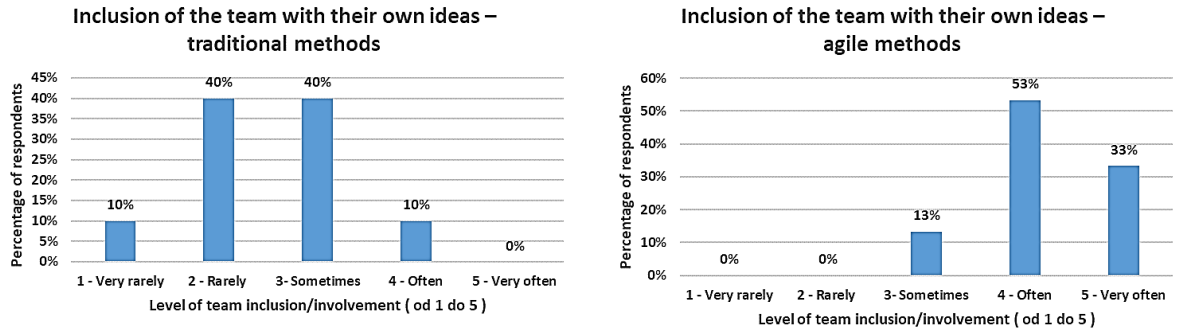


Figure 3. Inclusion of the team with their own ideas in traditional and agile methods

The situation is similar when it comes to the frequency of meetings (Figure 4) where respondents claim (as can be seen in the features, advantages and disadvantages they stated) that meetings are less common with traditional methods than with agile ones (where they are very common). This is ultimately considered an advantage, but it can also be a disadvantage. In the graphs in Figure 4, the average for traditional methods is 2.1, while the average for agile methods is 4.6 on a scale from 1 to 5. This confirms the assumption that with agile methods more time is needed for project meetings and much more frequent they are done .

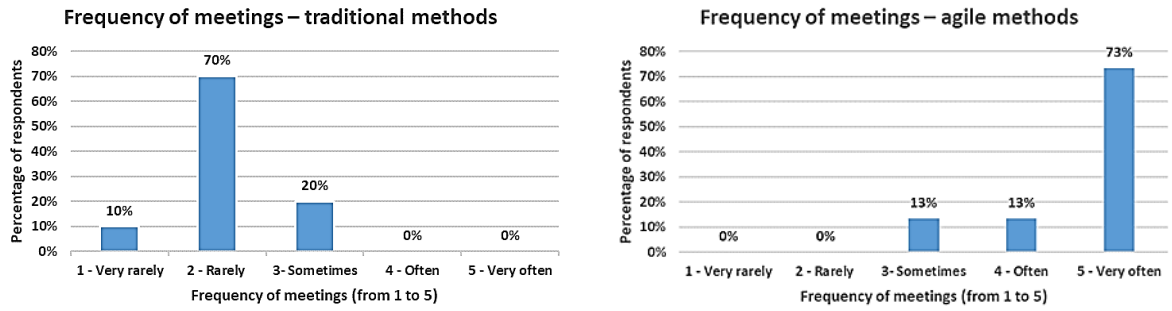


Figure 4. Frequency of meetings in traditional and agile methods

The frequency of changes (Figure 5) in the final product is closely related to the flexibility of a particular method. Respondents reported that agile methods are flexible while traditional ones are slow and sluggish.

According to them, their conclusion is that product changes during the project duration are rare in traditional methods, on average 1.7, while those in agile methods are often or very often, on average 4.2 (on a scale of 1 to 5).

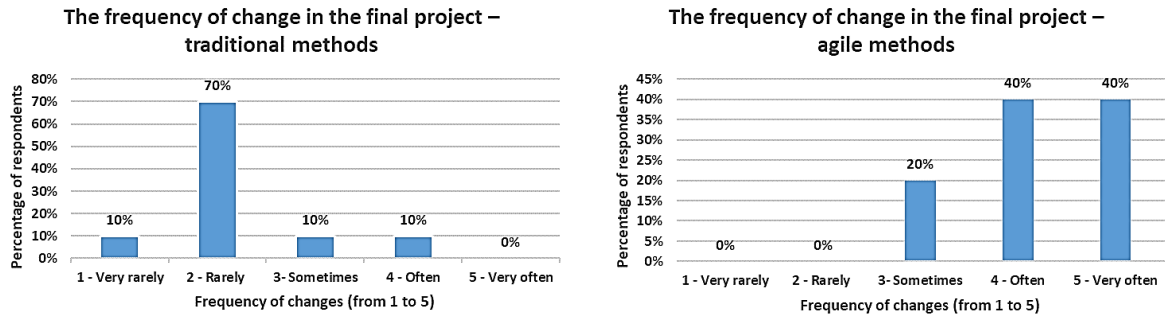


Figure 5. Frequency of changes in the final product in traditional and agile methods

Finally, the respondents expressed their opinion about the client's familiarity with the project during its implementation (see Figure 6). In the opinion of the respondents, on average the client is rarely familiar with the project in traditional methods. This means that the clients are only sometimes actively involved in the project. The average rating is 2.1. To the same question, but with reference to agile methods, respondents answered that familiarity with the project among clients is often or very often.

The average response is 4.2. This points to the need for the client to be involved in defining and redefining the requirements during the project, which is much more often the case with agile methods than with traditional ones. In traditional methods, it is considered that the requirements are defined at the beginning of the project and are usually not changeable during the project. The client does not have to be referred to the project or have expert knowledge in the project domain.

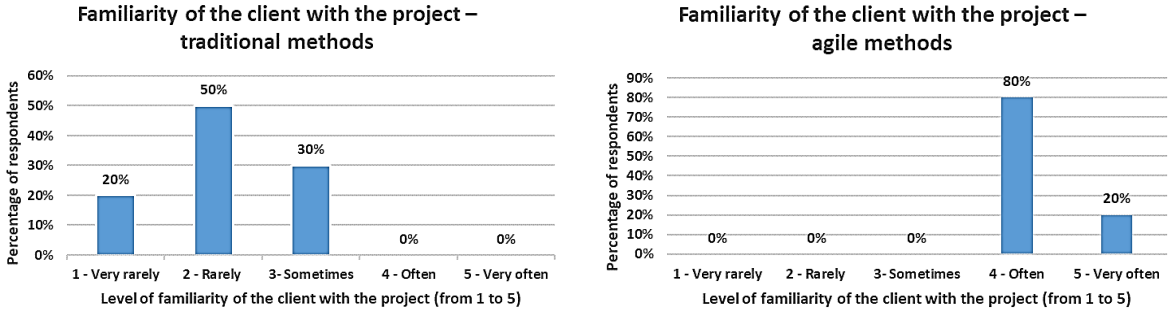


Figure 6. Familiarity of the client with the project in traditional and agile methods

5 Conclusion

When it comes to IT projects and methods that are more adequate to manage them, according to the results of the research, it is evident that the sample of employees agreed with the assumption that agile methods are a better choice in most IT projects compared to traditional methods. In most IT projects, not all requirements or characteristics of the results are known at the very beginning and a high level of flexibility of the project management method is needed in order to respond quickly and easily to these changes. Requests for IT solutions mostly come from other industrial sectors. The final requirements that would be sent to the client of an IT product or service are unclear even to them. Due to the lack of a clear vision regarding the solution and the requirements at the beginning of the project, difficulties and misunderstandings often occur. Traditional methods are limited in this sense because it is impossible to clearly define the project and project plan at the beginning and the results are visible only at the end of the project.

Thus, agile methods are ideal for these types of project results. They provide the mentioned flexibility and take into account frequent product changes. At the same time, greater client familiarity ultimately leads to greater satisfaction and the success of the project. Furthermore, agile methods are those where the project team is more involved in providing their own ideas. The team communicates more, and more freely, and it has a better response to client requests due to the existence of different opinions and views on a particular problem. This again leads to a more successful end result.

Of course, agile methods have their drawbacks. The biggest of them is certainly the frequency of meetings, where it is easy to spend a lot of time on them. There is also the lack of project documentation.

Ultimately, the choice of methods depends on the initial requirements and the product/service that the project team develops. There will always be projects within the IT sector whose management will be better served by traditional methods. However, in a broader context, agile methods are much more adequate for IT projects than traditional ones. This is supported by offers made by traditional institutions / certifiers / educators that work according to established traditional methods such as PMI, PRINCE2 and other globally known methodologies in which they offer an upgrade of their methodologies with agile approaches.

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The Impact of Influencers on Purchasing Decision Making Process - An Example of Croatian Social Networks Users

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Abstract. *Various factors influence consumer behavior and their purchasing habits. With the development of digital technology, the impact of these factors on buying habits of individuals is increasing much more every day. An individual goes through a certain stage of a purchasing decision making process, and when we combine that process with the need to belong to a certain group, usage of social networks has a significant impact on it. In this paper we will try to find out how big the impact of influencers on this process is and in which stage they impact the most.*

Keywords. consumer behavior, purchase decision, digital marketing, social networks, influencers

1 Introduction

Given that as much as 45% of the population actively uses social networks (Chaffey, 2019), it is obvious that companies want to use them to their advantage. The way companies interact with their consumers today has changed with the advent and development of social networks. Conducting marketing activities through social networks involves using these platforms to connect with company's audience, increase conversations, build a brand, boost brand awareness, launch a product, increase sales, improve SEO and generally drive internet traffic. This includes posting content on social media profiles, listening and engaging followers, analyzing results, and running ads on social networks (Buffer, no dat.). But nowadays, also influencers are often opted or forced to conduct those marketing activities through social networks. And this term is gaining in importance as social networks themselves evolve. Based on this presumption, we choose to conduct research to get some insights and to find out how influencers on the Croatian market impact on consumers' purchasing habits and at what stage of the purchasing decision making process their role may be the significant, if any. In this paper we presented results of a quantitative research conducted on Croatian consumers, users of social networks, in order to get answers to the stated research problems.

2 The Concept and Historical Development of Influencer Marketing

There are many definitions of influencer marketing, but almost all draw similar conclusions. Kling (2017) says influencer marketing is *"a type of marketing that focuses on using key leaders to drive a brand's message to the larger market"* rather than marketing directly to a large group of consumers. Sammis et al (2015) define influencer marketing as *"the art and science of engaging people who are influential online to share brand messaging with their audiences in the form of sponsored content"* while influencer marketing is viewed by Word of Mouth Marketing Association (WOMMA) as *"The act of a marketer or communicator engaging with key influencers to act upon influencers in pursuit of a business objective."*

It should be borne in mind that companies have always used celebrities as a way to increase brand awareness and perception, as people tend to trust celebrities they admire and sometimes want to be just like them. According to the literature, the beginnings of influencer marketing goes back to history when the pope and the queen promoted medical drugs to people who did not yet believe in them (Sammis et al., 2016). It can be said that since then, companies have started working with celebrities to promote their own products. Influencer marketing is similar in concept but has introduced a new way of defining celebrities. In addition to television and movie stars, professional athletes and musicians, there is a new kind of celebrities in the world, celebrities of social networking kind. People can build large, engaged audiences on social networks, such as blogs or Facebook, Twitter, YouTube, Instagram and other virtual communities. Their influence is similar to that of celebrities (Sammis et al., 2016).

In doing so, Brown and Hayes (2008) define influencers, as *"a third party who significantly shapes the customer's purchasing decision, but may even be accountable for it"*. According to Roope, Müller, and Brocke (2017), an influencer is *"a third party who significantly shapes the opinions and purchasing decisions of other customers"*. Mediakix (2016)

considers the influencer to be *"an individual with a large social reach that has the power to influence the decisions their audience makes"*. By building an engaged audience that follows them on social media channels, influencers can become powerful brand advocates as they promote and make a product or service relevant to their audience. They represent the voice that the consumer trusts when expressing opinions about a particular brand and experience with that product or service, that is, they represent one of the reference groups in an online environment.

2.1 Characteristics and Role of Influencers

While anyone can work with influencers to drive sales, having a true understanding of those in the brand niche and finding the right brand influencer can help campaigns reach maximum efficiency and authenticity. To identify influencers on social media that will have the biggest impact on a brand campaign, marketers first need to identify their target audience and then consider the types of topics, blogs, videos and multimedia that will generate the most engagement (Mediakix, 2016). Other factors companies should consider when choosing influencers, include: demographic - who follows them?, reach - how many followers or views?, engagement - do their followers comment, like and share content?, brand experience - do they have brand experiences as influencer?, frequency of posts - how active are they on your channel?, past campaigns - how well have your past campaigns been executed? (Mediakix, 2016). These questions must be answered by companies, given that partnering with the wrong influencer can lead to a weak campaign or damage a brand's message or reputation.

The power of persuading an influencer is based on its personality and positive character traits, which over time have contributed to image building. An ideal image of influence combines qualities such as credibility, trust, originality, and charisma. By combining them, individual profile of an influencer is developed (Deges, 2018).

- Credibility - Social network members expect the influencer to make recommendations only when he/she is confident in the products and uses them in their daily lives. Anyone who communicates with a high level of expertise on a particular topic is recognized and appreciated. Professional status is even more credible if the influencer's activity is linked to his profession and people's passions will trust them more. Therefore, credibility is about the coincidence of speech and action.
- Trust - Trust reduces subjectively perceived risk in purchasing decision process. The community trusts the influencer, recognizing him/her as an independent and neutral guide. Loss of confidence occurs if he/she does not act in accordance with its recommendations. Companions are aware of the fact that influencers work with companies, but this does not necessarily undermine trust unless the impression is given that the recommendations are "bought in" and do not reflect the influencer's beliefs. The influencer must announce its advertising partnerships and mark promotional content. Also, trust can be compromised if promotional content does not fit into organic content, if multiple companies are simultaneously advertised and there is a rapid change in advertising partnerships in the same product category.
- Authenticity - Authenticity indicates the type of information and communication. Over the years, influencers have developed their own individual style by emphasizing information in an unbiased and open manner. Originality, that is, authenticity, means passion and enthusiasm. Ideally, the influencer should also be seen as a fan of its own profile. Because many of them appeal to young communities, it is also about the right language and style.
- Charisma - Influencers can be ordinary people whose reputation and popularity is built upon their social media activities. They don't have to be artists, athletes, musicians, film, television and broadcast stars who are well known to the public and ubiquitous with their appearances in the media world. Influencer's strong characteristic is his/her personality in the digital world. They nurture their exposure there and do not look like foreign, inaccessible people to many followers because they seem to speak honestly and personally about their lives, giving their followers a sense of belonging to them.

The most successful influencers are not necessarily the ones who have the most followers or fans. Therefore, when choosing influencers who stay true to their style and those who offer carefully compiled, companies or their brands need to take into account the quality and relevance of content of their followers will give them much more. The influencer must be original, passionate, and authentic and strive to promote the products he really would use and knows more about. Because of this, the true influencer does not exactly present everything that is offered to him but should carefully choose which brands to represent. Depending on what he/she has already promoted, the audience assesses him/her as a reliable source of information and decides whether to trust them or not (Business Journal, 2018).

According to Deges (2018) there are several influencer classifications, one of them is social divisions used by influencer, so there are bloggers (writing their own blog and communicating with followers via text content and images through their blogs), youtubers (having their own YouTube channel where they interact with their followers with visual and audio content posted on their YouTube channel), instagrammers (use Instagram to communicate with

their followers through pictures and short texts and videos posted on their Instagram profile), etc. But today, most influencers are operating across multiple social networks or platforms to gain more reach, so it is difficult to say that they are only in one of these categories. Also, Deges (2018) gives one classification of influencer based on type content or topic they cover, as most influencers focus on one topic of their interest. Therefore, there are fashion bloggers, lifestyle bloggers, travel bloggers, fitness bloggers, food bloggers, etc.

However, most commonly, influencers are classified into four main categories, namely: mega, macro, micro and nano influencers (Ismail, 2018; Stevens 2017). Mega-influencers are the highest ranked influencers, usually having more than one million followers. They often have a very diverse audience with different topics of interests. Their relationships with an individual follower is more distant than it is the case in other categories. They are not necessarily experts in a particular topic, but they certainly have a greater reach. Mega-influencers are, for example, actors, artists, athletes, and social media stars who use influencer marketing as a secondary source of revenue to monetize their fame. Macro-influencers mostly have between one hundred thousand and one million followers. They gained fame through the internet, such as through vlogging or by producing funny and inspiring content. Macro-influencers can be executives, bloggers and other professionals who make money as influential people and generally show expertise in a particular industry, such as business, lifestyle or fashion. A micro-influencer is someone who has between one thousand and one hundred thousand followers and don't often boast celebrity status. They are focused on a specific niche or area and are generally considered to be an industry expert or certain subject matter expert. Micro-influencers have stronger relationships than typical influencers because these are everyday users or employees who have a relevant influence and may not know it or seek to become a macro-influencer. Their influence is fueled by the power of relationships within their networks. Lastly, nano-influencers are a relatively new type of influencer. They tend to have a smaller number of followers in comparison to micro-influencers, less than a thousand followers to be exact. A nano-influencer is someone who has influence in the local neighborhood or their community. Some examples might be a local pastor, a local community leader, or a local government leader or it can be said that in this category of influencers it is about ordinary, regular everyday people.

3 Research

Based on the secondary data, a questionnaire was created as an instrument for primary data collecting. The primary, quantitative data were collected through a questionnaire, distributed on social networks, since social media users are the primary target group of influencers (a non-probability sampling technique, convenience sampling). The questionnaire was completely anonymous and available from April 2019 to June 2019 on social networks. Questionnaire consisted of 20 questions divided into categories (social networks, purchasing decision making process, influencer impact on that same process and demographic characteristics). Most of the questions were closed-ended questions where respondents had to choose from multiple answers offered. The questionnaire was accessed total by 276 respondents, of whom 197 responded fully to all questions and their statistical analysis was presented below. The main goals of this research were to find out to what extent social network users are familiar with the concept of influencers, how many influencers they follow, and how ultimately influencers affect their purchasing habits, especially on each phase of the purchasing decision making process itself.

At the beginning, the results of the demographic characteristics are presented in table 1, using the absolute and relative values. The table shows that there are more female respondents, 164 (83,25%), that more than half of the respondents (52,28%) are in the age group of 18 to 23 years old, which is why in the sample we have the highest number of students (51,78%). Regarding the region in which the respondents are located, there are by far the most from Northern Croatia, 89,34%. It is on the basis of these results that we can see potential limitations of this research, so before showing other results it can be concluded that the results in this paper cannot be generalized to the entire population and the entire Republic of Croatia.

Table 1. Demographic characteristics of the respondents (Source: Research)

Variable	Category	Number of respondents (N = 197)	Percentage of respondents
Gender	Male	33	16,75%
	Female	164	83,25%
Age	18-23	103	52,28%
	24-29	40	20,30%
	30-35	14	7,11%
	36 and more	40	20,30%
Education completed	No college education	0	0%
	Primary school	6	3,05%
	High school graduation up to 3 years	40	20,30%
	Four Years High School	97	49,24%
	Higher education, college	49	24,87%
	Master's Degree, Ph.D.	5	2,54%

Region	Zagreb and surroundings	19	9,64%
	Northern Croatia	176	89,34%
	Slavonia	1	0,51%
	Lika, Kordun and Banovina	1	0,51%
	Istria, Primorje and Gorski Kotar	0	0,00%
	Dalmatia	0	0,00%
Status	Student	102	51,78%
	Employee (full-time or part-time)	74	37,56%
	Housewife	10	5,08%
	Unemployed	4	2,03%
	Retired	4	2,03%
	Other:	3	1,52%

The first category of questions was related to the social networks themselves, how familiar they are with the term influencer, and what content they like to follow. The first question was whether the respondents included in the sample use social network. 195 of them answered that they use social networks, which makes 98,98% of respondents, while only two respondents from the sample (1,02%) does not use social networks. The following question builds on the previous one and the respondents had to answer which social networks they use. In this question, the respondents could mark all the social networks they use, and under "Other" they could write some that were not offered in the question itself (Figure 1).

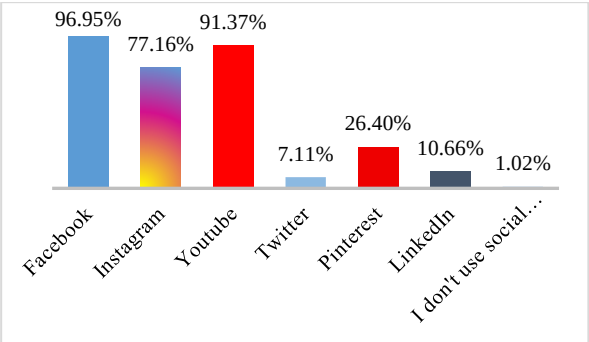


Figure 1. What social networks do you use? *(Source: Research)*

Figure 1 shows that most respondents use Facebook, 191 of them (96,95%), and YouTube users follow by 180 (91,37%) of respondents. The third most used network in this case is Instagram, 152 (77,16%) of respondents use this social network. Interestingly, more than half of the respondents (61,84%) who use Instagram are in the 18 to 23 age group. Which would mean that out of the total number of respondents from the age group of 18 to 23 (103 respondents), 94 (91,27%) have an Instagram profile, while only 9 of them don't, which is in line with the aforementioned claims that Instagram is very popular within younger population. The few respondents use Twitter, 14 of them (7,11%), although Twitter is also one of the social networks on which influencers are very active. Some of the other social networks mentioned by the respondents were Tumblr, Discord, Whatsapp, Snapchat.

The next question was about the time they spend on social networks. According to the results, 38,07% of respondents spend between two and three hours on social networks, while 33,50% of them spend more than three hours on social networks.

This was followed by a question regarding whether the respondents had heard of the term influencer. Interestingly, almost all respondents were active on social networks, and probably encountered some influencer postings, but not everyone was familiar with this term, at least they offered such answers. 180 of them (91,37%) are familiar with this term, while 17 (8,63%) are not. It is interesting that out of the total number of male respondents (33 respondents), as many as 7, which is 21,21%, did not hear about the term influencer, while on the other hand, only 10 (6,10%) of the total number of female respondents did not hear for influencers. When asked how they found out about the researched term, the majority of respondents, 149 (75,63%) answered that they heard about this term through social networks and circles of people with whom they share common interests. The respondents then had an open-ended question where they had to indicate which influencers they had heard about. Among the respondents, the most prominent were the names of Croatian influencers, such as: Ella Dvornik, Andrea Andrassy, Sonja Kovač, Jelena Perić, Martina Bosčić, Jelena Veljača, Ivana Blažoti Mijoč and Ana Ude. In addition to the domestic influencers, the Kardashians, Kylie, and Kendall Jenner sisters, followed by Carli Bybel, Chiara Ferragni, Isabella Fiori and many others.

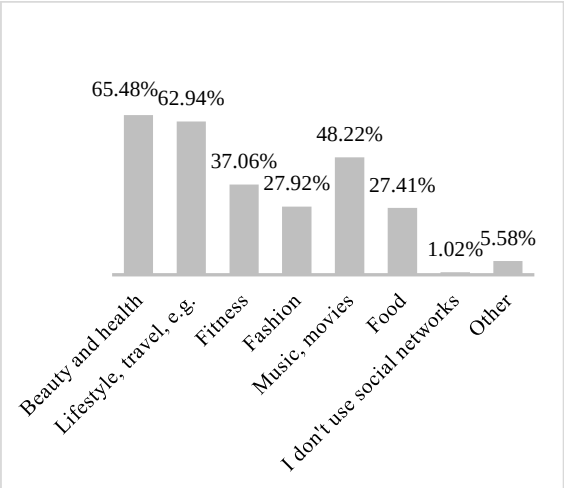


Figure 2. What type of content (product / service categories) do you follow the most on social networks? *(Source: Research)*

This was followed by the question of what type of content (product/service categories) the respondents follow the most on social networks. Figure 2 shows that most respondents like to follow content on beauty and health (65,48%), lifestyle and travel (62,94%), music and movies (48,22%), slightly less follow fitness, fashion and food products. Respondents had the opportunity to indicate in the "Other" some other areas, which also included children's facilities, design, interiors and exteriors, games, creative ideas, recipes, sports, animals, cars and e.g. It can be seen that almost all types of content are equally represented among the respondents, that is, respondents from the sample like to follow diverse content regardless of age, gender or other characteristics.

Below (in table 2) are the results with respect to the statements with which the respondents were required to express a degree of agreement (according to the Likert scale). Statements are created according to collected secondary data and previous research findings. The table also shows the mean scores for each of these statements.

Table 2. The degree of agreement with consumer claims *(Source: Research)*

STATEMENT	1	2	3	4	5	I can't evaluate
When deciding to buy products/services, I look for information on social networks.	10,66%	6,09%	34,01%	27,92%	18,27%	3,05%
Recommendation for a product/service from family and friends is important to me.	4,06%	8,12%	17,77%	40,10%	29,44%	0,51%
Product posts on social networks affect my purchase.	12,18%	13,20%	36,55%	24,37%	12,18%	1,52%
I'm willing to pay more if the product/service is promoted through social networks.	30,96%	27,92%	23,86%	10,15%	5,58%	1,52%
When making a buying decision, I trust influencers.	19,29%	22,34%	38,07%	11,68%	4,57%	4,06%
The number of subscribers is important to me when following influencers.	31,47%	20,30%	24,37%	13,20%	8,12%	2,54%
It is important to me that influencer provide quality product/service information.	12,18%	8,63%	17,77%	28,43%	29,95%	3,05%
The paid posts diminish my confidence in influencers.	12,18%	11,17%	34,01%	17,77%	17,77%	7,11%
If a certain influencer gives a negative review about a product, I will stop using it even though I like it.	51,78%	19,80%	18,27%	5,58%	2,03%	2,54%

Table 2 shows the results of the respondents' answers to the stated claims, related to the topic and objectives of the conducted research. What is important to point out is that for the respondents are, on average, the most important recommendation from family and friends when considering buying a product or using services, so that the primary reference group that stands out through the existing literature, stands out as the most important in this research. That is confirmed by the respondents and a mean score of 3,83 for the statement "Recommendation for a product/service from family and friends is important to me.". Regarding the topic of this research, how influencers and social networks generally influence their shopping habits, it can be noticed that on average respondents are hesitant about the impact of social media posts and their influence on purchases, which was confirmed by a mean score of 3,11 for that statement. On the other hand, to what extent influencers influence the purchase decision, it can be noted that on average for respondents' influencers are irrelevant, as shown by the mean score of 2,58.

Following these results, it is also important to analyze specifically at what stage of the purchase decision making process influencers have a strongest impact on respondents. The respondents' responses from the observed sample can be seen in Table 3. The impact on purchase decision making process was estimated by the Likert scale, where rating 1 implies that influencer has no influence at all, while rating 5 meant that influencer has the greatest influence on that stage of the buying decision process.

Table 3. Impact of influencers on each stage of the buying decision process *(Source: Research)*

STATEMENT – The extent to which influencers affect a particular stage of the buying decision process	1	2	3	4	5	I can't evaluate
Knowledge of need / Spotting the problem	15,74 %	13,20 %	45,18 %	17,77 %	4,57 %	3,55 %
Searching for information	7,61 %	9,14 %	39,59 %	31,47 %	9,14 %	3,05 %
Evaluation of alternatives	8,12 %	12,18 %	40,61 %	27,92 %	6,60 %	4,57 %
Purchase decision	10,15 %	11,68 %	44,16 %	24,87 %	3,05 %	6,09 %
Post-purchase behavior	14,21 %	14,72 %	38,07 %	20,81 %	4,06 %	8,12 %

From these results, it can be concluded that influencers have the greatest impact on the information seeking and evaluation phase with average scores of 3,26 and 3,13. Although it should be taken into account that from the perspective of the respondents this impact is not so great, that is, on average, they think that impact neither affect nor influence them. Which confirms obtained results, so according to these results on average, respondents do not trust influencers when making a purchase decision (the average rating for the stated claim is 2,58).

Respondents were also asked if they purchased a product simply because it was promoted by a particular influencer. Figure 3 shows that the majority of respondents, 154 (78,17%) have never purchased a product or used the service simply because it was promoted by a particular influencer, while six (3,05%) did not want to answer this question. Those who answered the question in the affirmative were able to indicate which product/service was/were and if they were satisfied. Most of the respondents answered that they purchased cosmetics and other products of decorative cosmetics, body care products, and fashion and textile products and other similar products. An interesting fact is that all respondents were generally satisfied, satisfied or delighted with the products purchased and promoted by influencers.

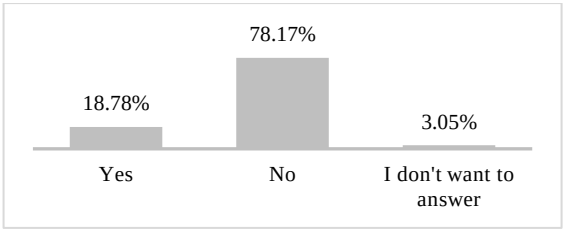


Figure 3. Have you ever purchased a product or used a service just because it was promoted by a particular influencer? *(Source: Research)*

The last question in the questioner was regarding whether respondents consider influencers a cost-effective form of promotion. More than half of the respondents, 103 (52,28%) of them consider influencers as a cost-effective form of promotion, while 37 (18,78%) respondents think that they are not cost-effective, as can be seen from Figure 4. It is also interesting to note that a large number of respondents (57, i.e. 28,93%) do not know whether influencers are a cost-effective or non-viable form of promotion. One possible reason for this may be the fact that influencers do not publicize how much they earn on publication, so consumers are not aware of how much a brand pays influencers to promote them. Likewise, it is difficult for consumers to estimate how many people choose to buy a particular product or use the service simply because it has been promoted by a particular influencer.

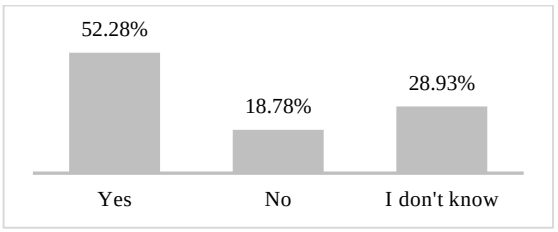


Figure 4. Do you consider influencers as a cost-effective form of promotion? *(Source: Research)*

4 Conclusion

A well-known fact is that consumer's behavior is influenced by a large number of factors which are primarily divided into social and personal factors. But it is important to keep track of what is happening to them with the development of technology and the increasing use of technological tools on a daily basis by consumers. This paper illustrates how influencers, as one of the reference groups that have evolved with the increasing role of social networks, are affecting consumers' purchasing habits, or whether they have any influence on them at all. Our main findings are presented through the analysis of the results obtained by quantitative research.

The paradox that the research points out is that influencers are being monitored by respondents, but they believe that they have no influence on their purchasing habits, that is, on the purchasing decision making process itself, and at no stage in this process. Therefore, future research should examine this paradox more closely and see what the reasons for monitoring influencers may be, whether a sense of belonging to a particular group, tracking trends to keep up with everything, or something else. Future research could also avoid the limitations of this research, which are primarily related to the research sample itself, which does not allow generalizing the data obtained to the entire population.

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Intelligent Information Systems

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Emerging Opportunities for Education in the Time of COVID-19 - Adaptive e-Learning Intelligent Agent Based on Assessment of Emotion and Attention

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Emerging Opportunities for Education in the Time of COVID-19 - Adaptive e-Learning Intelligent Agent Based on Assessment of Emotion and Attention

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Abstract. *The COVID-19 pandemic is a disastrous and rapidly evolving situation. It brings changes to many aspects of life, including teaching. A very important area for improvement of e-learning pedagogies is the ability to assess student engagement and the learning curve objectively and continuously. To this regard, we propose a novel procedure for personalized and adaptive assessment of learning performance based on methods for automated estimation of affective states. In this preliminary report we envision an intelligent agent which constantly monitors students' behaviour parameters during online learning classes. Using unobtrusive video surveillance and machine learning the agent appraises key psychophysiological features related to emotion and attention.*

Keywords. digital learning, adaptive learning, technology enhanced learning, intelligent algorithms, emotion recognition

1 Introduction

Coronavirus disease 2019 (COVID-19) is a global pandemic unprecedented in modern times. It is forcefully changing all aspects of everyday life. However, in this adverse course of events, new opportunities arise for adaptation and improvement. In this regard, online learning or e-learning is quickly emerging as the predominant education paradigm. Schools are literally forced to shift academic activities online and away from customary methods of teaching. It has previously been shown that technology can enhance learning in and out of the classroom, especially by impacting student interest, motivation, and engagement (Jagušt, Botički & So, 2018). In traditional education paradigms feedback on education, quality is obtained through various knowledge assessments and student questionnaires. However, although commonplace and straightforward, these methods are also generic and largely unsuitable for learning personalization (Jagušt & Botički, 2019).

Adaptive learning provides personalized learning experience with the goal of optimizing learning efficiency, increasing student engagement, and addressing specific needs, interests, or preferences of each learner (Hsiao, Sosnovsky & Brusilovsky, 2010). Adaptive pedagogies are of the most discussed topics in the field of technology-enhanced learning (Kirschner, 2017). It is advocated to help balancing different abilities, learning speed, skills, and to improve student engagement, interest, and knowledge (Shute & Zapata-Rivera, 2012).

New unobtrusive video sensor technologies enable monitoring and qualitative measurements of learners' facial expression features and gaze points, which can uncover nonverbal cues related to the success of e-learning education paradigms (Li et al., 2016). These traits related to emotional and cognitive functioning are involuntarily expressed during learning sessions. Detection of such indicative features for all students in a class may be very time-consuming in practice, and thus exceptionally difficult even for the most experienced educators or almost impossible for a novice. However, these visual features may be extremely valuable indicators for the successful learning paradigm, adaptation, and personalization. The additional information could help in avoiding potential misinterpretation, and even misunderstanding of students' behaviour, better evaluation of the acquired knowledge, and achieved levels of proficiency during a series of online learning sessions.

For this paper, a software application has been developed written in C#.NET computer language for emotion detection from facial features using the Active Shape Model (ASM) method. Face localization and extraction is accomplished with Microsoft Azure Cognitive Services API. Although a number of technologies for estimation of emotion and attention are available as commercial-of-the-shelve (COTS) components, an integrated recommendation system for e-learning conceived as an adaptive intelligent agent – and described in this preliminary report – cannot be commercially acquired.

2 Related Work

In the literature, there are several previously published research papers on the topic of student engagement and attention in classrooms, such as (Henrie, Halverson & Graham, 2015) (Thomas & Jayagopi, 2017). It has been long established that estimation of long-term student engagement in the learning process is needed in order to evaluate courses and improve learning results (Fredricks et al., 2011). This evaluation is usually done through questionnaires, but with the proliferation of modern e-learning, it became possible to collect implicit usage data to estimate the activity and engagement of students or children within learning activities (Martinez et al., 2015). A review of research on the measurement of student engagement in technology-mediated learning (Henrie, Halverson & Graham, 2015) has provided a review of quantitative and qualitative observational measures (instruments) to measure behavioural, cognitive, and emotional indicators of student engagement. Attention was classified as one of the factors of cognitive engagement, while interest, anxiety, and boredom contributed to emotional engagement. Attention is best described as the sustained focus of cognitive resources on information while ignoring distractions (Myers, Stokes & Nobre, 2017). For a recent review of pedagogical guidelines for the creation of adaptive digital educational resources see (Rozo & Real, 2019).

In the field of education, the terms of sustained attention or vigilance describe the ability to maintain concentration over prolonged periods of time, such as during lectures in the classroom. Pedagogical research is often focused on maintaining student attention (i.e. concentration, vigilance) during lectures because sustained attention is recognized as an important factor of the learning success (Al-Shargie et al., 2019). However, tracking of individual students' attentive state in the classroom by using questionnaires is difficult and interferes with the learning process, which is also the case for using psychophysical data sensors (Chen, Wang & Yu, 2017).

Besides the estimation of engagement and attention, automated measurement of affective parameters in the general public has also been intensively researched. Importantly, it has been proven that the automated estimation of emotional states is feasible in practice and can be used to make valid conclusions on perception, behaviour, attention, and emotion (Ćosić et al., 2013).

Non-intrusive visual observation and estimation of affective parameters is commonly using recorded video (RGB) signal, for example, to estimate student engagement from facial expressions (Monkaresi et al., 2016). A number of studies have been reported on automatic emotion estimation methods using various physiological channels (video, EKG, EMG, eye tracking, ...) in off-line and real-time settings (per example (Shu et al., 2018) (Lim, Mountstephens & Teo, 2020) (Kukolja et al., 2014) (Horvat et al., 2018). Eye tracking devices are very successful in measuring affective parameters such as concentration in the computerized learning environments. In (Tonguç & Ozkara, 2020) computer vision methods are used to register faces and estimate student emotions from facial expressions during a lecture. This study deals with the engagement of a single student during computerized learning which exactly corresponds to the types of pedagogies used during the COVID-19 pandemic. The above cited reviews of affect estimation methods emphasize the importance of face gaze and facial expression as clues to assess cognitive engagement or inattention of students.

In addition to a low-cost HD camera, Microsoft Kinect One is potentially very beneficial type of sensor because it provides advanced capabilities to detect facial features and face gaze. However, this device is much rarer and more expensive than nowadays ubiquitous built-in cameras. In a thorough and methodical study, Kinect sensor has been used to predict students' attention in the classroom (Zaletelj & Košir, 2017. Attention of students has been successfully modelled using eye tracking sensors (Veliyath, 2019), and types of attention have been classified with trackers operating in the thermal part of the spectrum (Abdelrahman, 2019). Also, in a recent research, visual attention has been unambiguously correlated to the observed visual features (Moroto, 2019). The gaze direction has been detected from combined video and depth signals (Hong et al., 2018) and utilized in the visual attention model to estimate human-to-human interaction. In one system using artificial neural networks, student-student behaviour has been classified using a spatio-temporal model from sequences of digital images (Jalal & Mahmood, 2019).

3 Estimation of Emotions and Attentions Based on Facial Expressions

Facial expressions can be considered as aspects of both an emotional response to certain stimuli and of social communication. Facial expressions are shaped through muscular activity, which is driven by complex underlying neurobiological mechanisms that are still being intensively researched (Ćosić et al., 2015). The process of facial expression recognition involves linking visual representation of the face, reflecting a generation of knowledge about the category of emotion that it belongs to.

Facial expressions are a rich source of information in the process of understanding emotions, which can be represented as a complex psycho-physiological and mental state that consists of various multimodal responses (physiological, vocal and acoustic, facial, etc.). Based on the similarity of facial responses, induced by a group of stimuli with similar emotional content, they can be divided into different disjoint

categories (discrete emotional states). The categorization process is of paramount importance in a social communication environment, due to the high informational complexity and rapid behavioural response to facial emotions.

The first step in the estimation of emotions from facial features using visual sensors is to detect a human face in a video. To do this, the incoming video stream is sampled into frames. Individual static pictures are then evaluated separately. The relation of two pictures in terms of detected objects or emotions is not necessary. The Viola-Jones method is efficiently used for face detection in the literature (Deshpande & Ravishankar, 2017). The result of Viola-Jones detector is a rectangle that envelopes the region of the sampled video frame, most probably, containing a human face. After faces in a scene have been identified, the system can proceed to recognize facial features and estimate emotions from each sampled frame. An example of facial detection is in Fig. 1. Microsoft Azure Cognitive Services (Microsoft Azure Services, 2020) offers computer software developers a convenient tool for facial detection that can be easily integrated with different application architectures.



Figure 1. Face detection using Microsoft Cognitive Services API with the accompanying JSON code defining one of the face boxes in the picture.

Facial feature extraction is based on relative displacements of main anatomical region that are coded by the Active Shape Model (ASM) method (Le & Savvides, 2016). ASMs are statistical models that iteratively deform according to the current shape of object in the picture. The ASM method has two steps: 1) training based on examples, and 2) model fitting. The training is usually done by methods such as Principal Component Analysis (PCA) (Deshpande & Ravishankar, 2017). The variation of the shape of the model depends on variations of the position of facial points in the learning set. In doing so, the shapes created by the variation of a neutral face are in accordance with the contribution of each eigenvector in the total variance of the learning set. Fitting of the ASM is an iterative procedure that attempts to find a set of transformation parameters (e.g. scaling, translation, rotation) so the initial form of the ASM is as close as possible to the defined facial points. The procedure stops if at least one halting condition has been met: 1) the difference in the parameters of two consecutive iterations is below of a certain threshold, or 2) the maximum number of iterations has been achieved.

Based on their visual appearance, face emotions can be represented by a set of geometric properties (i.e. spatial features), which describe both position, movement direction, and temporal dynamics of main anatomic structures of the face. A technique for measurement of facial movements which is still used today has been described in (An et al., 2017). In this system, human facial expressions, better known as Facial Action Coding System (FACS) have been taxonomized (Rosenberg & Ekman, 2020). The FACS encodes various movements of individual facial muscles which are called Action Units (AUs). Action Units are a standardized form of describing visual movements of particular anatomical face regions. The presence of specific AU can be detected by observing the spatial characteristic of a certain related morphological structure of the face expression with regard to the corresponding spatial characteristic in the neutral face. Neutral face is a special representation of spatial properties of main anatomical regions of the face where the mouth is closed, the gaze is directed perpendicular to the screen plane, eyes are open and the eyelids are tangent to the iris (Sun et al., 2016). In total there are 46 main AUs which are used for coding movements of facial muscles.

Facial expressions of six basic emotions (or norms as they are also called) are demographically and culturally independent (Ekman & Friesen, 1971). A set of AUs describing spatial characteristic of face regions for basic emotions has also been established. The list of AUs relevant to the six basic norms adapted from (Ekman & Friesen, 1971) is listed in Table 1. Primary AUs must be present for an expression to be classified. Auxiliary AUs do not have to be detected but they will increase belief in the classification.

Table 1. List of AUs relevant for estimation of the six basic emotions. Adapted from (Ekman & Friesen, 1971).

Norm	Primary AUs	Secondary AUs
Happiness	6, 12	25, 26, 16
Sadness	1, 15, 17	4, 7, 25, 26
Disgust	9, 10	17, 25, 26
Surprise	5, 26, 27, 1+2	
Anger	2, 4, 7, 23, 24	17, 25, 26, 16
Fear	20, 1+5, 5+7	4, 5, 7, 25, 26

As an example, the difference between spatial features of a neutral face and expression of happiness is shown in Fig. 2. As can be seen in Fig. 2, and from Table 1, the expression of happiness is identified with two primary action units AU6 ("Cheek raiser") and AU12 ("Lip corner puller"), and one secondary action unit AU16 ("Lower lip depressor"). Apart from detecting specific action units, Euclidian distance between corresponding points on the face can be measured. By doing this it is possible to measure intensity of facial expressions and related emotion with a larger distance being positively correlated with an increased emotion intensity (Ćosić et al., 2013).

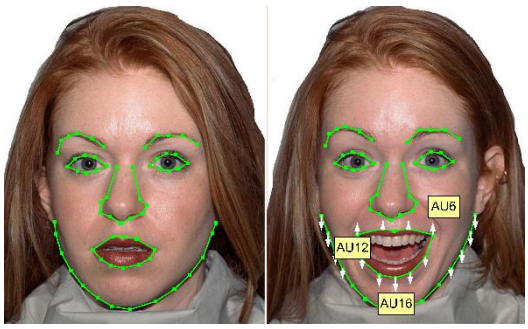


Figure 2. Comparation of spatial features between a neutral face (left) and expression of happiness (right) with affiliated AUs.

Students' attention may be estimated through observation of eye movements during e-learning course. It has been established, per example (Ono & Taniguchi, 2017), that the number and duration of fixations are larger and longer for attention grabbing targets than for non-targets. Further, the probability of first fixation is higher for a target than provokes an emotional reaction than for a neutral target. The exact relationship of gaze patterns and displayed course content must be established once the e-learning intelligent agent has been developed and tested. Gaze estimation tools exist today that are already quite capable (Lasa et al., 2017). Using commonplace visual sensors novel tools can discriminate facial features and gaze direction in high resolution, and in ambient lightning conditions. A limiting factor to these methods is that they recognize facial expressions only within certain limits (the so-called headbox). Still, the freedom of movement is still sufficiently large for students to be relatively unrestricted – at least in terms of a normal range of movement while watching an online class on the screen.

4 Adaptive e-Learning Intelligent Agent Based on Assessment of Emotion and Attention

Captured video stream transmitted to other participants is continuously analysed by the intelligent agent for recognition of facial expressions. For ease of use it is vital to use existing infrastructure, instead of requiring to equip each user with specialized devices. Such equipment may be high cost, fragile, cumbersome, or difficult to acquire. Fortunately, today all notebooks and smartphones are equipped with a camera facing the user (the so-called "selfie camera" on mobile communication devices, and "webcam" on computers).

As a student participates in an e-learning session, the intelligent agent is receiving video signal from his computer in real time. First, the agent processes raw image and segments the video feed into frames. Then a set of features is extracted from each picture. In the third step the agent makes statistical inferences about the student's emotion and attention based on visual features. The student's emotional state is evaluated for intensity of six basic emotions (happiness, sadness, surprise, fear, anger, and disgust) on the scale 0 – 100, with 0 indicating total absence of an emotion and 100 the most intensive sensation of that particular emotion. Student attention level and target is inferred with eye gaze estimation. Rapidly shifting focus to the lectured topic or current assignment will indicate responsiveness and lecture awareness. Furthermore, prolonged periods of low arousal, if preceded with high valence or arousal may be indicative of low interest in the conveyed subject. Specially if they are accompanied with low body movements and slow or stationary gaze point.

The integrated results are displayed on the teacher's terminal. The functioning of the e-learning intelligent agent is illustrated in the figure below (Fig. 3).

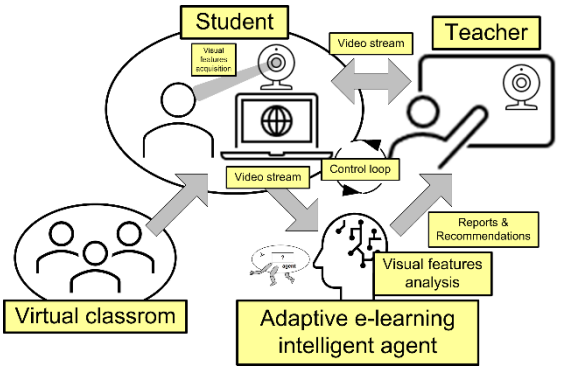


Figure 3. Diagram of adaptive e-learning intelligent agent based on assessment of emotion and attention.

The psychophysiological impact of a lecture or exam is evaluated for each student separately by the intelligent agent. The teacher is notified of extreme levels (low or high), and sudden and sharp variations of emotion and attention, in relation to a specific class content. Also, student's values are compared with performance in previous classes, and with other students in the same class and school. Thus, the most appropriate next step in their e-learning process may by indicated to the teacher. This adaptive process is illustrated in UML activity diagram (Fig. 4).

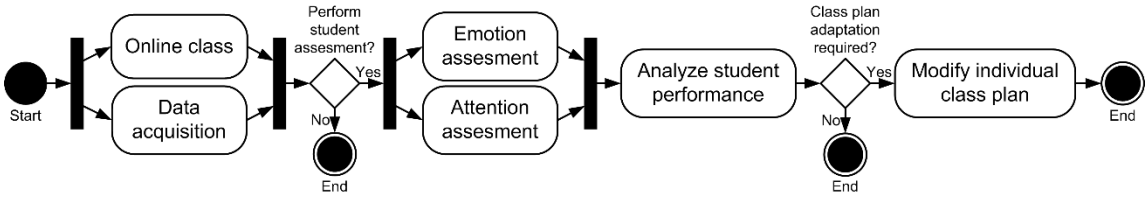


Figure 4. UML activity diagram describing the dynamic aspects of the proposed concept. Class plan is independently conformed to each student based on emotion and attention assessments by the intelligent agent, and the teacher's decision.

In later versions of the intelligent agent, the intelligent agent may not only report but also recommend on the best actions to improve pedagogic efficiency.

It is very important to objectively measure and evaluate students' overall facial and eye movement activity throughout the learning sessions. There are a variety of options for evaluating cognitive engagement, like the sum of all relative spatial offsets of facial characteristic points, e.g. ASM characteristic points, from the baseline neutral face point set. Information regarding differences between the estimation result of student's personalized estimator and the expected emotion estimation value, e.g. by using referent estimator learned over the general student population for the same class, can also be integrated in the estimation process of a student's acquired knowledge levels during online learning sessions.

The online course is segmented into lectures and exams, allowing the course to be dynamically and modularly constructed thereby optimally improving adoption of lecture materials for each student.

The adaptive process is repeated until the end of all lectures has been reached. The system is not capable of independent decision making and only acts act in a decision-support role letting an expert to decide on the course of study. Importantly, because of the unobtrusive nature of the video sensors, the student is unaffected by monitoring procedures, learns and acts spontaneously.

5 Discussion

In our approach, the key visual sensor is a high-definition camera. The same camera is used for e-learning, i.e. additional sensors are not required. Such sensors are ubiquitous and integrated into all mobile computers. They are easy to manage and operate by end-users and software developers alike.

The biggest concern for the practical application of the proposed intelligent agent is the reliability of the information on emotion and attention of students from consumer-grade visual sensors. The increased quality and abilities of such sensors, the popularity of mobile computers and smartphones contribute to the prospect of using this paradigm virtually anywhere. Another potential concern is the usefulness of obtained information for improving learning pedagogies. However, a great body of previously published research give a strong reason to believe that the adaptive e-learning intelligent agent based on assessment of emotion and attention is a workable concept. Intelligent systems and computer vision technologies are mature and already proven in practice.

Because of the limitations of employed algorithms, estimation of emotions from facial expression will depend on the possibility of determining a neutral face. The ground-truth may be either a universal neutral face (as in Section 3), or it can be determined before the start of the class for each student or a group of students.

Information security and privacy concerns are a very important issue that must be considered. Legal frameworks and the appropriate legislation must be respected to protect the privacy of personal data. The use of the system should be optional and not mandatory. Also, students and teachers must be informed before on the purpose of the intelligent system, and how the collected data is utilized. The collected data should not be misused. In this respect, it would be best if personal information is not permanently stored, and only used during sessions within a predetermined timeframe.

Also, it would be beneficial if the proposed paradigm could be integrated into a popular Learning Management System (LMS) as an optional feature. For example, as a Moodle plugin[1]. In this way, features of both systems would be immediately available from a single standardized user interface to a wide audience. Also, it would not be necessary for users to set up and manage the two systems separately.

6 Conclusion and Future Work

The COVID-19 pandemic is a tragic, sudden, and rapidly changing situation greatly affecting global health and economy, but it also reshapes all aspect of life including e-learning. Perhaps paradoxically, this also creates opportunities to improve learning processes comprehensively and permanently. The change is brought on not because of the choice, but out

[1] https://moodle.org/plugins/

of urgency. New visual pedagogies and intelligent algorithms are crucial in enabling this transformation.

To this regard, a new assistive paradigm for objective assessment of learners' success in acquisition of curriculum has been proposed. The intelligent agent delivers potentially useful information to teachers allowing them to adapt the teaching process for each student. Based on information importance, the instructor may decide on the actions to be takes, if any. Also, the educator can decide to what extent he wants to rely on information and recommendations that the intelligent agent provides. Data on student attention and emotion regarding class and exams units, depending on the context, may be invaluable for personalization of pedagogies. This paradigm can help students who experience difficulties in knowledge acquisition or ability to apply their knowledge into different learning settings.

It must be pointed out that a computer system with the described features currently does not exist. A number of enabling technologies for assessment of emotion and attention are indeed commercially available, but an integrated system incorporating an adaptive intelligent agent for e-learning represents a new concept.

We believe that the proposed concept could facilitate team-facilitated, active, and self-directed learning, and promoting individualized and interprofessional education. Importantly, it can be used on different platforms since visual sensors are present with a wide range of personal electronics, computers and smartphones.

Recognition of emotion and attention with commonplace visual sensors is the key technology for the proposed concept to work in practice. However, based on previously published research, intelligent systems paired with computer vision technologies are mature and already proven in practice. Hence, we believe that the described system is entirely feasible and could be realistically used to improve efficiency of e-learning paradigms.

In the future we envision the possibility of evolving the system to a truly multimodal estimation paradigm with the usage of numerous additional information channels such as pupil dilation, eye blink rate, body position, body posture, gestures, head orientation, voice recognition, keyboard usage, and mouse dynamics.

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Topic Modelling in Social Sciences - Case Study of Web of Science*

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Abstract. *Topic modelling is one of the most popular topics investigated in the area of Natural Language Processing. One of the techniques used for topics modelling is Latent Dirichlet Allocation (LDA). It is an unsupervised machine learning technique which creates topics using a collection of documents based on words or n-grams with similar meaning.*
In this paper, we applied a Structural Topic Model with LDA to extract topics from scientific papers in Social Science. A structural topic modelling of 3663 articles from Web of Science Core Collection from 1999 to 2019 was conducted. The obtained results indicate that an optimal number of topics coincides with the existing number of research areas defined in Social Science or with its integer multiple. This opens an area for research into the comparison between the existing taxonomy and the taxonomy proposed by the LDA model and for the future identification of interdisciplinarity.

Keywords. topic modelling, Latent Dirichlet Allocation, Structural Topic Model, social sciences

1 Introduction

In the last few years, the demand for interdisciplinarity between scientific disciplines has increased. Many interdisciplinary programs are being developed to solve key problems that a single discipline cannot. Interdisciplinarity is not only important in the academic world but also in other areas where it brings about innovation.

In the literature on higher education, interdisciplinary research is defined as "a process of answering a question, solving a problem or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline and draws on the disciplines with the goal of integrating their insights to construct a more comprehensive understanding" (Repko, 2008). In scientometrics, research interdisciplinarity is quantified by examining the network of citations and measuring, for instance, the percentage of citations outside the main discipline of the citing paper.

The automatic identification of interdisciplinarity from a text has already been attempted with text mining approaches (Ramage & Manning & Dumais, 2011), (Chuang et al., 2012), (Nichols, 2014). Dietz et al. (Dietz & Bickel & Scheffer, 2007) used the Latent Dirichlet Allocation (LDA) for topic modelling to quantify the impact that research papers have on each other. Gerrish and Blei (Gerrish & Blei, 2010) showed that LDA could identify a qualitatively different set of relevant articles when compared to traditional citation-count metrics. In the same way, Hall et al. (Hall & Jurafsky & Manning, 2008) identified different methodological trends in the field of computational linguistics across almost 30 years of publications. Despite these studies, which generally utilized LDA as a corpus exploration method, it did not determine the LDA's reliability for recognizing interdisciplinary works. Nichols (Nichols, 2014) presented a novel method for measuring interdisciplinary research in National Science Foundation award portfolios. It proposed using the National Science Foundation (NSF) topic model and the NSF's institutional structure by examining research grant proposals and awards rather than publications. Nanni et al. (Nanni & Dietz & Ponzetto, 2018) investigated the performance of LDA with the outcomes obtained by using other text mining methods such as lexical features within a support vector machine (SVM) or a Rocchio classifier for automatic identification of interdisciplinary works from a corpus of doctoral dissertation abstracts. Considering that, we intend to verify the usefulness of topic modelling for identifying interdisciplinarity in articles. In future work, we would compare the results of the LDA to the results obtained by Social Network Analysis (SNA).

The ultimate goal of the presented analysis is to investigate whether text mining methods, such as Latent Dirichlet Allocation (LDA) topic modelling, could represent a valid alternative for researcher's interest in identifying interdisciplinary fields directly from the textual content of papers titles, abstracts, or keywords. The analysis aims to show how terms characterize a particular scientific field and create new topics using LDA topic modelling. To find the convenient number of topics, we have trained a few topic models using different numbers of topics and

*This paper is published and available in Croatian language at: http://ceciis.foi.hr

evaluated them with measures of semantic coherence of the topics, the likelihood for held-out datasets, residuals, and lower bound on the marginal likelihood.

The paper is organized as follows. The following section describes methods used for topic modelling. Section 3 presents data descriptions and preprocessing techniques, the results of an experiment data analysis, followed by the description of the results. The paper concludes with section 4 related to future work. The research design is presented in Fig. 1.

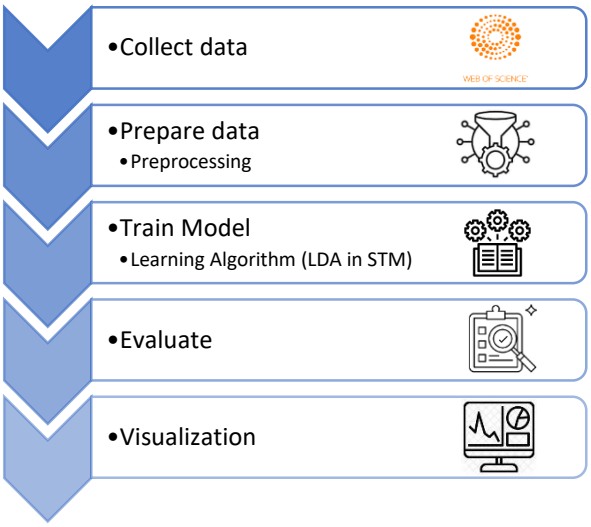


Figure 1. Graphical representation of the research design.

2 Methods

2.1 Text Mining

Text mining aims to detect relevant knowledge that is possibly unknown or covered underneath the obvious one. There are several typical unsupervised and supervised text mining techniques such as text categorization, text clustering, document summarization, and keyword extraction. Topic modelling is a text mining technique which utilizes supervised and unsupervised machine learning techniques.

2.2 Latent Dirichlet Allocation Topic Modelling

Topic modelling is a statistical method which aims to discover an abstract "topics" in a set of documents. It is an unsupervised machine learning technique because it does not require a training dataset or a predefined list of topics. Topics are created from different documents based on words or expressions with similar meaning. One of the most popular methods of topic modelling is Latent Dirichlet Allocation (LDA). LDA attempts to organize all documents to the topics in such a way that the latent topics primarily define the words.

The Latent Dirichlet Allocation method for fitting a topic modelling treats each document as a mixture of topics and each topic as a mixture of words. This method allows documents to "overlap" with each other in terms of content, rather than be separated into discrete groups, which in a way mirrors the typical use of natural language ("Text Mining with R", 2020). LDA is widely used in numerous machine learning, natural language processing (NLP), and information retrieval applications. Griffiths and Steyvers (Griffiths & Steyvers, 2004) used LDA for capturing scientific topics in a collection of documents.

LDA is a generative, probabilistic hierarchical Bayesian model that induces topics from a document collection in three steps (Blei & Ng & Jordan, 2003) (Fig. 2):

1. Each document in the collection is distributed over topics that are sampled for that document based on the Dirichlet distribution.
2. Each word in the document is connected with one single topic based on chosen Dirichlet distribution.
3. Each topic is signified as a multinomial distribution over words that are assigned to the sampled topic.

The following notations will be used:

- M – number of documents,
- N – number of words in each document,
- $\boldsymbol{w}$ – representation of a document represented as a unit-basis vector $\boldsymbol{w} = (w_1, w_2, \dots, w_N)$, where w_n is the n^{th} word in the sequence; vector $\boldsymbol{w}$ has a single component equal to one and all other components equal to zero,
- V – the size of the vocabulary where the v^{th} word in the vocabulary is represented by V – vector such that $w^v = 1$ and $w^u = 0$ for $u \neq v$,
- D – corpus (collection) of M documents, represented as $D = (\boldsymbol{w}_1, \boldsymbol{w}_2, \dots, \boldsymbol{w}_M)$
- k – number of topics a document belongs to,
- z – topic from a set of k topics.

The probability of the observed dataset is calculated and obtained from the corpus D as follows:

$$P(D|\alpha,\beta) = \\ = \prod_{d=1}^{M} \int p(\theta_d|\alpha) \left(\prod_{n=1}^{N_d} \sum_{z_{dn}} p(z_{dn}|\theta_d) p(w_{dn}|z_{dn},\beta) \right) d\theta_d \qquad (1)$$

where variables θ_d are document-level variables, sampled once per document, and variables z_{dn} and w_{dn} are word-level variables and are sampled once for each word in each document.

There is a parameter α which has the topic distribution θ for each document (Fig. 2). Each of M documents has some θ distribution. θ is a randomly $(M \times k)$ shaped matrix where $\theta(i,j)$ represents the probability of the i^{th} document containing words belonging to the j^{th} topic. θ has a Dirichlet distribution Dir(α).

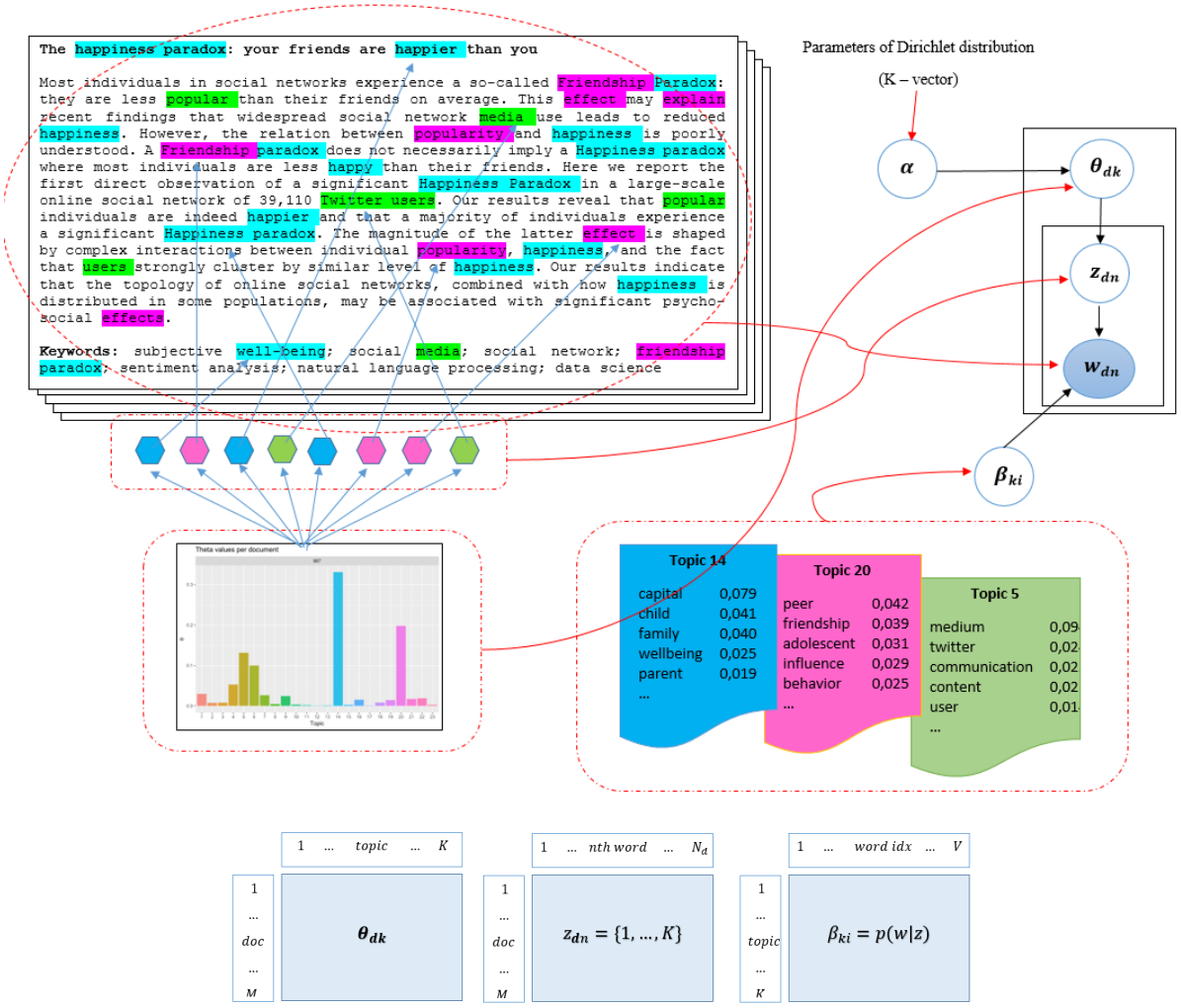


Figure 2. Graphical representation of LDA topic modelling presented on one of the documents from a corpus

Assume that there is a single document with N words, and each word is generated by a topic. We generated N topics that should be filled with words. Based on a single scalar parameter η for each topic, β also has a Dirichlet distribution. β generates k individual words for each topic according to the Dirichlet distribution. Similarly, β is a $(k \times V)$ shaped matrix, where $\beta(i,j)$ represents the probability of the i^{th} topic belonging to the j^{th} word.

To train the LDA model, we need to estimate the hidden parameters α, θ, η and β, where α is a distribution-related parameter that determines what the distribution of topics looks like for all documents in the corpus, θ is a random matrix where $\theta(i,j)$ represents the probability of the i^{th} document containing the j^{th} topic, η is a parameter related to the distribution which determines how words are distributed in each topic, and β is a random matrix where $\beta(i,j)$ represents the probability of i^{th} topic containing the j^{th} word. LDA is a probabilistic model, so we need to calculate the joint distribution of the topic mixture θ, $P(\theta, z, \beta | D; \alpha, \eta)$. For a set of M documents, where each document has N words, and each word is generated by a single topic from a set of k topics, we have to look for the posterior joint probability of θ, z and β, given D and using parameters α and η. The solution to this problem is given in the paper of Blei et al. (Blei & Ng & Jordan, 2003).

For the application of LDA topic modelling, we have used Structural Topic Models (STM) which have an implementation in the **stm** R package ("stm: R Package for Structural Topic Models", 2020).

2.3 Measures for Model Evaluation

The measures we used to find a convenient number of topics are described below.

Semantic coherence is a measure introduced by Mimno et al. (Mimno et al., 2011). The semantic coherence for the topic k is calculated using a list of the N most probable terms in topic k as:

$$C_k = \sum_{n=2}^{N} \sum_{m=1}^{n-1} \log\left(\frac{D(v_n, v_m) + 1}{D(v_m)}\right) \quad (2)$$

where $\boldsymbol{v}$ is a vector of the top N terms in the topic arranged in a descending order, $D(v)$ is the number of documents with at least one term v, and $D(v, v')$ is the number of times that terms v and v' appear together in a document. Intuitively, this is a sum over all term pairs in the top topic terms, returning the log of the co-occurrence frequency divided by the baseline frequency. The one is added in the nominator to prevent taking the log of zero in case a pair of terms never co-occurs. Semantic coherence is maximized when the terms with the highest probability in a given topic frequently co-occur together, and it is a metric that correlates well with the human judgment of topic quality. If there are a few topics that dominate with very prevalent terms, then it is necessary to look at both semantic coherence and exclusivity.

Exclusivity measures the difference between topics by comparing the similarities of word distribution β in various topics. A topic is exclusive if the top words cannot exist among other topics. Exclusivity for term v in topic k is defined as:

$$EX_{k,v} = \frac{\beta_{k,v}}{\sum_{j=1}^{K} \beta_{j,v}} \tag{3}$$

Frequency and exclusivity are important factors in the determination of a term's semantic content. Thus the univariate measure of topical importance may be a useful approximation for different tasks such as dimensionality reduction, feature selection, and content discovery. Therefore, it is modified harmonic mean to move the "average" rank to the lower score (Bischof & Airoldi, 2012). Frequency Exclusivity (FREX) labelling metric is the weighted harmonic mean of the term's rank given as:

$$FREX_{k,v} = \left(\frac{w}{ECDF(EX_{k,v})} + \frac{1-w}{ECDF(\beta_{k,v})} \right)^{-1} \tag{4}$$

where ECDF is an empirical cumulative distribution function for the term v in its topic distribution β_k, and w is a weight for exclusivity set to 0.7 in our experiments.

Another measure for model comparison used to check how well each model predicts terms within the document is the held-out likelihood estimation. In the **stm** package, the held-out likelihood estimation uses two functions ("stm: R Package for Structural Topic Models", 2020). The first function uses the document-completion held-out likelihood method, which is the estimation of the probability of the words occurring within a document when those words have been removed from the document in the estimation step. The second function evaluates the held-out likelihood for missing words based on the model run on the held-out documents. The held-out likelihood estimation is similar to cross-validation and helps to estimate the model's prediction performance.

The assumptions of the model could be tested through residuals. The function `residuals` in the **stm** package measures whether there is overdispersion of the variance of the multinomial variance within the LDA method of generating data. As mentioned in Taddy (Taddy, 2012), if residuals are overdispersed, more topics might be required to absorb some extra variance. Although there is no certain method for choosing the number of topics, both the residuals check and held-out likelihood estimation are useful measures of the number of topics to be selected.

The lower bound is a measure of convergence of the model. Once the bound has a small enough change between iterations, the model is considered converged.

3 Experimental Results

3.1 Dataset and Preprocessing

For experimental evaluation, the analyzed dataset was obtained from the Web of Science (WoS) Core Collection database by searching articles containing phrase *social network** in the WoS Social Science research area in the period from 1999 to 2019. The phrase *social network** is used for the purpose of narrowing of the monitored set of data. The search was performed in March 2020, and a total of 3,664 articles were retrieved. Each of these articles is described with a series of metadata such as author(s), title, abstract, authors' keywords, research area, and year of publication. The main idea is to investigate research topics in the field of social sciences through the number of terms from titles, abstracts, and authors' keywords.

According to the WoS classification, there are 25 categories in the Social Sciences research area. All articles are classified in at least one category from the WoS Social Sciences research area. Only two categories, *Archaeology* and *Development studies*, did not contain any articles from our dataset. Most articles are categorized in *Biomedical Social Sciences*, *Business and Economics*, *Mathematical Methods in Social Sciences*, *Psychology*, *Social Sciences – Other topics* and *Sociology*. Titles, abstracts, and authors' keywords were extracted from each article and merged to get a dataset of one variable and 3,664 instances. 29,199 index terms indexed those articles.

Before the analysis, the dataset was edited using **tm** R package to remove stop words, punctuations, numbers, unnecessary and whitespace characters. High frequently words *social*, *network*, *study*, *analysis*, *model* and *datum* were also removed from the vector of words to reduce the negative impact in the analysis and lemmatization was performed. We created the document-term matrix in which rows represented the documents, and the columns the terms from documents. After described the preprocessing steps, the document-term matrix, created in such a way, had 3,663 documents and 20,718 terms. To reduce the sparsity of matrix, we ejected the index terms

appearing in only one document, and the resulting document-term matrix. After this, the last preprocessing step contained 3,663 documents and 9,096 terms. Finally, each entry in the matrix took values from Term Frequency – Inversed Document Frequency (TF−IDF). Term frequency (TF) is a measure of the importance of a term in a document. Fig. 3 shows the bar chart plot of terms that occur most frequently in the corpus of 3,663 documents. A term's inverse document frequency (IDF) is a measure that penalizes the commonly used terms. By combining IDF with TF measures using multiplication, we obtained the TF-IDF measure of the importance of a term in a document of a corpus. TF-IDF score for the term t in the document d from the document set D was computed as follows:

$$TF - IDF = TF \cdot IDF \tag{5}$$

where

$$TF = \log(1 + freq(t, d)) \tag{6}$$

$$IDF = \log\left(\frac{M}{count(d \in D: t \in d)}\right) \tag{7}$$

where M is the total number of documents and $freq(t, d)$ is the frequency of term t in document d .

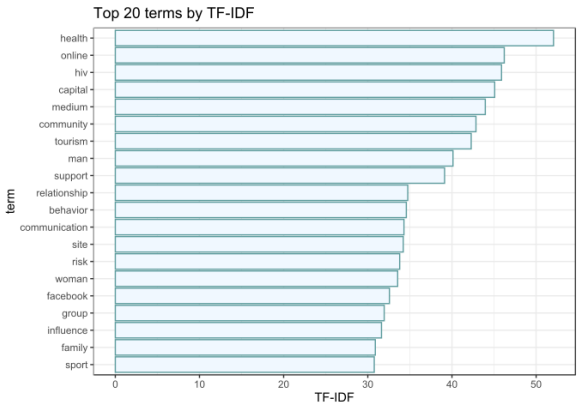


Figure 3. Bar chart plot of the terms with the greatest TF-IDF weight in the dataset.

3.2 Data Analysis

In the next step, we built the Document Term Feature from the corpus and applied the LDA. Before estimating the LDA, we needed to define the number of topics. We trained a group of topic model with a different number of topics and evaluated these topic models to estimate how many topics were appropriate for the given corpus. After we set different values for the number of topics (k) from 2 to 100, we explored how many topics are suitable. These values were intuitively taken to fit the model since there are 25 categories of Social Sciences research area from the WoS classification.

The LDA has two approaches to explore the topics that are estimated. The first approach is to look at how words are associated with topics, and the second approach is to examine documents that are estimated to be highly related to the specific topic.

We evaluated model with measures of semantic coherence of the topics, the likelihood for held-out datasets, residuals and lower bound by making some diagnostic plots to understand how the models perform for the different number of topics and to choose a target number of topics. The topics are then compared with centroids of WoS categories by using cosine similarity. Centroids for specific WoS category k is given by:

$$Cent_k = \frac{1}{n_k}\sum_{j=1}^{n_k} \vec{d}_{k,j} \tag{8}$$

where $\vec{d}_{k,j}$ is the representation of document j in the WoS category k, and n_k is the number of documents in WoS category k. Cosine similarity measures similarity by calculating the cosine of the angle of two vectors $\vec{a}$ and $\vec{b}$:

$$\cos(\vec{a}, \vec{b}) = \frac{\vec{a} \cdot \vec{b}}{||\vec{a}|| \cdot ||\vec{b}||} \tag{9}$$

The similarity between topics obtained by LDA and WoS categories is measured as cosine similarity between the vectors of the word probability distribution of topics and centroids for certain WoS category. The values of the cosine of angle are between 0 and 1 since both vectors have positive values of its elements. We considered that topics from topic modelling are similar to the category from WoS if the value of cosine similarity is greater than 0.5.

3.3 Results

After the model evaluation with semantic coherence of the topics, the held-out likelihood, residuals and lower bound we made some analytical plots using these amounts to know how models perform on a range of topics (Fig. 4). From diagnostic plots, we could see that a good number of topics would be around 25 since around that value growth/fall of corresponding measures of evaluation slows down. When we looked at both semantic coherence and exclusivity of terms to topics together, we could assume that a good choice of the number of topics was 23 (Fig. 5).

The following results are described in two ways. The first approach is to look at the sets of words that are joint with topics. The second approach is to look at the real documents that are estimated to be highly related to each topic. Both of these approaches are presented in Fig. 6. Among the 23 most prevalent topics, topic 22 has the most documents. We can also see that several topics are focused to health (Topic 17 with the most probable terms *HIV*, *man*, *sex*, *sexual*,

risk; Topic 16 with the most probable terms *health, support, age, old, adult*; Topic 15 with the most probable terms *health, care, support, service, access*), communication, internet and social networks (Topic 5 with the most probable terms *medium, twitter, communication, content, user*; Topic 4 with the most probable terms *online, site, internet, Facebook, sns*), tourism, political themes, or business and economics.

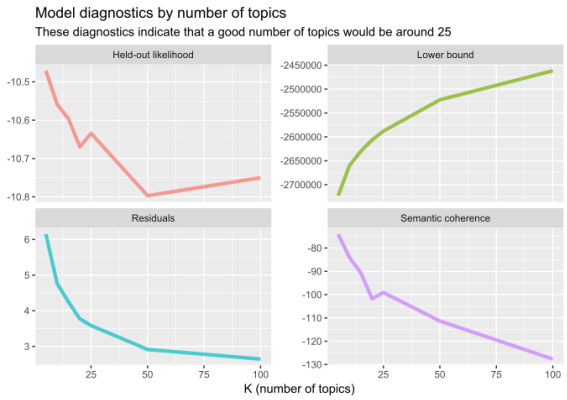


Figure 4. Model diagnostics by the number of topics indicates that a convenient number of topics is around 25.

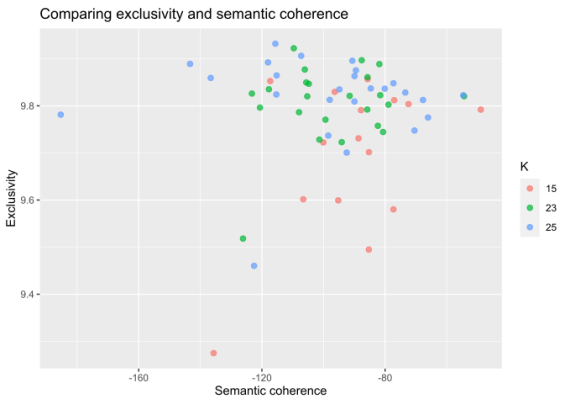


Figure 5. Comparing semantic coherence and exclusivity.

Cosine similarity between vectors based on word probability distribution from topics and centroids for chosen WoS categories (BE – *Business and Economics*, BSS – *Biomedical Social Sciences*, COM – *Communication*, Edu – *Education and Educational Research*, FS – *Family Studies*, GL – *Government and Law*, MathM – *Mathematical Methods in Social Sciences*, Psy – *Psychology*, SI – *Social Issues*, Soc – *Sociology*, SS – *Social Sciences – Other Topics*) is presented in Table 1.

From the results in Table 1, we can see that some topics have something in common with the categories from WoS. For example, Topic 7 is related to the *Mathematical Methods in Social Sciences*, Topic 17 to *Biomedical Social Sciences*, and Topic 11 to *Business and Economics*.

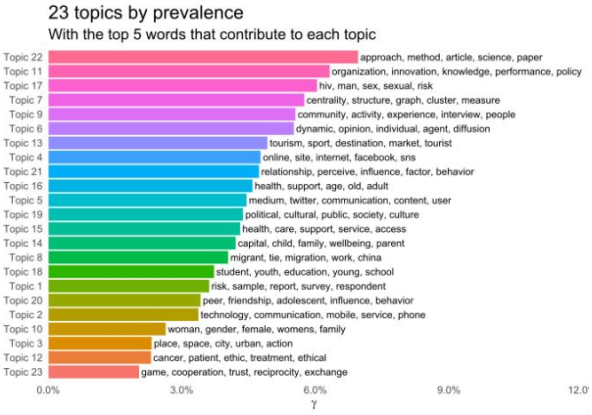


Figure 6. The prevalence of the 23 topics within the entire corpus and top five words associated with the topic.

Table 1. Cosine similarity between topics and selected WoS categories

	BE	BSS	COM	Edu	FS	GL	MathM	Psy	SI	Soc	SS
1	0.17	0.34	0.10	0.07	0.16	0.13	0.22	0.30	0.20	0.24	0.24
2	0.23	0.16	0.24	0.11	0.14	0.13	0.20	0.19	0.29	0.18	0.31
3	0.20	0.20	0.09	0.21	0.16	0.21	0.20	0.22	0.22	0.28	0.29
4	0.21	0.16	0.32	0.11	0.13	0.20	0.14	0.24	0.29	0.19	0.36
5	0.21	0.13	0.26	0.13	0.11	0.18	0.18	0.20	0.17	0.15	0.32
6	0.36	0.25	0.10	0.16	0.21	0.22	0.54	0.27	0.20	0.35	0.37
7	0.40	0.23	0.08	0.17	0.16	0.13	0.68	0.28	0.17	0.43	0.33
8	0.32	0.26	0.10	0.16	0.31	0.30	0.26	0.30	0.23	0.35	0.35
9	0.20	0.28	0.11	0.22	0.21	0.18	0.18	0.30	0.22	0.29	0.32
10	0.13	0.29	0.06	0.13	0.33	0.15	0.11	0.24	0.15	0.18	0.19
11	0.56	0.24	0.12	0.23	0.16	0.27	0.37	0.29	0.26	0.35	0.45
12	0.21	0.35	0.08	0.14	0.12	0.18	0.17	0.32	0.29	0.22	0.26
13	0.46	0.15	0.12	0.20	0.14	0.16	0.18	0.19	0.18	0.30	0.42
14	0.22	0.27	0.08	0.22	0.19	0.15	0.15	0.30	0.26	0.37	0.31
15	0.15	0.49	0.06	0.13	0.16	0.14	0.13	0.33	0.24	0.29	0.24
16	0.17	0.50	0.07	0.17	0.16	0.14	0.17	0.38	0.22	0.35	0.27
17	0.14	0.60	0.09	0.07	0.47	0.10	0.14	0.50	0.17	0.19	0.22
18	0.20	0.20	0.14	0.44	0.16	0.19	0.17	0.32	0.30	0.32	0.33
19	0.23	0.18	0.17	0.22	0.17	0.37	0.20	0.26	0.25	0.26	0.36
20	0.27	0.29	0.19	0.12	0.15	0.16	0.35	0.30	0.23	0.33	0.28
21	0.26	0.27	0.12	0.13	0.16	0.16	0.22	0.32	0.27	0.29	0.30
22	0.37	0.23	0.12	0.29	0.20	0.24	0.37	0.27	0.24	0.34	0.42
23	0.31	0.24	0.10	0.27	0.21	0.13	0.32	0.30	0.29	0.30	0.30

We can also notice that some topics do not overlap with only one category from WoS but several, so we can assume that there is interdisciplinarity between these scientific disciplines from WoS, which is not surprising, given that most articles are categorized into multiple disciplines. Topic 22 has approximately equal values of cosine similarity for *Business and Economics*, *Mathematical Methods in Social Sciences*, *Sociology* and *Social Sciences – Other Topics*, while topic 17 has approximately equal values of cosine similarity for *Biomedical Social Sciences*, *Family Studies*, and *Psychology*. Another thing we noticed is

that individual areas from the WoS categories have approximately equal cosine similarity values for different topics. We can assume that this is because the LDA algorithm identified subcategories within this category. For example, *Sociology* has approximately equal cosine similarity values for topics 6, 7, 8, 11, 14, 16, 20 and 22.

4 Conclusion

In this paper, we have given a brief introduction of Latent Dirichlet Allocation (LDA) topic modelling, which was applied in Structural Topic Models (STM) on the dataset from the Web of Science Core Collection.

The main goal of the research was to compare topics obtained by LDA topic modelling with categories of Web of Science Core Collection for the field of Social Sciences. The research was conducted on the sample of papers from 1999 to 2019 with the keyword *social network** and the results are restricted to publications containing that phrase. The comparison between the topic obtained by LDA and the given taxonomy in terms of cosine similarity indicates that social networks are mainly applied in disciplines of *Business and Economics* (BE), *Biomedical Social Sciences* (BSS), *Mathematical Methods in Social Sciences* (MathM) and *Psychology* (Psy) which seems like an intuitive result. Furthermore, based on cosine similarities, we were also able to identify interdisciplinarity between disciplines of BE and MathM, BSS and MathM, BSS and Psy, BSS, FS, and Psy.

Based on the intuitive results obtained on this sample of papers, we plan to extend our research to all papers in the collection in the field of Social Sciences to identify interdisciplinary fields and conduct further research by analyzing social networks and symbolic data.

In future research, we intend to investigate the interdisciplinarity between science disciplines which are hidden or masked and reconsider the existing taxonomy of research areas in social sciences and its temporal changes.

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Quality of Software and Services

Nadica Hrgarek Lechner
An Overview of Global Professional Publications Related to Medical Device Cybersecurity

Sonja Nidogon Višnjić, Katarina Pažur Aničić
Attitutes of Students and Employers to the Use of Student Centers' IT Services

Valentina Kirinić, Renata Mekovec, Tatjana Zrinski
Rethinking the Process of the Student Evaluation of Teaching

Davor Maček, Ivan Magdalenić, Nina Begičević Ređep
Towards a Hybrid Model for the Evaluation of Critical IT Systems

An Overview of Global Professional Publications Related to Medical Device Cybersecurity

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Abstract. *The purpose of this paper is to provide an overview of the current professional literature about medical device cybersecurity from a regulatory point of view and at the global level. This paper provides the most comprehensive overview of such publications to date. It may assist healthcare, medical device, regulatory affairs, quality management, and cybersecurity professionals, researchers, regulators, and other subject matter experts in identifying applicable cybersecurity regulations, standards, and industry best practices for medical devices.*

Keywords. cybersecurity, FDA, guidance, medical devices, regulation, standard

1 Introduction

Medical device companies are operating in a highly regulated industry and need to comply with applicable laws and regulations on data privacy protection and cybersecurity. In the past, medical devices were mostly designed and developed as non-networked devices. The main focus was on general safety and performance requirements, and less on security. Nowadays, medical devices often incorporate third-party hardware and software components and we observe an increase in use of wireless, Internet connected, networked, and interconnected medical devices. The expanded use of smartphones, tablets, wearable devices, and cloud services has fostered the development of Internet of Medical Things (IoMT) in the last few years. Due to the growing number of networked medical devices, which can be vulnerable to a wide variety of security threats, medical device manufacturers should address security risk management from initial device conception to disposal. Together, these trends have resulted in an increase in professional publications (i.e., national laws and regulations, standards, guidance documents, technical (information) reports, trend reports, white papers, industry best practices, frameworks, playbooks, information for consumers, etc.) to strengthen cybersecurity requirements for medical devices at the global level.

This paper aims to provide an overview of the current professional publications related to medical device cybersecurity across the globe. Related work is provided in section 2. Section 3 presents the results of conducted narrative literature review. The final section gives a brief summary and discussion of the findings, and identifies areas for further research.

2 Related Work

In 2005, the Food and Drug Administration (FDA), a federal agency of the United States, issued a first guidance document about cybersecurity for networked medical devices containing off-the-shelf software. This guidance (FDA, 2005) recommends validating computer software changes to address cybersecurity vulnerabilities and developing a cybersecurity maintenance plan.

In June 2013, the FDA issued a draft guidance document that addresses management of cybersecurity in medical devices throughout the premarket phase. The final guidance was released by the FDA in October 2014. In this final guidance, the FDA (2014) defines cybersecurity as the process of preventing unauthorized access, modification, misuse or denial of use, or the unauthorized use of information that is stored, accessed, or transferred from a medical device to an external recipient. In October 2018, the FDA updated the premarket guidance. This draft guidance (FDA, 2018) also includes some postmarket recommendations.

In December 2016, the FDA published a second guidance that addresses management of cybersecurity in medical devices during the postmarket phase. According to this guidance (FDA, 2016), cybersecurity applies to the following types of medical devices: a) devices that contain software, firmware, or programmable logic, b) software that is a medical device, including mobile medical applications, c) interoperable devices, and d)

marketed and distributed legacy devices. Over the last three years, many countries around the world published their own regulatory guidelines about cybersecurity of medical devices.

At the moment, there are many standards about information security management and standards covering different aspects of cybersecurity such as vulnerability disclosure, vulnerability handling processes, risk management for IT-networks incorporating medical devices, etc., that can be adopted by medical device manufacturers and healthcare organizations. There is a lack of an international consensus cybersecurity standard that is solely focused on the medical device industry. The International Electrotechnical Commission (IEC), the international standards and conformity assessment body for all fields of electrotechnology, is developing a new standard IEC/DIS 80001-1 (*IEC/DIS 80001-1: Safety, effectiveness and security in the implementation and use of connected medical devices or connected health software – Part 1: Application of risk management*, 2020) to support medical device manufacturers with respect to security risk management for connected medical devices and connected health software.

While there are many scientific papers about current international standards and trends of medical device cybersecurity, to the best of the author's knowledge, they only focus on: a) one or more professional publications (Anonymous, 2019), (Baranchuk et al., 2018), (Brown et al., 2016), (Jagannathan & Sorini, 2015), (Jump, 2019), (Jump & Finnegan, 2017), (Mankovich & Fitzgerald, 2011), (Murthy, 2019), (Sametinger et al., 2015), (Schwartz et al., 2018), (Stern, 2017), (Stern et al., 2019), (Vargas, 2017), (Walker, 2018), (Wu & Eagles, 2016), b) major countries (Chen et al., 2018), (Fu & Blum, 2013), (Kim et al., 2020), c) a particular geographic area (Abraham et al., 2019), (Best, 2020), (Burns et al., 2016), (Coburn, 2016), (Martinez, 2018), (Owens, 2016), (Pasanisi, 2017), (Pesapane et al., 2018), (Skierka, 2018), (Webb & Dayal, 2017), d) particular types of medical devices (Carroll & Richardson, 2016), (Gladden, 2016), (Hrgarek, 2012), (Hrgarek Lechner, 2017), (Pirker & Hrgarek Lechner, 2019), (Yuan et al., 2018), e) a particular ability of medical devices (Hatcliff et al., 2019), (Hrgarek Lechner, 2018), or f) a particular activity of the cybersecurity process (Arbelaez et al., 2018), (Jiang et al., 2020), (Moshi et al., 2019), (Suárez & Scott, 2017). No paper has been found that provided a comprehensive overview of professional medical device cybersecurity publications at the global level.

3 Narrative Literature Review

The purpose of the conducted narrative literature review was to identify relevant professional publications related to medical device cybersecurity across the globe. The scope of this review was limited to English and German professional publications that were published in the time period from August 1996 to August 2020. August 1996 was chosen because the Health Insurance Portability and Accountability Act of 1996, the U.S. federal law that requires the protection of sensitive patient health information, was published at this time. Literature search was performed using: a) e-mail notifications from FDA and normScan (an online monitoring and tracking tool for new and updated medical device standards), b) searches in IEC and ISO webstores, c) various keyword searches in Google web search engine, and d) content shared on the LinkedIn platform by the TÜV SÜD (a notified body in Germany), the British Standards Institution (the UK national standards body), and regulatory affairs professionals in the medical device industry. Some publications were identified in scientific papers referenced in the previous section.

As listed in Table 1, a total of 156 relevant professional publications addressing cybersecurity for medical devices were searched. This table provides the most comprehensive overview of global professional publications from various sources to date and indicates the complexity of the evolving medical device cybersecurity ecosystem in a highly regulated environment. Since cybersecurity in the medical device industry requires shared responsibility among stakeholders (e.g., medical device manufacturers, healthcare providers, patients, security researchers, etc.), a number of laws, regulations, standards, guidance documents, and other types of publications is currently needed to cover the entire device life cycle.

Maintaining compliance with other regulatory requirements in the medical device industry, such as a risk management process or a usability engineering process, is easier due to a relatively small number of regulations and standards. For example, ISO 14971 (*ISO 14971: Medical devices – Application of risk management to medical devices*, 2019) is an international, harmonized standard for a risk management process that has been specifically designed for the medical device industry. The standard has been recognized as a consensus standard by international regulators such as the FDA and the Australian Therapeutic Goods Administration (TGA).

Table 1. An overview of global professional publications related to medical device cybersecurity

Area/country	Publisher name	Publication title	Publication type	Year
Australia	Therapeutic Goods Administration (TGA)	Medical device cyber security guidance for industry, Version 1.0	Guidance	2019
		Medical device cyber security guidance for	Guidance	2019

Area/country	Publisher name	Publication title	Publication type	Year
		users, Version 1.0		
		Medical device cyber security – Consumer information	Consumer information	2019
Canada	Health Canada	Guidance Document: Pre-market Requirements for Medical Device Cybersecurity	Guidance	2019
China	China Food and Drug Administration (CFDA)	Medical Device Network Security Registration on Technical Review Guidance Principle	Guidance	2017
European Union (EU)	European Parliament and the Council	Directive (EU) 2016/1148 – Measures for a high common level of security of network and information systems across the Union	Directive	2016
		Regulation (EU) 2016/679 – General Data Protection Regulation (GDPR)	Regulation	2016
		Regulation (EU) 2017/745 – Medical Devices Regulation (MDR)	Regulation	2017
		Regulation (EU) 2017/746 – In Vitro Diagnostic Medical Devices Regulation (IVDR)	Regulation	2017
		Regulation (EU) 2019/881 – Cybersecurity Act	Regulation	2019
	European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry (COCIR)	Advancing Cybersecurity of Health and Digital Technologies	White paper	2019
	European Committee for Electrotechnical Standardization	EN 45502-1:2015 Implants for surgery – Active implantable medical devices. Part 1: General requirements for safety, marking and for information to be provided by the manufacturer	Standard	2015
	European Union Agency for Network and Information Security (ENISA)	Baseline Security Recommendations for IoT in the context of Critical Information Infrastructures	Information report	2017
		PROCUREMENT GUIDELINES FOR CYBERSECURITY IN HOSPITALS: Good practices for the security of Healthcare services	Guidance	2020
	Medical Device Coordination Group (MDCG)	MDCG 2019-16 - Guidance on Cybersecurity for medical devices	Guidance	2019
France	National Agency for Medicines and Health Products Safety (ANSM)	ANSM's guideline – Cybersecurity of medical devices integrating software during their life cycle[a]	Guidance	2019
Germany	Expertenkreis CyberMed	Sicherheit von Medizinprodukten: Leitfaden zur Nutzung des MDS2 aus 2019	Guidance	2019
	Federal Institute for Drugs and Medical Devices	Das Fast-Track-Verfahren für digitale Gesundheitsanwendungen (DiGA) nach § 139e SGB V: Ein Leitfaden für Hersteller, Leistungserbringer und Anwender	Guidance	2020
	Federal Ministry of Health	Gesetz für eine bessere Versorgung durch Digitalisierung und Innovation (Digitale-Versorgung-Gesetz – DVG)	Law	2019
		Verordnung über das Verfahren und die Anforderungen zur Prüfung der Erstattungsfähigkeit digitaler Gesundheitsanwendungen in der gesetzlichen Krankenversicherung (Digitale Gesundheitsanwendungen-Verordnung – DiGAV)	Regulation	2020
	Federal Office for Information Security (BSI)	BSI-CS 132 Cyber Security Requirements for Network-Connected Medical Devices, Version 1.1	Best practices	2018
		BSI TR-03161 Sicherheitsanforderungen an	Technical	2020

Area/country	Publisher name	Publication title	Publication type	Year
		digitale Gesundheitsanwendungen, Version 1.0	guidance	
	TÜV Rheinland, OpenSky	AN INTRODUCTION TO MEDICAL DEVICE CYBER SECURITY: A European Perspective	White paper	2016
	TÜV Rheinland	Cybersecurity Trends 2018: Cybersecurity in einer zunehmend digitalen Welt	Trend report	2018
		Cybersecurity Trends 2020: New thinking on cybersecurity and privacy in a world where digital transformation beckons	Trend report	2020
	TÜV SÜD, Johner Institute, Dr. Georg Heidenreich	IT Security Guideline for Medical Devices	Guidance	2018
	Verband der Diagnostica-Industrie (VDGH)	IT-Product Security Whitepaper Template, Version 1.4	White paper	2020
International	Advanced Medical Technology Association (AdvaMed)	AdvaMed Medical Device Cybersecurity Foundational Principles	Guidance	2017
	ECRI Institute	Top 10 Health Technology Hazards for 2020	Executive brief	2019
		2019 Top 10 Health Technology Hazard	Executive brief	2018
		Top 10 Health Technology Hazards for 2018	Executive brief	2017
		Top 10 Health Technology Hazards for 2017	Executive brief	2016
		Top 10 Health Technology Hazards for 2016	Executive brief	2015
		Top 10 Health Technology Hazards for 2015	Executive brief	2014
		Top 10 Health Technology Hazards for 2014	Executive brief	2013
		Top 10 Health Technology Hazards for 2013	Executive brief	2012
	EPFL International Risk Governance Center (IRGC)	Governing cybersecurity risks and benefits of the Internet of Things: Connected medical & health devices and connected vehicles	Workshop report	2017
	Frost & Sullivan, Inc.	Medical Device and Network Security: Coming to terms with the Internet of Medical Things (IoMT)	White paper	2019
	Global Digital Health Partnership (GDHP) Cybersecurity Workstream	Medical Device Manufacturer Internet of Things (IoT) Code of Conduct[a]	Guidance	2020
	Healthcare Information and Management Systems Society (HIMSS)	HIMSS Privacy Impact Assessment Guide, Version 2	Guidance	2008
	IEEE Cybersecurity Initiative (CYBSI)	Building Code for Medical Device Software Security	Report	2015
	IEEE Standards Association (SA)	P11073-40102 - IEEE Draft Standard - Health informatics - Device interoperability - Part 40102: Cybersecurity - Capabilities for Mitigation[a]	Standard	2019
	Integrating the Healthcare Enterprise (IHE) Patient Care Device (PCD) Technical Committee	Medical Equipment Management (MEM): Cyber Security, Revision 2.0	White paper	2011
		Medical Equipment Management (MEM): Medical Device Cyber Security – Best Practice Guide, Revision 1.1	White paper	2015
	IHE PCD Technical Committee, Medical Device Innovation, Safety, & Security Consortium (MDISS)	Medical Device Software Patching, Revision 1.1	White paper	2015
	International Electrotechnical Commission (IEC)	IEC 62304:2006 + AMD1:2015 Medical device software – Software life cycle processes	Standard	2015
		IEC/DIS 62304.2 Health software – Software life cycle processes[b]	Standard	---

Area/country	Publisher name	Publication title	Publication type	Year
		IEC 82304-1:2016 Health software – Part 1: General requirements for product safety	Standard	2016
		IEC 80001-1:2010 Application of risk management for IT-networks incorporating medical devices – Part 1: Roles, responsibilities and activities	Standard	2010
		IEC/DIS 80001-1 Safety, effectiveness and security in the implementation and use of connected medical devices or connected health software – Part 1: Application of risk management	Standard	---
		IEC/TR 80001-2-1:2012 Application of risk management for IT-networks incorporating medical devices – Part 2-1: Step by Step Risk Management of Medical IT-Networks; Practical Applications and Examples	Technical report	2012
		IEC/TR 80001-2-2:2012 Application of risk management for IT-networks incorporating medical devices – Part 2-2: Guidance for the communication of medical device security needs, risks and controls	Technical report	2012
		IEC/TR 80001-2-3:2012 Application of risk management for IT-networks incorporating medical devices – Part 2-3: Guidance for wireless networks	Technical report	2012
		IEC/TR 80001-2-4:2012 Application of risk management for IT-networks incorporating medical devices – Part 2-4: General implementation guidance for Healthcare Delivery Organizations	Technical report	2012
		IEC/TR 80001-2-8:2016, Application of risk management for IT-networks incorporating medical devices – Part 2-8: Application guidance – Guidance on standards for establishing the security capabilities identified in IEC 80001-2-2	Technical report	2016
		IEC/CD 80001-5-1 Safety, security and effectiveness in the implementation and use of connected medical devices or connected health software – Part 5-1: Security Activities in the product lifecycle[b]	Standard	---
		IEC/TR 60601-4-5 ED1 Medical electrical equipment – Part 4-5 Guidance and interpretation – Safety related technical security specifications for medical devices[b]	Technical report	---
	International Organization for Standardization (ISO)	ISO/AWI TS 82304-2 Health software – Part 2: Health and wellness apps – Quality and reliability[b]	Standard	---
		ISO/CD TR 11633-2 Health informatics – Information security management for remote maintenance of medical devices and medical information systems – Part 2: Implementation of an information security management system (ISMS)[b]	Technical report	---
		ISO/DIS 81001-1 Health software and health IT systems safety, effectiveness and security – Part 1: Principles, concepts, and terms[b]	Standard	---
		ISO 13485:2016 Medical devices – Quality management systems – Requirements for regulatory purposes	Standard	2016
		ISO 14971:2019 Medical devices – Application of risk management to medical devices	Standard	2019
		ISO 27799:2016 Health informatics – Information security management in health using ISO/IEC 27002	Standard	2016

Area/country	Publisher name	Publication title	Publication type	Year
		ISO/TR 22696:2020 Health informatics – Guidance on the identification and authentication of connectable Personal Healthcare Devices (PHDs)	Technical report	2020
		ISO/TR 24971:2020 Medical devices – Guidance on the application of ISO 14971	Technical report	2020
		ISO/TR 80001-2-7:2015 Application of risk management for IT-networks incorporating medical devices – Application guidance – Part 2-7: Guidance for healthcare delivery organizations (HDOs) on how to self-assess their conformance with IEC 80001-1	Technical report	2015
		ISO/TS 11633-1:2019 Health informatics – Information security management for remote maintenance of medical devices and medical information systems – Part 1: Requirements and risk analysis	Standard	2019
	ISO, IEC	ISO/IEC 27000:2018 Information technology – Security techniques – Information security management systems – Overview and vocabulary	Standard	2018
		ISO/IEC 27001:2013 Information technology – Security techniques – Information security management systems – Requirements	Standard	2013
		ISO/IEC CD 27002 Information security, cybersecurity and privacy protection – Information security controls[b]	Standard	---
		ISO/IEC 27003:2017 Information technology – Security techniques – Information security management systems – Guidance	Standard	2017
		ISO/IEC 27005:2018 Information technology – Security techniques – Information security risk management	Standard	2018
		ISO/IEC 27017:2015 Information technology – Security techniques – Code of practice for information security controls based on ISO/IEC 27002 for cloud services	Standard	2015
		ISO/IEC 27032:2012 Information technology – Security techniques – Guidelines for cybersecurity	Standard	2012
		ISO/IEC 27035-1:2016 Information technology – Security techniques – Information security incident management – Part 1: Principles of incident management	Standard	2016
		ISO/IEC 27035-2:2016 Information technology – Security techniques – Information security incident management – Part 2: Guidelines to plan and prepare for incident response	Standard	2016
		ISO/IEC 27039:2015 Information technology – Security techniques – Selection, deployment and operations of intrusion detection and prevention systems (IDPS)	Standard	2015
		ISO/IEC 29134:2017 Information technology – Security techniques – Guidelines for privacy impact assessment	Standard	2017
		ISO/IEC 29147:2018 Information technology – Security techniques – Vulnerability disclosure	Standard	2018
		ISO/IEC 29151:2017 Information technology – Security techniques – Code of practice for personally identifiable information protection	Standard	2017
		ISO/IEC 30111:2019 Information technology – Security techniques – Vulnerability handling processes	Standard	2019
	International Medical Device Regulators	IMDRF Principles and Practices for Medical Device Cybersecurity	Guidance	2020

Area/country	Publisher name	Publication title	Publication type	Year
	Forum (IMDRF)			
	Joint NEMA/COCIR/JIRA Security and Privacy Committee (SPC)	Patching Off-the-Shelf Software Used in Medical Information Systems	White paper	2004
	Open Web Application Security Project (OWASP)	OWASP Secure Medical Device Deployment Standard	Standard	2017
Japan	Pharmaceuticals and Medical Devices Agency (PMDA)	Ensuring Cyber Security of Medical Devices	Notification	2015
		Guidance on Ensuring Cyber Security of Medical Device	Guidance	2018
New Zealand	Medical Council of New Zealand	Telehealth	Statement	2020
	Ministry of Health	HISO 10029:2015 Health Information Security Framework	Standard	2015
		HISO 10037.1 Connected Health Architectural Framework	Standard	2010
		HISO 10037.2 Network to Network Interface Specifications	Standard	2010
		HISO 10037.3:2015 User to Network Interface Specifications	Standard	2015
		HISO 10064:2017 Health Information Governance Guidelines	Standard	2017
Republic of Korea	Korea Internet & Security Agency	Cyber Security Guide for Smart Medical Service	Guidance	2018
Saudi Arabia	Saudi Food and Drug Authority (SFDA)	MDS – G36 Guidance to Medical Devices Cybersecurity for Healthcare Providers, Version 1.0	Guidance	2019
		MDS – G37 Guidance to Post-Market Cybersecurity of Medical Devices, Version 1.0	Guidance	2019
		MDS – G38 Guidance to Pre-Market Cybersecurity of Medical Devices, Version 2.0	Guidance	2019
Singapore	Cyber Security Agency of Singapore (CSA)	Security-by-Design Framework, Version 1.0	Framework	2017
	Health Sciences Authority (HSA)	Regulatory Guidelines for Software Medical Devices – A Lifecycle Approach	Guidance	2019
	Enterprise Singapore	TR 67 : 2018 Connected medical device security	Technical reference	2018
Switzerland	eHealth Suisse	Guide for app developers, manufacturers, and distributors	Guidance	2018
		Checklists: Addendum to the guideline for app developers, manufacturers and distributors	Checklist	2018
Taiwan	Ministry of Health and Welfare	Guidance on Management of Cybersecurity in Medical Devices for Manufacturers	Guidance	2019
United Kingdom	British Standards Institution (BSI)	Cybersecurity of medical devices: Addressing patient safety and the security of patient health information	White paper	2017
	Department for Digital, Culture, Media & Sport (DCMS)	Code of Practice for Consumer IoT Security	Guidance	2018
	Imperial College London, Institute of Global Health Innovation	Improving Cyber Security in the NHS	Report	2020
	Medicines and Healthcare products Regulatory Agency (MHRA)	Guidance: Medical device stand-alone software including apps (including IVDMDs), Version 1.06	Guidance	2020
	NHS Digital	Protecting medical devices	Guidance	2019
	Royal Academy of Engineering	Cyber safety and resilience: strengthening the digital systems that support the modern	Report	2018

Area/country	Publisher name	Publication title	Publication type	Year
		economy		
USA	American National Standards Institute (ANSI), Association for the Advancement of Medical Instrumentation (AAMI)	ANSI/AAMI CI86:2017 Cochlear implant systems: Requirements for safety, functional verification, labeling and reliability reporting	Standard	2017
	ANSI, National Electrical Manufacturers Association (NEMA)	ANSI/NEMA HN 1-2019 American National Standard – Manufacturer Disclosure Statement for Medical Device Security	Standard	2019
	ANSI, Underwriters Laboratories (UL)	ANSI/UL 2900-1:2017 Standard for Software Cybersecurity for Network-Connectable Products, Part 1: General Requirements	Standard	2017
		ANSI/UL 2900-2-1:2017 Software Cybersecurity for Network-Connectable Products, Part 2-1: Particular Requirements for Network Connectable Components of Healthcare and Wellness Systems	Standard	2017
	AAMI	AAMI TIR57:2016 Principles for medical device security – Risk management	Technical information report	2016
		AAMI TIR97:2019 Principles for medical device security – Postmarket risk management for device manufacturers	Technical information report	2019
	Carnegie Mellon University	CMU/SEI-2017-SR-022 The CERT® Guide to Coordinated Vulnerability Disclosure	Guidance	2017
	Department of Health and Human Services (DHHS) Office for Civil Rights	HIPAA Security Rule Crosswalk to NIST Cybersecurity Framework	Crosswalk	2016
	Food and Drug Administration (FDA)	Content of Premarket Submissions for Management of Cybersecurity in Medical Devices[a]	Guidance	2018
		Content of Premarket Submissions for Management of Cybersecurity in Medical Devices	Guidance	2014
		Cybersecurity for Networked Medical Devices Containing Off-the-Shelf (OTS) Software	Guidance	2005
		Design Considerations and Pre-market Submission Recommendations for Interoperable Medical Devices	Guidance	2017
		Medical Device Safety Action Plan: Protecting Patients, Promoting Public Health	Action plan	2018
		Multiple Function Device Products: Policy and Considerations	Guidance	2020
		Postmarket Management of Cybersecurity in Medical Devices	Guidance	2016
		Radio Frequency Wireless Technology in Medical Devices	Guidance	2013
	Healthcare and Public Health Sector Coordinating Council (HSCC)	MEDICAL DEVICE AND HEALTH IT JOINT SECURITY PLAN	Joint security plan	2019
	Health Care Industry Cybersecurity (HCIC) Task Force	REPORT ON IMPROVING CYBERSECURITY IN THE HEALTH CARE INDUSTRY	Report	2017
	Healthcare Supply Chain Association (HSCA)	Medical Device and Service Cybersecurity: Key Considerations for Manufacturers & Healthcare Providers	Best practices	2018
		Recommendations for Medical Device Cybersecurity Terms and Conditions	Recommendation document	2018
	Health-ISAC Inc.	Medical Device Security Part 1: Landscape of Global Regulatory Guidance	White paper	2020

Area/country	Publisher name	Publication title	Publication type	Year
	HS Design, Inc.	Cybersecurity in Medical Devices through Full Systems Design Strategies	Best practices	2015
	Medical Device Innovation Consortium (MDIC)	Medical Device Cybersecurity Report: Advancing Coordinated Vulnerability Disclosure	Report	2018
	National Institute of Standards and Technology (NIST)	Framework for Improving Critical Infrastructure Cybersecurity, Version 1.1	Framework	2018
		SP 800-30 Guide for Conducting Risk Assessments, Revision 1	Guidance	2012
		SP 800-37 Risk Management Framework for Information Systems and Organizations: A System Life Cycle Approach for Security and Privacy, Revision 2	Framework	2018
		SP 800-66 An Introductory Resource Guide for Implementing the Health Insurance Portability and Accountability Act (HIPAA) Security Rule, Revision 1	Guidance	2008
		SP 800-95 Guide to Secure Web Services	Guidance	2007
		SP 800-121 Guide to Bluetooth Security, Revision 2	Guidance	2017
		SP 800-144 Guidelines on Security and Privacy in Public Cloud Computing	Guidance	2011
	NIST, National Cybersecurity Center of Excellence (NCCoE)	SP 1800-1 Securing Electronic Health Records on Mobile Devices	Guidance	2018
		SP 1800-8 Securing Wireless Infusion Pumps in Healthcare Delivery Organizations	Guidance	2018
	Senator Hannah-Beth Jackson	SB-327 Information privacy: connected devices	Senate bill	2018
	Senator Richard Blumenthal	Medical Device Cybersecurity Act of 2017	Congressional bill	2017
	The MITRE Corporation	Medical Device Cybersecurity: Regional Incident Preparedness and Response Playbook, Version 1.0	Playbook	2018
		Rubric for Applying CVSS to Medical Devices, Version 0.12.04	Playbook	2019
	The Office of the National Coordinator for Health Information Technology (ONC)	Guide to Privacy and Security of Electronic Health Information, Version 2.0	Guidance	2015
	United States Government Accountability Office (GAO)	GAO-12-816 MEDICAL DEVICES: FDA Should Expand Its Consideration of Information Security for Certain Types of Devices	Report	2012
	U.S. Department of Health and Human Services (HHS)	Health Information Technology for Economic and Clinical Health (HITECH) Act	Law	2009
		Health Insurance Portability and Accountability Act of 1996 (“HIPAA”)	Law	1996
		Health Industry Cybersecurity Practices: Managing Threats and Protecting Patients	Best practices	2018
		Standards for Privacy of Individually Identifiable Health Information (“Privacy Rule”)	Rule	2002
		Health Insurance Reform: Security Standards (“Security Rule”)	Rule	2003
		Technical Volume 1: Cybersecurity Practices for Small Health Care Organizations	Best practices	2018
		Technical Volume 2: Cybersecurity Practices for Medium and Large Health Care Organizations	Best practices	2018
		Health Industry Cybersecurity Practices: Managing Threats and Protecting Patients, Resources and Templates	Template	2018
	U.S. Department of	Attack Surface: Healthcare and Public Health	Bulletin	2012

Area/country	Publisher name	Publication title	Publication type	Year
	Homeland Security, National Cybersecurity and Communications Integration Center	Sector		
	U.S. Department of Veterans Affairs (VA)	Medical Device Security, Version 1.0	Enterprise design pattern	2017

[a.] Draft

[b.] Under development

Since 2015, there was a significant increase in the number of released professional cybersecurity publications listed in Table 1. As shown in Figure 1, a total of 117 professional cybersecurity publications were issued between 2015 and 2020 (80.7%), another 22 publications were published during 2008-2014 (15.2%), while only six publications were released during 1996-2007 (4.1%). Three publications were published as a draft version and eight publications are under development and have not been published yet.

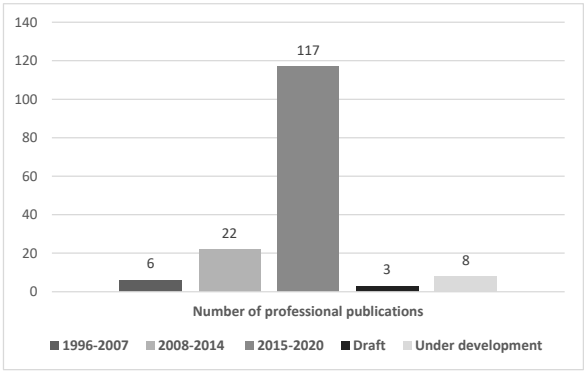


Figure 1. Professional cybersecurity publications by publication timeline

All publications listed in Table 1 were reviewed and classified into 31 different types according to their content. Table 2 lists publication types and shows the number of times they occur in Table 1.

Table 2. Publication types by frequency

Frequency	Publication type
1	Directive, technical guidance, technical reference, information report, workshop report, enterprise design pattern, crosswalk, recommendation document, consumer information, notification, statement, bulletin, joint security plan, action plan, checklist, template
2	Bill (i.e., proposed legislation), rule, technical information report, trend report, playbook
3	Law, framework
5	Regulation
6	Report, best practices
8	Executive brief
10	White paper, technical report
38	Standard
41	Guidance

4 Discussion and Conclusions

This paper has shown that medical device manufacturers operating in global context must tackle a high number of professional cybersecurity publications and different publication types. Since the first FDA's guidance document outlining the agency's cybersecurity expectations from a premarket perspective was published in 2014, many international regulators introduced their own guidance documents.

Due to the increasing number of regulations and regulatory compliance requirements that are sometimes listed within the guidance documents, implementing cybersecurity is very challenging for medical device industry practitioners and other stakeholders. Medical device companies must identify applicable cybersecurity regulations in countries where they plan to market their products and find an effective solution how to comply with applicable cybersecurity regulations and to maintain compliance.

This paper may assist different groups of professionals, researchers, regulators, and other subject matter experts in identifying applicable cybersecurity regulations, standards, and industry best practices for medical devices. Introducing an international standard that is recognised by most international regulators may help to address the challenges from a regulatory point of view.

The main weakness of this paper was that no systematic literature review could be performed due to the nature of professional cybersecurity publications. Only a relatively small number of such publications can be found in academic databases and search engines that are used for finding and accessing scientific papers.

Due to the scope of conducted narrative literature review, only English and German publications were included. Future work should seek to broaden this

further. It would be interesting to develop a centralized database containing a catalogue of applicable professional publications related to medical device cybersecurity. Such database should be extensible with new entries and contain metadata and keywords for easier search. Further research might explore relevant professional publications related to data privacy protection within the medical sector.

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Attitutes of Students and Employers to the Use of Student Centers' IT Services

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Abstract. *The work of students through authorized intermediaries, during their secondary, tertiary and post-academic education is an important segment that is largely related to academic success, and carries with it both positive and negative characteristics. The development of information and communication technology (ICT), new tools that enable education and distance work, as well as adaptations of the institutions dealing with student work, should contribute to better coordination between student work and individual academic success. An additional impetus to the use of ICT in mediation in the performance of student work was stimulated by the appearance of COVID-19. This paper explores the attitudes of users of student services in the Republic of Croatia, students and employers, towards the use of online student contracts. Although the system of issuing online student contracts has existed for several years, the research results show that students are still more inclined to pick up student contracts at physical student service locations, but also that external incentives, such as the recent situation with COVID-19, affect increased use of online student contracts.*

Keywords. student work, student contracts, online services

1 Introduction

The temporary and occasional work of students is, not only a positive contribution to the developmental and cognitive skills of the individual, but it also represents the financial aspect, which is an important driver of work engagement. Student work during academic education is a common occurrence, and is widespread in economically developed countries around the world. The work of students and other persons in the Republic of Croatia (RH) is regulated by the Law on conducting student jobs, which is relatively recent, from November 8, 2018. (Narodne Novine, n.d.-b). Until its adoption, the Rule book on mediation in the employment of full-time students from 1996 (Narodne Novine, n.d.-a) was in force. For the first time, the 2018 law prescribes the mediator to keep electronic databases and issue electronic contracts, thus directly encouraging the digital transformation in the work of student centers, which includes the introduction of an electronic student contract, electronic invoice and electronic signature. Although the e-inclusion of all stakeholders when it comes to student work is an assumption that is legally regulated, in practice it is currently not fully feasible. An online student contract has been introduced in the practice of student services, which cannot be treated as an electronic contract, because neither employers nor students sign it with smart electronic signatures. Currently, all student services have enabled the issuance of online student contracts, but they cannot be considered electronic contracts. In practice, there is often a confusion as uninformed users believe that a scanned user signature (sent electronically) is an electronic signature.

The aim of this paper is to investigate the attitudes of students and employers towards the use of existing information and communication services available by student centres in the Republic of Croatia and to determine the impact of the emergence of COVID-19 on their use.

2 Theoretical Framework

2.1 Previous Research

It has been found that early employment of young people results in better work experience in the long term and that education and work during education have a positive effect on employment and financial independence (Adams, 1978). Some authors deny the negative consequences of student work, and conclude that work during studies even improves academic success, but only if paid work does not exceed a certain

threshold of the number of working hours, which does not take away students the time needed to master academic obligations (Kosi et al., 2013), (Applegate & Daly, 2006). The cost of higher education in the UK and the need for self-financing of students through employment during their studies contributes to a higher probability of employment of students whose parents have higher education, and a higher probability of employment of female students belonging to ethnic minorities (Metcalf, 2003). The need for self-financing of studies leads to the division of studies into those that facilitate work during studies and those that do not prefer work during studies, with an emphasis on more prestigious universities (Metcalf, 2003). Working during studies is important for future careers, not only as a financial factor but also to help students increase their competitive advantage and gain certain work experiences. Work attitudes and career choice itself are important factors influencing student work during their studies (Wang & Chen, 2017), (Patel et al., 2012).

Observing the countries of the Western Balkans, the authors emphasize the positive side of student work as an investment in human capital, highlighting the age of students in all three countries as a predictor. In Serbia, the level of studies stands out as a predictor, in Montenegro the level and field of studies, while in Bosnia and Herzegovina the educational level of parents is an important predictor (Savić & Kresoja, 2018). Research on the consequences of combining study and work with special emphasis on stress shows that work does not cause additional stress for students but represents valuable work experience, but as a result they spend less and less time in compulsory education, and therefore institutions should enable and adjust student obligations to student work (Smith & Schoffstall, 2020), (Savić & Kresoja, 2018), (Robotham, 2012). Students are not dissatisfied with the fact that they spend part of their free time working, but with the academic schedule and obligations that are inconsistent and consider them a burden (Robotham, 2013), (Lingard, 2007). Studying the socio-economic aspects of student work, it was noticed that occasional work actually enriches school life and increases social inclusion, but at the same time harms students' relationships with parents (Manthei & Gilmore, 2005), (Lingard, 2007).

The number of students in the Republic of Croatia is declining, which is in line with the demographic picture of the Republic of Croatia. At higher education institutions in the Republic of Croatia in the academic year 2018/2019 a total of 181,424 students were enrolled. In 2019, a total of 94,786 students earned compensation for performing student work on the basis of student contracts (source: data available to the first authors through Student Centre Varaždin), which means that more than 52% of students have a need to work while studying (given that some were employed or did work through employment contracts).

2.2 Student Online Contract Issuance System

Today, when the basic information literacy is considered a prerequisite for normal daily activities and when electronic information exchange is present in both business and private spheres of life, it is logical to expect that the student population will readily accept the possibilities of online student contracts. The emergence of the COVID-19 pandemic changed the habits of many users of everyday services in a very short time, and thus affected the business of registered employment agencies. Although the Student Center Rijeka has had the possibility of issuing online contracts since 2008, and the Student Center Varaždin since 2017, only with the adoption of the Law on conducting student jobs (Narodne Novine, n.d.-b) in 2018, the electronic contract became a legal obligation of all intermediaries in student employment.

For the purposes of this paper, it is necessary to distinguish the concept of electronic contract, which is defined by the Law, from the current possibility of online issuance of student contracts. For the full implementation of the electronic student contract, all legal preconditions have not yet been met, i.e. all participants in the tripartite relationship (student, employer, student centre) should also have electronic signatures, which is not the case in practice. Although online contracts were expected to completely crowd out the issuance of forms at the intermediary's physical location this did not happen.

According to the available data of intermediaries, who had the opportunity to issue online student contracts even before the legal obligation, it takes a longer period to eradicate old habits and for users to accept more modern ways of doing business. Table 1 shows the percentage of contracts issued online in relation to the total number of contracts issued.

Table 1. Number of contracts issued online in Student service Varaždin and Student service Rijeka (source: data available to the first authors through Student Centre Varaždin)

	Student service Varaždin	Student service Rijeka
Year	% of contracts issued online	% of contracts issued online
2015		26,65
2016		28,68
2017	2,37	32,08
2018	12,63	34,95
2019	15,71	32,12
January – June 2020	34,91	51,53

In the Student Service Varaždin (the same software solution is used by 11 student services in the Republic of Croatia), each registered member can independently

create a contract on their computer and print it. The system is accessed through the student center's website, and the user logs in using user AAI data (Figure 1).



Figure 1. Display of the initial screen of the system for online contract issuance of the Student Center Varaždin

When creating a contract, the basic data defined by the Law that the contract must contain (data on the student, data on the employer, time, type and place of work) are entered, i.e. all the data that the student should tell the student service officer when picking up the student contract in person. After the adoption of the Law on conducting student jobs, all other student services in the Republic of Croatia enabled the issuance of online contracts (based on AAI user data), except for the Student Center Rijeka, which assigns each user a separate code and password that allows members to issue online contracts. Reasons for a kind of resistance to digitalization of this type of business should be sought primarily in the internal organization of individual student services, so if the work of individual branches of student services was evaluated through the number of issued contracts, then employees did not aim to encourage users to issue contracts online. Salaries of employees in student services are not defined by the number of issued contracts, but this is data that is monitored for the purpose of monitoring turnover at the level of individual student centers, but also at the level of the Ministry of Science and Education. The emergence of the COVID-19 pandemic has in some way forced the vast majority of working students and employers to turn to the online issuance and calculation of student contracts, as evident from Table 1, and this paper will explore in more detail the extent to which.

3 Methodology

3.1 Instrument

The research was conducted electronically using a survey questionnaire using Google Docs tools, was anonymous and voluntary, and the results were interpreted exclusively in groups. The link to the survey was available on the official Facebook page of Student Services Varaždin, and on the websites of student services in Rijeka, Osijek, Karlovac, Zadar and Pula, and on the Studentski.hr portal. The research was conducted in the period from March 18, 2020 to May 18, 2020. in the period when students were largely prevented from moving outside their place of residence due to the pandemic of COVID-19 in the Republic of Croatia. The questionnaire consisted of 42 items, of which 7 were related to demographic data and one item was open-ended, for respondents' comments only. The instrument was measuring general attitudes of respondents about the COVID-19 pandemic and its impact on everyday students and employers, but this paper presents only part of the results, which is related to online student contracts and the acceptance of ICT in the work of student services.

3.2 Respondents

The sample consists of 96 respondents, of which 20 employers (16 of which who have already used the student services for the purpose of employment mediation) and 76 students. Convenience sampling method was used. Respondents were students, existing users of student services, but also employers who used online issued student contracts. Of the 20 respondents on the employer side, women made up 85% and men 15% of the sample. Among students (N = 76), women were represented by 82% and men by 18%. Among employers, respondents represent 15% with secondary education, undergraduate level with 30%, while 55% of respondents have completed graduate or higher academic level of education. Among students, respondents with completed secondary education participate with 39.47%, undergraduate level with 59.22% graduate level with 1.31%. Although the sample is occasional, looking at the whole sample, respondents from all parts of the Republic of Croatia are represented, so that 76% of respondents are from Central and Northwestern Croatia, 12.5% from North Adriatic, 7.3% from Eastern Croatia and 4,2% from Central and South Adriatic. The sample represents all branches of the company's activity (if we look at the activity where the student worked at the time of completing the questionnaire or the employer at the time of completing the online student contract). The most represented activities are services with 43.7% and production with 19.8%. The representation of respondents from telecommunications, computer and software services is 10.4%.

4 Results

Figures 2, and 3 shows demographic characteristics of all respondents, their age structure and user type.

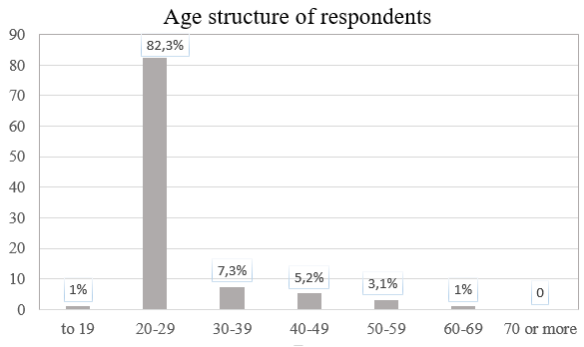


Figure 2. Age structure of all respondents (N=96)

It is logical that the largest number of respondents are in the age group 20-29 years, given that the service is primarily intended for students. Older respondents are employers, clients who use online contracting services on the client's side, those who fill out student contracts.

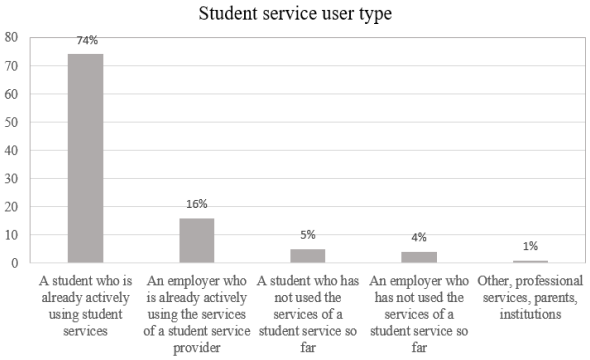


Figure 3. Student service user type (N=96)

The largest number of respondents, 74% are students and employers who already use online contracting services. However, to get a broader picture, the questionnaire was available to potential users who have access to the service but for some reason have not used it yet.

4.1 Respondents' Attitudes About Working From Home

Of the total number of respondents (N = 96), according to the results of the survey, 75% employers (N = 20) fully support work from home, teleworking, while only 58% of students (N = 76) support work from home. 55% of employers and only 34.2% of students strongly or completely agree with the statement "I have personally used the possibilities of working from home before", while 42.1% of students do not agree with this statement at all. At the same time, 10% of employers and 40.78% of students fully agree with the statement "Due to the nature of my work and the activity I am engaged in, I am not able to work objectively from home." The same claim is completely rejected by 50% of employers and 26.31% of students. The claim of supporting work from home in exceptional situations is largely supported by 60% of employers and 80.26% of students. None of the employers thinks that working from home is of lower quality than working in the office, i.e. at the physical location of the employer, and 30% of them do not agree at all with the stated statement. When it comes to students, 6.56% of them fully agree with the statement that working from home is of lower quality than working in the office.

When it comes to the use of ICT, 76.3% of students and 90% of employers largely or fully use ICT in their daily work. 50% of employers in the sample believe that the new opportunities will to a greater extent affect the greater use of ICT in them personally, while on the side of students this percentage is 55.26%. The vast majority of employers, 95%, largely or completely agree with the statement: "I think that the use of ICT technology currently greatly facilitates business." When it comes to students, 63.16% of them largely or completely agree with the previous statement.

4.2 Respondents' Views on the Use of Online Contracts

To examine respondents' views on the existing system of issuing online student contracts and its intuitiveness (Figures 4, 5, and 6), an ordinal scale was used, with the following five degrees of agreement: 1-Completely Disagree, 2- Mostly Disagree, 3- Undecided, 4- Mostly Agree and 5- Completely Agree. When it comes to the attitudes of respondents about the issuance of online student contracts, 55% of employers completely believe that the existing system is fully tailored to all users.

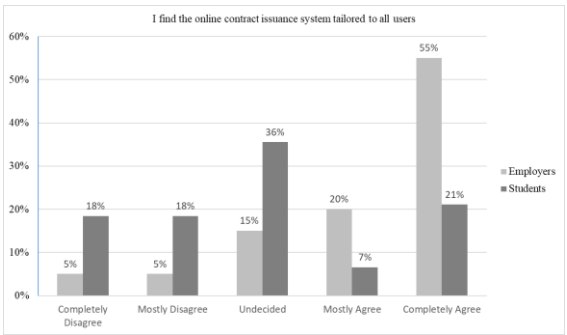


Figure 4. Attitudes of employers and students about the existing system of issuing online contracts

Opinions of students are quite uneven when it comes to the existing online system of issuing student contracts, which can be seen in Figure 4, so only 21%

fully agree with the statement that the system is tailored to all users. As expected, a large percentage of employers (85%) largely or completely agree with the statement that the online contracting system requires only basic IT literacy, while only 30% of employers say that the system is tailored to more advanced users, who use more advanced tools and techniques. The percentage of students who largely or completely agree with the statement that the system requires only basic IT literacy is 81.58%, while only 2.6% of students hold that the system is tailored to more advanced IT users. On the question of the intuitiveness of the system and its functioning in practice, opinions are divided (Figure 5, Figure 6)

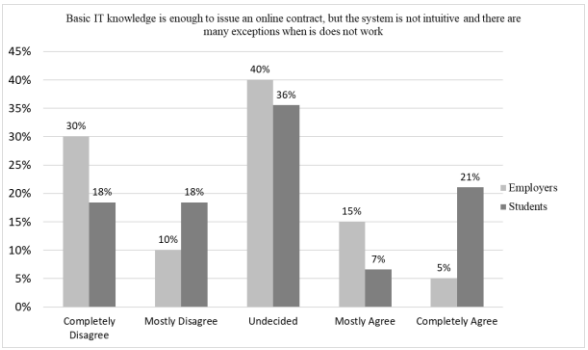


Figure 5. Attitudes of employers and students about the intuitiveness of the online contract issuance system

Given that the system of online contract issuance is primarily intended for students, academic citizens, it essentially implies basic computer literacy, and 60% of employers and 65.42% of students agree with this to a large extent or in full. A small part of the surveyed employers, 5% of them completely agree with the statement that the system is impractical because not all students have the opportunity to use computers and printers, and none of the employers think that the system is impractical because students do not have enough free time to they create contracts themselves.

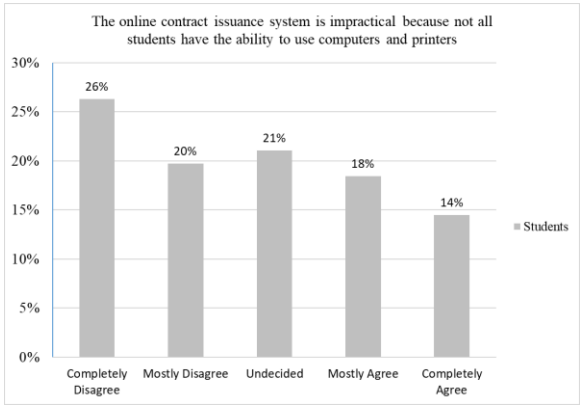


Figure 6. Students' attitudes about the impracticality of the system due to lack of computers and printers

Unexpectedly, 14.47% of students think that the system is impractical due to the inability to use computers and printers. When it comes to students' free time to create contracts on their own, 68.42% of students do not consider this to be a limiting factor at all.

When it comes to employers' awareness of the fact that the online contract issuance system has been operating in some student services since 2008, and in all since 2018, 15% of employers state that they have been using this system for years, 60% of them have been using the system since application of the Act (Narodne Novine, n.d.-a), while 10% of employers only accepted the possibility of issuing contracts online recently with the appearance of the COVID-19.

Students, on the other hand, are a little better acquainted with the possibilities of online contracting, so 19.73% of students have been using the system for years, 47.37% of them started using online contracts after the implementation of the new Law, while 27.63% sought an alternative to issuing contracts at physical locations only with the appearance of COVID-19.

4.3 Respondents' Attitudes About the Use of ICT in Communication With Student Services

Employers prefer communication via e-mail (37.21%), followed by communication via fixed (30.23%) and mobile (16.28%) telephone lines. Students prefer to communicate via websites (using their AAI data they have access to open work positions, they are enabled to monitor the status of contract payments but also to issue online contracts). In the second place in terms of the representation of communication channels is the calling of student services on fixed telephone lines, followed by communication by e-mail, and as expected, communication via fax takes the last place (Figure 7). Although these are young people who have access to ICT, 23.68% of them prefer to physically visit student service locations, although alternatively they can do all communication remotely.

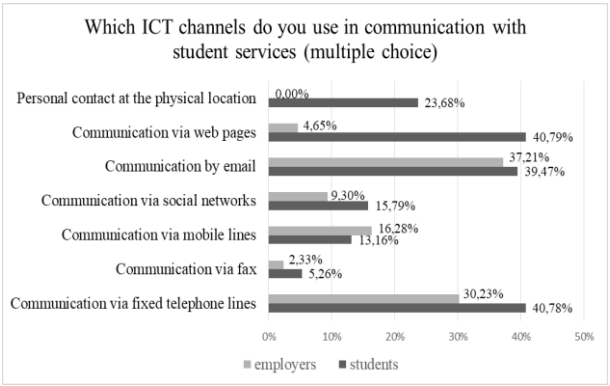


Figure 7. Types of ICT used in the communication of employers and students with student services

5 Discussion

The appearance of COVID-19 in the whole world, including the Republic of Croatia, has certainly left its mark in every sphere of private and business life of every individual. Students, as one of the more sensitive categories in the labour market, were under direct attack. Not only did most have to leave their temporary accommodation (student dormitories or accommodation with private renters), get used to the conditions of online education, but like the vast majority of employees they had to adjust to online working conditions as well. Interestingly, a higher percentage of employers than students prefer working from home, teleworking, although both categories of respondents largely use ICT in their daily work. One of the possible reasons may be that a larger number of students work in production, warehousing, assembly and distribution of products, in shopping malls, etc., Therefore 40.78% of students say that due to the very nature work and activities in which they are engaged so far have not objectively used the possibilities of teleworking.

Perhaps the emergence of extraordinary circumstances, such as the appearance of the COVID-19, gave birth to some positive aspects, and in some way forced some users to stop resisting all the benefits and advantages of ICT technology in everyday business, as the vast majority of employers (95%) and 63.16% students acknowledges that the use of ICT technology has greatly facilitated their business in the new circumstances. Moreover, it is evident that the number of issued online student contracts has raised significantly in the first half of 2020, when the epidemic situation forced most of the users to use online services.

It should be taken into account that the results of this study are based on an occasional sample, and the assumption is that the respondents who participated in the online survey have already adapted to the conditions of teleworking. Still, some students (6.56%) believe that working from home is of lower quality than working at a physical location, while no one on the side of employers fully agrees with this, which certainly depends on the type of activity in which the company is engaged.

Although the online contract award system for students is quite intuitive and simple for most student services, it is enough to know the user's AAI data and the employer's OIB, according to the data shown in Figure 4, only 21.05% of students stated that agrees with the statement that the online contracting system is tailored to all users, and 81.58% that the system requires only basic IT literacy. It is not a negligible fact that 23.68% of students have not used any communication channels in their work with student services, but solve everything by personal departures, although in fact they can get all the information online.

6 Conclusion

When interpreting the results, it is necessary to take into account the limitation related to the appropriate sample of respondents and the method of data collection. Also in further research it is necessary to include respondents based on a random sample, which will be representative of the entire student population. In conclusion, a series of legal measures to raise the quality of student services, as well as activities to raise awareness of the student population and the employer, it is possible to change the existing social and business situation in business organizations in the Republic of Croatia. The results of this research showed the perception of respondents about the benefits of using ICT technology, both in everyday work and especially in unforeseen circumstances, when online business is the safest way to do business.

The Law on conducting student jobs also defines the handling of electronic student contracts, but they have not yet taken root in practice due to the fact that an extremely small percentage of students and employers use advanced electronic signatures, which is a basic prerequisite for electronic contracts. It would be desirable to investigate in more depth the reasons why some students and employers, who live surrounded by ICT technology and who grow up with smartphones still prefer to physically go to the location of a public institution, although all activities can be done electronically.

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Rethinking the Process of the Student Evaluation of Teaching*

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Abstract. *Students are usually required to complete teacher assessment surveys (SET – student evaluation of teaching) at higher education institutions around the globe. In some countries, focus is put on assessing teaching effectiveness with a view to influencing pay and promotion, but in fact such assessments are a part of broader quality management systems, with focus on enhancing teaching and as a reference for the creation of teaching practice. Within the DIP2Future project in this paper, some experiences and important points regarding the process of student assessment of teaching are highlighted which should be considered and discussed. The primary aim is to render such evaluations purposeful (for student, staff, management of the faculty), but still practical and feasible.*

Keywords. quality of teaching, SET, student evaluation

1 Introduction

The project DIP2Future is implemented by the Faculty of Organization and Informatics Varaždin (FOI) in partnership with the Department of Informatics, University of Rijeka (OIRI). Within the project four new study programs are being developed: 1) Data systems and artificial intelligence, 2) Management of information security and privacy systems, 3) Distributed and interactive systems and 4) Management of business systems transformation and innovation.

The aim of the project is to develop new study programs in the field of ICT in which the demand for appropriate skills and competencies of ICT professionals in accordance with the requirements of the labour market and trends in technological progress will be met. One of the results of the DIP2Future project refers to the quality of teaching and the improvement of the system of student surveys on the quality of teaching and other forms of evaluation at the faculties.

2 Background

2.1 Teaching as a Service

Education/teaching is, along with research and knowledge transfer/contribution to the community, the major pillar of the activities of a higher education institution.

According to the ISO 21001 (2018), the management (system) principles of institutions dealing with education should include, among others:

- focus on the needs of learners and other beneficiaries;
- learning-centeredness;
- engagement of learners and interested parties;
- improvement;
- evidence-based decisions.

The standard (ISO 21001, 2018) promotes "the adoption of a process approach when developing, implementing and improving the effectiveness of a quality management system, to enhance learner and other beneficiary satisfaction by meeting learner and other beneficiary requirements".

Furthermore, according to the ISO 21001 (2018), the application of the process approach in management (system) enables:

1. "understanding and consistency in meeting requirements;
2. the consideration of processes in terms of added value;
3. the achievement of effective process performance;
4. improvement of processes based on evaluation of data and information."

The application of assessment methodologies of the educational effectiveness and the results of the assessment of the educational effectiveness are elements of each process, including the process of teaching.

In the context of the aforementioned, it could be emphasized that:

* This paper is published and available in Croatian language at: http://ceciis.foi.hr

- learners are the main beneficiary of the education /teaching process i.e. service customer;
- the needs of learners which relate to the teaching process/education as a service should be satisfied;
- the process approach in the management of teaching/education and evidence-based decisions are the way to meet the needs of learners (and other stakeholders) effectively; and finally,
- the relationship with learners as the main beneficiaries/customers should be of high quality; learners should be engaged/involved in all processes of teaching and learning (education) management and decision making (joint decision making) to ensure that their needs are well defined and met, and educational processes are managed well and improved constantly, continually.

The high quality of teaching (process) is one the main indicators that a (higher) education institution is close to fulfilling the needs of learners/students. This is the reason that Student Evaluation of Teaching (SET) may have greater importance/weight than peer/expert and/or self-evaluation of teaching.

According to Uttl, White and Gonzalez (2017), "Student Evaluation of Teaching (SET) ratings are used to evaluate faculty teaching effectiveness based on an assumption that students learn more from highly rated professors". In (Scheepers, 2019) it is stated that "when SETs are used, it often serves not only as an instrument in the quality control cycle, but also as instrument for teachers' individual performance review".

For many years, student evaluation of teaching has been in the focus of many studies dealing with different factors which may influence the SET ratings/results. For example, based on those studies Pounder (2007) discusses factors which relate to student (Gender effect, Student's academic level and maturity, Students punishing their teachers via SET scores), teacher (Gender, Age, experience, rank, Teachers' influencing tactics, Teachers' behavioural traits) and course (Grading, Class size, Course content, Class timing).

Many factors affecting SET as well as many doubts and issues connected with SET in different educational systems/environments were motivation to begin this research and discuss teacher/teaching evaluation in this paper.

2.2 The Quality of Teaching

According to the ISO 21001 (2018), tools for evaluation in Educational Organizations in general may include: Cost Analysis; Satisfaction Surveys; Suggestion Schemes; Complaint and Appeal Systems; Impact Evaluation; Needs Analysis; Statistical Data Analysis; Focus Groups; Self-Assessment; Peer Assessment; Boards and Committees to analyse performance; SWOT; Brainstorming; Quality Methodologies: TQM, Lean Six Sigma, Kaizen.

When it comes to the quality of teaching it could be evaluated by students (student evaluation), by peers/experts (peer/expert evaluation) or by the teacher/educator himself/herself (self-assessment) among which a student evaluation of teaching/teacher work is the most common.

According to the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG, 2015) "quality, whilst not easy to define, is mainly a result of the interaction between teachers, students and the institutional learning environment". Furthermore, "quality assurance should ensure a learning environment in which the content of programs, learning opportunities and facilities are fit for purpose". In the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG, 2015) it is stated that "the heart of all quality assurance activities are the twin purposes of accountability and enhancement" which together "create trust in the higher education institution's performance".

"A successfully implemented quality assurance system will provide information to assure the higher education institution and the public of the quality of the higher education institution's activities (accountability) as well as provide advice and recommendations on how it might improve what it is doing (enhancement)" (ESG, 2015).

In the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG, 2015), standard 1.3 Student-centred learning, teaching and assessment refers the most to the content of student evaluations of the quality of teaching (and learning), stressing that "the implementation of student-centred learning and teaching

- respects and attends to the diversity of students and their needs, enabling flexible learning paths;
- considers and uses different modes of delivery, where appropriate;
- flexibly uses a variety of pedagogical methods;
- regularly evaluates and adjusts the modes of delivery and pedagogical methods;
- encourages a sense of autonomy in the learner, while ensuring adequate guidance and support from the teacher;
- promotes mutual respect within the learner-teacher relationship;
- has appropriate procedures for dealing with students' complaints".

So, student evaluation of teaching/teachers is the best way to gain insight into the teaching process/teachers' performance and to identify possible improvements.

2.3 Evaluation of the Quality of Teaching in the Higher Education in Croatia

Evaluation methods are used at higher education institutions in the Republic of Croatia to assess the work of teachers. These evaluation methods belong to the area of quality assurance systems within which quality assurance measures and activities are carried out. The area of quality assurance and improvement is regulated by rules and procedures, including the procedure of evaluation and assessment of teachers' work.

In the Republic of Croatia, the regulation covering the area of quality assurance is the Quality Assurance in Science and Higher Education Act. Said act regulates quality assurance and improvement in science and higher education through initial accreditation, re-accreditation, thematic evaluation and external independent periodic evaluation of the internal quality assurance system (audit). It also defines the status, activities and organization of the Agency for Science and Higher Education as public institutions in the Republic of Croatia, which takes care of quality assurance and improvement in science and higher education, and the role of other bodies in the Republic of Croatia that take care of quality assurance and improvement in science and higher education. The provisions of the Act apply to public and private higher education institutions, public scientific institutes and other scientific organizations founded by the Republic of Croatia, as well as private scientific institutes and other legal entities registered in the Register of Scientific Organizations.

At the level of universities in the Republic of Croatia, the following are related to the evaluation of the quality of teachers' work:

- the Ordinance on the quality assurance system at the University of Zagreb,
- the Ordinance on the quality assurance and improvement system of the University of Rijeka,
- the Manual on Quality Assurance at the University of Zagreb, University of Rijeka,
- the Ordinance on quality assurance of the Faculty of Organization and Informatics
- the Ordinance on the quality assurance and improvement system of the Department of Informatics of the University of Rijeka.

The Ordinance on the Quality Assurance System at the University of Zagreb regulates the goal, purpose, areas of evaluation and organization of the quality assurance system at the University of Zagreb. The goal of quality assurance is to build mechanisms to promote quality and achieve its highest level in educational, scientific and artistic activities, and administrative activities at the University.

The Ordinance on the quality assurance and improvement system of the University of Rijeka prescribes the area of evaluation, structure and operation of the quality assurance and improvement system of the University of Rijeka. The goal of the quality system is to promote a culture of quality and the development of institutional mechanisms for systematic evaluation, with the long-term purpose of ensuring and improving quality and promoting high standards of professional and vocational development of participants in all areas of the University.

The evaluation of teachers' work is based on the results of student assessment of the teaching process, and the procedure is prescribed at the level of each university. Student surveys examine students' opinions about the work of individual teachers. The purpose of these surveys is to improve the quality of teaching and analysis of results, which should be aimed at highlighting good examples.

The evaluation of the quality of teaching work of teachers and associates of a certain subject as well as the engagement of students in a certain subject takes place in order to improve the work of teachers and teaching in each individual subject on the basis of this evaluation. The goal of conducting a student survey is to identify areas and activities that need to be improved or changed.

Universities in the Republic of Croatia conduct surveys as an evaluation method by which students evaluate the work of their teachers and surveys by which they assess their overall study experience. This gives students the opportunity to give feedback and their opinions.

The aim of the survey is to evaluate the teaching work of teachers in a particular course. From the academic year 2011/2012 at the University of Zagreb, teaching evaluation was carried out according to a three-year Revised Cyclic Survey Plan. According to a decision of the Senate on October 16, 2015, each faculty/department is obliged to carry out the evaluation of teaching using the paper-pencil method once every three years. The survey is conducted using the Teacher Assessment Questionnaire, which is also available in an English version, and the accompanying Control sheet. Considering that an increasing number of foreign students are studying at the University of Zagreb, from academic year 2012/2013 the English version of the Survey is also available.

In both semesters the survey is conducted during the last two to three weeks of the semester and, for courses taken alternately, during the last week of teaching the course. The rules and instructions related to the implementation of the Survey are regulated by the Student Survey Implementation Plan, Instructions for Conducting the Student Survey, Instructions to the Interviewer and Recommendations for Handling University Survey Results for Systematic Reporting to Teachers and Students.

There are more methods that can be used in order to receive information about the quality of teaching: self-evaluation and peer evaluation. With the help of these methods, the teacher can obtain information from a completely different perspective. Using all the above

methods, information is obtained about the work of an individual teacher and what is important for students.

In order to self-evaluate their own teaching work, teachers have the opportunity to synthesize their own findings by filling out an appropriate form that concerns three aspects of teaching: teaching skills, motivation and communication, and preparation and organization.

At the University of Rijeka, the evaluation of teachers' work is possible on the basis of different procedures or a combination of the same. Evaluation is carried out in the following forms: evaluation of teachers' work by students, self-evaluation of teachers (teacher evaluates his/her work independently), evaluation of teachers' work by other teachers, evaluation of assistants, postdoctoral fellows and mentors, analysis of study success, assessment of availability and suitability of teaching materials and institutionally coordinated direct regular communication with student representatives.

The evaluation of teachers' work is based on the results of the student assessment of the teaching process. It is conducted on the basis of standardized questionnaires at the University level (for the purpose of comparability), supplemented, if necessary, with the specifics of work at each faculty. Internal evaluation of teachers' work is carried out regularly, at least every three years, i.e. for teachers whose evaluation results are used in the process of election to a higher title or re-election, at least twice during the period between elections to a particular scientific-teaching or teaching title.

From all the above, it is evident that the universities in the Republic of Croatia have organized procedures for evaluating the work of teachers in accordance with the positive regulations of the Republic of Croatia.

2.4 Student Evaluation of Quality of Teaching -The Case of the Faculty of Organization and Informatics

Student evaluation of the teaching quality at the Faculty of Organization and Informatics is done, in accordance with all procedures defined by the University of Zagreb/The University Office for Quality Management, every third year as a paper-based survey. However, it has been performed every year for teachers who want this because of personal reasons (e.g. checking the effects of new methodologies/course contents introduced), or as one of the corrective measures taken based on the results of previous student survey results to assure the quality of teaching. It should be emphasized that the student survey of teacher evaluation is anonymous and voluntary (for students, as respondents). On the other side, the teachers should, for the purpose of their academic advancement (promotion), have and provide the valid (more than 50% of completed survey forms out of the total students involved in at least one course they teach), which sometimes could be challenging to accomplish and satisfy (the overall teacher grade greater than 3) results of the student surveys of their teaching.

At the level of the Faculty of Organization and Informatics, implementation of the student evaluation survey is managed by the Vice-dean for Teaching and Students (in its function responsible for the area of quality assurance too) and the Student Survey Implementation Committee (consisting of three members), with the help of interviewers, mostly from the ranks of assistants (which all, of course, sign the Data Confidentiality Agreement/Statement).

Upon invitation by the University Office for Quality Management, the Vice-dean for Teaching and Students together with the Student Survey Implementation Committee prepares the Student Survey Plan and asks all the teachers for which the survey would be done to check, comment and/or change the Plan. The Plan is sent to the University Office for Quality Management for coding. A code refers to the pair "teacher-course" denoting for which teacher the survey would be done on which of his/her courses. Coding ensures data protection and privacy during the survey results handling. The Student Survey Implementation Committee asks the University Office for Quality Management for paper-based survey materials which encompass the standard teacher evaluation survey forms (the questionnaire), control sheets and envelopes for protecting/storing the filled in survey forms.

The teacher evaluation standard survey form is available both in Croatian (UNIZG-a) and English (UNIZG-b) language versions, consisting of the three parts:

1. A-part: General information on the student – encompassing the student-respondent's gender, regularity of the student-respondent's attendance at this particular teacher's classes, the level of interest of the student-respondent in the topic of the course at the beginning, the student-respondent's prior grade average, and the student-respondent's expected grade in the course;
2. B-part: Teacher evaluation for the given course – encompassing the ten statements (for which students are expected to use the Likert scale from *1 - I fully disagree* to *5 - I fully agree* to evaluate how well they (the statements) describe the teacher's work, or to use the option *I cannot evaluate*, referring to the teacher's clear definition of learning outcomes and what is expected of students, structuring of his/her classes and efficient use of available time, clarity and understandability of the material's presentation, use of various teaching materials to raise the quality of teaching (e.g. e-learning, pre-prepared materials), methods, examples and exercises which facilitate the achievement of learning outcomes, possessing good communication skills and creating a pleasant working atmosphere,

motivation and conscientiousness in performing his/her tasks, treating the students fairly and respectfully, regularity of holding his/her classes and punctuality when beginning the classes, and finally, his/her overall evaluation;

3. C-part: Comments on the teacher's performance – in the form of answers to the questions: "What did you like most about this teacher's work in this course?" and "What you didn't like especially about the teacher's work in this course or what improvements would you propose in order to enhance the quality of teaching?".

The control sheet (UNIZG-c, n.d.) is intended for interviewers and it encompasses ID (identification) of the teacher, i.e. the code for the pair "teacher-course" which is mandatory to identify to which teacher-course the survey form(s) belongs, and more detailed data on the institution/department and (year of) study programs of the course, the teacher and who (which interviewers) and when did the survey and how many survey forms have been filled in.

The Student Survey Implementation Committee prepares the student survey implementation plan (the survey schedule - exact dates, time and place of the survey for each course) and forms the group of interviewers. For the group of interviewers, an education is usually organized to introduce them to the survey's aims, procedures and documents and to assure consistent and high-quality survey implementation.

The surveys are scheduled, according to the University Office for Quality Management, during the last two weeks of teaching on the course for which teachers are evaluated. Therefore, it could be quite demanding for the students as are invited to complete many survey forms in a short time period.

The Student survey implementation plan (the survey schedule) is published on the web page of the Faculty and teachers are also invited to inform and motivate their own students to participate in the survey via the e-learning platform on which each course, in its online version, exists.

The survey is conducted in such a way that the interviewers come to the beginning or end of the lecture and follow the prescribed procedure to get completed survey forms which are placed and sealed in an envelope for each teacher separately and immediately in front of the students. All envelopes with the completed survey forms are collected and stored safely and when the survey plan is fulfilled and finished all are delivered when requested to the University Office for Quality Management together with the short data on the number of envelopes and surveys done.

The results of the student surveys are available to the responsible person (in the case of Faculty of Organization and Informatics it is the Vice-dean for Teaching and Students) which invites all teachers to examine them personally and analyse and reflect on them. It should be emphasized that the individual results of teacher evaluations are available only to the responsible persons i.e. to the Vice-dean, Dean and to the teachers themselves (each teacher sees only his/her survey results). The Vice-dean prepares the cumulative results of the survey which are presented to the Faculty Management Board, to the Quality Management Board as well as to the Faculty Council (to all teachers). The results are discussed at the Quality Management Board, which, according the University prescribed procedure, gives their Opinion, Recommendations and Action Plan based on the Results of the Teacher Evaluation Survey and publishes it on the Faculty web pages. In the document, the action plan refers to poorly rated teachers with overall scores of 3 or lower (as defined in the University procedure) and usually it specifies improvement measures as well as repetition of the student survey next (each) academic year to monitor the results.

When needed for personal, academic enhancement/promotion, the teachers ask the responsible person (Vice dean for Teaching and Students) to issue a Certificate in Institutional Research of the Quality of Teaching in the prescribed form for each course for which he/she has been evaluated. Additionally, at the Faculty of Organization and Informatics, the teachers are advised to ask the Faculty Quality Board for its opinion on teacher work based on the student survey results and scans of the completed survey forms which, in this case, the teacher displays to the Quality Board.

In this case, the teacher voluntarily gives, to the Quality Management Board, insight into the results of student surveys and scanned individual completed survey forms needed to prepare and issue the opinion. The opinion contains an overview of the results of student surveys that have been conducted for the teacher in question in the last three years.

3 Problem Formulation and Research Methods

Based on the experience the authors gained with teacher evaluation student surveys during the last few years some initial issues may be identified:

1. the dual nature of the student survey for the evaluation of teachers – voluntary for students and mandatory for teachers when asking for academic enhancement/promotion;
2. motivation of students to participate in the survey and reasons for not participating;
3. implementation of the survey – in a quite short period at the end of the semester which could be very demanding, stressful and tiring for students;
4. questionable authenticity of the survey and its results (in some cases, for example on the courses with many teachers/teaching assistants, students evaluated a wrong teacher);

5. questionable purpose of the survey from the perspective of students who sometimes express suspicion that something is being done/changed based on the results of the survey.

These initial issues identified have been the trigger for starting the research on the perception of the student survey for teacher evaluation and finding approaches for its potential improvement. The inductive approach (Tay & Jebb, 2016) to scale creation was used where people involved in SET were asked to describe concepts and these descriptions were derived in order to form the items. To evaluate each of the items for content relevance, representativeness, and technical quality (content quality) we used evaluation by experts and evaluation by the population (Boateng, Neilands, Frongillo, Melgar-Quiñonez & Young, 2018).

4 Result – SET Indicators

The aim is to gather information on experiences and examples of good practice related to the treatment and evaluation of the teaching quality in order to define SET indicators for overall evaluation improvement.

4.1 Information on Experiences and Examples of Good Practice Regarding SET

A questionnaire was prepared in order to systematically collect data. The questions are organized into three parts:

1. organization of evaluation of the quality of teaching and work of teachers at the university level;
2. organization of evaluation of the quality of teaching and teacher work at the faculty level;
3. general purpose of the survey.

Organization of evaluation of the quality of teaching and work of teachers at the university level refers to current methods used to evaluate quality of teaching which are defined by the university/faculty. There have been 16 indicators defined:

1. the ordinance defines the implementation of the evaluation of the quality of teaching and the work of teachers;
2. instructions for surveying and conducting other methods of evaluation, methods of reporting and acting on the basis of survey results;
3. evaluation documents, e.g. questionnaires/online forms, instructions for interviewers, survey plans, instructions for handling survey results;
4. methods of evaluation of the quality of teaching and work of teachers are defined/prescribed and used (student surveys, peer-evaluation, self-evaluation);
5. the assessment of the quality of teaching identified as one of the criteria for promotion /selection to a certain scientific-teaching title;
6. whether completing the survey on the quality of teaching and teacher work is mandatory for students or voluntary;
7. forms of the evaluation (e.g. paper-based survey or online);
8. the frequency of evaluation - every year or cyclically (every 2, 3 years);
9. the autonomy of the faculty/department in organizing/defining and conducting evaluations;
10. method and extent of publishing the results of evaluation of individual faculties/ departments;
11. the average results of the entire university and the results of other faculties/departments;
12. ranking lists of faculties/departments according to the summary results;
13. procedures for poorly rated teachers and for excellently rated teachers;
14. the range of grades and the minimum acceptable level of quality of teaching;
15. publishing evaluation results to students;
16. access to detailed evaluation data.

Organization of the evaluation of the quality of teaching and teacher work at the faculty level refers to the practices that departments or faculties prescribe with the purpose of improving the quality of teaching.

The third group of questions General purpose of the survey refers to the perception of the purposefulness of the survey. Here, it is examined whether a particular department or faculty conducts the survey of students and teachers about the purposefulness and effectiveness of conducting evaluations and improvement activities based on evaluation results. It should be determined:

1. whether individual evaluation results are monitored (for each teacher) continuously and at what level (at the level of subjects, departments/faculties);
2. whether and what corrective measures are being taken for poorly graded teachers;
3. whether and how excellently rated teachers are rewarded;
4. are corrective measures being taken to improve the identified poor elements of teaching quality at the faculty level;
5. whether the results of the corrective measures taken are checked and evaluated. Are students informed about the corrective measures taken and their results.

5 Conclusion

There is a range of literature that defines the advantages or lack thereof of SET, and discuss if it is necessary to change or present the reasons why such research should be abandoned. Jones et al. (Jones, Gaffney-Rhys & Jones, 2014) provide a review of previous ideas on student evaluation of teaching (SET) outcomes in higher education institutions (HEIs), with special emphasis on possible validity problems and concerns that should be discussed by HEI decision-makers before evaluating and summarizing survey findings. Recommendations regarding SET data collection include:

- to attend the workshop on SET to gain insights into the reason for SET, its application and their obligations regarding it;
- avoid utilizing mixed SET data collection approaches (e.g. online / offline);
- use various tools / methods to get input, use focus groups or peer-review;
- ensure that the students who complete the SETs can be identified and their anonymity preserved.

This paper introduces activities which are part of the DIP2Future project's initiative of the planning the improvements in student evaluations of teaching. The primary aim is to render such evaluations more purposeful (for pupils, staff and management of the faculty), but still practical and feasible.

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Towards a Hybrid Model for the Evaluation of Critical IT Systems

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Abstract. *Given that today's very complex and interconnected business processes meaningly rely on Internet communication with other business entities, organizations are increasingly exposed to numerous security threats and imminent risks. Due to the lack of all relevant information and the time and resource constraints, it is not possible to collect and process all necessary information about an information system so that it can be adequately evaluated within an acceptable timeframe, which puts the organization into a state of increased security risk. By studying the relevant literature and existing models and techniques used in practice, it was determined that there is no solution to the stated problem of multicriteria decision-making in conditions of uncertainty in the domain of information security. Thus, the proposal is to design a model for more efficient (in terms of costs and time) decision-making on the security state of a critical information system by selecting the appropriate IT solution. In this paper we will present the iterative steps of DSRM (Design Science Research Methodology) for development of a new hybrid multicriteria model for the purpose of evaluation, ranking and selection of critical IT systems.*

Keywords. Information security, risk assessment, multicriteria decision-making, hybrid model

1 Introduction

Unavailability of the information system or any part of it may be caused by equipment failure, improper configuration or inadequate management. Also, there are notable external factors like emerging cyber attacks on organizations, particularly financial institutions and their clients (Biancotti, 2017; Bouveret, 2018; Raghavan and Parthiban, 2014), where particularly dangerous WannaCry and Petya attacks should be highlighted (Hsiao and Kao, 2018; Aidan et al., 2017). There has been a significant increase of security threats and cyber attacks on financial institutions, so according to Verizone Institute (Data Breach Investigations Report, 2020), as many as 86% of successful cyber attacks (i.e. breaches) were financially motivated, and according to the International Monetary Fund (Lagarde, 2018), the risk of cyber attacks is recognized as the most significant one in the financial sector.

Today's business of financial institutions relies heavily on communication over the Internet with their clients and other business entities, so banks are in fact increasingly exposed to numerous security threats and unavoidable risks. Assessment and management of IT security risks is a critical process. It's a set of related activities to control and manage risks of the information system. The main goal of this process is to reduce risks to an acceptable level (NIST SP 800-30; NIST SP 800-37), depending on the level of risk appetite which the organization's management is willing to accept (Mbowe et al., 2014). It is precisely the task of security professionals to enable the organization to operate in such conditions of uncertainty, i.e. risk.

Due to the rapidly growing trend of increasing security threats and newly discovered vulnerabilities and very often insufficient amount of time and other resources in organizations to effectively respond to risks, addressing the most critical ones and consequently assessing security countermeasures, controls and critical IT systems becomes an essential problem. Thus, the following research questions arise:

- Q1: How to enable more efficient decision-making on the security posture and the selection of appropriate critical information systems in a financial institution?
- Q2: Which elements of security risk analysis and assessment are appropriate and relevant for the development of a hybrid multicriteria model for the assessment and selection of critical information systems in order to more effectively make informed decision about the observed critical IT system in a financial institution?

- Q3: For which critical information systems is the proposed hybrid multicriteria model applicable and valid?

Therefore, the planned research deals with the issue of information security risk management in the field of critical information systems in a financial institution in the context of selecting an appropriate IT solution, all using multicriteria decision-making (MCDM) methods, in order to reduce risk to an acceptable level.

2 Related Work

The research initiative stems from the experience where the author identified a problem in the absence of an effective (in terms of costs and time) method or model for the assessment of critical information systems in a financial institution in order to better address security risks and make an appropriate decision on the security posture of the observed system, and then finally help in choosing an adequate IT solution. In order to provide answers to the research questions, it is necessary to make an analysis of the literature and existing models and methods in the areas of multi-criteria decision-making and risk management, which are used for the evaluation of IT systems.

By searching scientific citation databases, the following relevant papers were found on the topic of risk management and application of methods for multi-criteria decision-making for the purpose of evaluation and ranking of information systems:

In their paper (Fenz et al., 2014), the authors reviewed and compared current approaches to risk management, noting that they do not provide explicit mechanisms to support decision makers in developing risk management strategies in relation to cost trade-offs. So, as a result of the comparison, an abstract methodology was created in order for the problem to get aligned with the identified solution according to its generic phases.

According to (Barker, 2014), the gap between perceived and actual risk is extremely large. Although the vast majority of senior management claims that their cyber programs are effective, the number of significant security incidents and breaches of the information system with serious consequences for the company's operations is growing, with the financial damage also increasing.

According to (Wangen et al., 2018), a framework for evaluating the integrity of information security risk assessment methods is proposed, where a comprehensive comparison of ISRA (Information Security Risk Assessment) methods was conducted, representing a new framework developed using the DSR (Design Science Research) methodology. Taking into account only three aspects of observation, namely risk identification, estimation and evaluation, it was concluded that ISO / IEC 27005 is actually the most complete method.

In research (Maček et al., 2011), two methods for risk analysis and assessment are combined together, where the VECTOR method initially served to prioritize critical assets while later on OCTAVE-Allegro method is used for more detailed analysis, assessment and proposals for dealing with critical risks. Research has shown that the proposed ISRA methods are complementary and can be used sequentially, but there is still a problem of risk quantification.

In his work (Smojver, 2011), the author systematized and ranked international standards and methods for risk analysis and management, where the ENISA ranking list of ISRA methods was used as an input parameter. But the ENISA list is actually not complete and can be considered obsolete because some recently developed methods are not included.

In their research studies (Anikin, 2015; Hongsheng, 2015; He and Xin, 2016; Huang and Sun, 2018), the authors finally proposed the use of multicriteria decision-making methods (dominantly AHP) for the purpose of information security risk assessment, which can serve as certain guidelines and basis for developing a future hybrid multicriteria model for evaluating of critical IT systems.

ISRA is recognized as a vital method for identifying and prioritizing information assets, but in these papers or industry standards related to information security risk analysis and management, no frameworks or methods are found to effectively assess the security posture of an IT system using multicriteria decision-making in a way to select an appropriate solution in order to reduce risk to the organization.

Although there is a relatively significant number of publications on threats, vulnerabilities and associated risks and also relevant scientific papers in the field of multicriteria decision-making, a systematic review of index citation databases (Maček et al., 2020) shows that there is still no method or model based on solid mathematical foundations for assessment, ranking and selection of critical information systems combining methods for multicriteria decision-making with methods (or elements) for information security risk analysis and assessment. Thus, the observed problem is also interesting from the perspective of scientific research.

3 Proposal for a Hybrid Model

Given that there are many elements influencing the decision on an IT solution where time and other resource constraints become key challenges, a complex problem of multicriteria decision-making in conditions of uncertainty, i.e. risk in the field of information security, has been identified.

There are two general goals to be satisfied with the further research:

(1) Development of a new hybrid multicriteria model for more efficient decision-making on

the security posture and selection of an appropriate critical information system in a financial institution.

(2) Increasing the productivity and quality of the assessment process of critical IT systems.

By creating a new hybrid multicriteria model with elements for risk analysis and risk assessment and thus satisfying the first general objective, consequently the answers to research questions Q1 and Q2 are also given. The second general objective is satisfied when applicability, validity and efficiency of the new model is proven with relevant case studies, and thus also giving the answer to research question Q3.

After defining the research questions and the goals, it's also necessary to present the generalization of a possible solution to the observed problem, which is actually stated as a recommendation in the first phase of DSRM methodology. The generalization of the model itself is necessary in order to get a better overview of what is actually to be done and with which elements of the model.

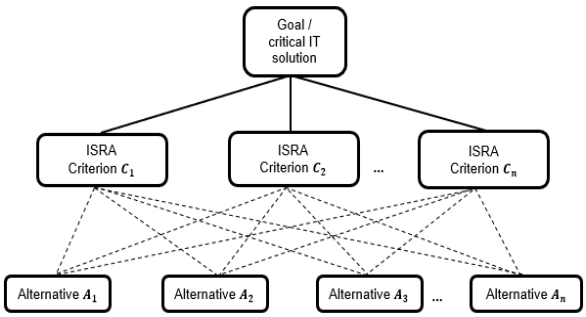


Figure 1. Generic conceptual model

In Fig.1, a generic conceptual model is presented where the goal is to assess, rank and choose the appropriate critical IT solution among the given alternatives which best fits security needs, and where information security risk assessment elements are used as evaluation criteria. On this occasion, the generic conceptual model is presented in the form of a hierarchy for simplification and easier understanding of the issue, while the final model will also include a network structure due to interdependencies and influences between elements for information security risk analysis and assessment.

The motivation for the planned research is to further deepen the knowledge on the application of ISRA and MCDM areas, and to discover the opportunities for more efficient decision-making on critical information systems with the necessary reduction of risks to the organization. The analysis of specific problems related to the selection of a particular security IT solution or a critical element of the information system in conditions of uncertainty (risk) leads to the problem of generalization.

The intention of the research is to collect empirical data, the analysis of which should improve the knowledge about the selection of critical IT systems in conditions of risk. Based on this knowledge, it is planned to develop a new model for more efficient decision-making on the security posture and the selection of a critical IT solution in the organization, which is actually the main goal of the research.

The model should enable the assessment of critical information systems using multicriteria decision-making methods, where attributes from the relevant methods for risk analysis and assessment will be used as evaluation criteria. Since the hybrid model will use generic criteria for IT risk assessment with the purpose of systems' evaluation, that actually presents a novelty given that the criteria inherent in the subject of evaluation are traditionally used. The new hybrid multicriteria model should be more efficient in terms of costs and time.

The target group of solutions for the application of a new hybrid multicriteria model are critical information and security systems in a financial institution, e.g. network security systems, cryptographic systems, online transaction systems, identity and access management systems, cloud services, etc.

4 Research Methodology

The research paradigm that will be followed in this research is called Design Science Research Methodology (DSRM) (Peffers et al., 2007), which is used for research purposes primarily in engineering and information systems. Research using this paradigm involves creating new knowledge by designing new or innovative artifacts. Artifacts can include algorithms, computer interfaces, system design methodologies or languages, and models. Researchers in design science can be found in many disciplines and fields, especially in engineering and computer science, using a variety of approaches, methods, and techniques (Peffers et al., 2007). In this particular case, the artifact that aims to solve the identified problem is a new hybrid model for evaluating, ranking and selecting IT solutions or critical security elements of an information system in a financial institution using multicriteria decision-making with elements for analysis and assessment of information security risks. According to the guidelines for the implementation of design based research (Hevner, 2007), it is planned to conduct an additional activity in the research methodology. It' about creating a knowledge base where the goal is to conduct a detailed review of research areas and show that there is currently no solution to the research problem.

After explaining the observed problem and defining the goals and research questions, the research continues by applying the method of systematic literature review, SLR (Kitchenham, 2007). SLR is a formalized and repeatable process to document relevant knowledge in a particular subject area. This method is currently considered the best for domain review and a prerequisite for objective method

selection. In the planned research it will be used as a means of evaluating and interpreting available studies from defined domains (ISRA and MCDM) in order to create a knowledge base that will serve as a reference point for the new model.

This research phase has been already conducted and the relevant results are presented (Maček et al., 2020). Due to the complexity of the research topic which includes two interdisciplinary domains, namely risk management and multicriteria decision-making, the literature search was done on the most important scientific citation databases that were available to the authors during the research period. A systematic literature review has determined which methods for multicriteria decision-making would be suitable for the development of a new hybrid model and its validation in case studies in the field of critical IT systems.

A review of the literature showed that in many analysed studies some kind of quantification was searched for the assessment and ranking of IT security risks, risk factors or software solutions, and thus the use of some of the quantitative MCDM methods was required. The survey showed that the international industry standard ISO/IEC 27005 (with different release years) was dominantly analysed and used for the purposes of information security risk analysis, assessment, treatment and management. Other widely accepted ISRA standards and methods are OCTAVE, NIST SP 800-30, CORAS, CRAMM and ISO/IEC 31010:2009. Also, the survey discovered the frequency of application of MCDM methods and techniques in ISRA domain, where the predominantly used MCDM method for the purposes of IT security risk analysis and assessment is the AHP. This could be attributable to the relative ease of application of the AHP itself and its great popularity among researchers. Other frequently used MCDM methods in the ISRA domain are the ANP, DEMATEL and TOPSIS. The DEMATEL technique is used to calculate the influence weights, while the ANP is used to calculate interdependencies of the elements. This is very important roadmap and has a strong impact for the further research to extend the core ISRA elements, define their mutual influences and interdependencies, and integrate those elements within one (or even more) of the MCDM methods in order to make an evaluation of the critical IT systems in a more efficient way. Additionally, the SLR has revealed a trend in development of hybrid models for risk analysis, for determining on the security posture or selecting an appropriate IT system by using multicriteria decision-making.

The next qualitative research step is to conduct a survey among IT security professionals regarding the domain of information security risk assessment. Previous research has shown that currently none of the most significant ISRA methods fully meets the requirements of comprehensiveness and complementarity of its attributes for risk analysis and assessment with any of the MCDM methods. The earlier solution proposal was found in the form of the simple VECTOR method for risk ranking and prioritization obtained by the author's preliminary research (Maček et al., 2012; Maček et al., 2017). But, the VECTOR method itself is very rarely used and is not proven with the relevant number of studies. Thus, it becomes necessary to conduct a research where from the most common ISRA methods the most relevant attributes used in the process of risk analysis and assessment will be extracted. It's planned to examine experienced IT security experts from various countries and different financial institutions holding relevant industry certifications (e.g., CISSP, CISM, CEH, etc.). The results obtained in this phase of the research will be used for input and development of the knowledge base and later on as input parameters (i.e. generic elements) of the new hybrid multicriteria model. The Delphi technique is intended to be applied in this research phase, and the survey form will be distributed to the research participants via e-mail.

Based on previous phase and defining the necessary knowledge base, the next step is to move to the design and development phase of the model for more efficient decision-making on the evaluation, ranking and selection of a critical IT solution in a financial institution in conditions of uncertainty (risk). In order for the new model to be developed and tested, it is necessary to provide certain prerequisites and point out the assumed limitations of the model itself:

- Development of a conceptual model: Before creating a final model based on research of ISRA and MCDM methods, it is necessary to set a specific conceptual model, i.e. try to make a generalization.
- Complementarity: Selection of appropriate, i.e. complementary methods and elements for risk assessment and multicriteria decision-making. Given the number of existing methods, techniques and tools in both observed research domains, namely risk management and multicriteria decision-making, the challenge is certainly to find exactly those complementary (i.e. their elements) that solve the observed complex problem in the most efficient way, and with the purpose of which the creation of the knowledge base was conceived.
- Generic attributes: In order to obtain a standard model that enables more efficient solution of the identified complex problem, generic risk criteria for the evaluation of critical IT systems are a kind of limitation in terms of flexibility of the model and its application to only certain segments in the field of IT security in the financial sector.

The design and development phase is followed by a case study to demonstrate and evaluate the designed model in order to verify the applicability and usefulness of the model itself on critical IT systems in a financial institution. The evaluation of the model will be done in collaboration with information security experts, as well as in the previous DSRM phase. The

case study will include 2 process steps of the DSRM methodology: demonstration of a new hybrid model and evaluation of the same. The aim of the first phase of the case study is to demonstrate the applicability of the new model on critical IT systems, while the aim of the second phase is to validate the model in order to see its usefulness. Validation of the model would be done by comparing the results obtained by applying a new hybrid multicriteria model using the inherent (common) attributes of a critical IT solution with the results of the target model using generic risk criteria.

Since the DSRM is a repetitive process, a calibration of the model is also foreseen in case of need in order to achieve additional efficiency. At the end of the validation process, data analysis will be done in the final research step which is conclusion and communication, with the following aims:

- Making a decision on achieving the main research goals
- Presentation of answers to research questions
- Proving or disproving hypotheses.

Table 1. DSRM phases and methods for development of a hybrid multicriteria model

DSRM phases	Methods used
Problem identification and motivation	Systematic observation of ISRA domain
Defining the objectives of a solution	Proposal of tentative design by generalization
Creating a knowledge base	• Systematic literature review (SLR) – analysis • Delphi survey for a panel of IT security experts regarding ISRA elements
Design and development	Synthesis of elements and modeling a new artifact, i.e. hybrid multicriteria model
Demonstration	Demonstration of the new model that is developed according to the inputs from the previous DSRM phases
Evaluation	• Case studies, comparisons and measurement in order to check applicability, validity and efficiency of the new model • Model calibration – iterate back to design and development phase
Conclusion and communication	Presentation of the solution, i.e. publication in the form of a scientific paper in a journal and doctoral dissertation communication

Table 1 represents a summary of DSRM phases and methods for development of a new hybrid model planned for use in the research. This also gives an additional scientific contribution in the context of the methodology along with the methods used for development of a new multicriteria model for evaluation of critical IT systems.

5 Conclusion

The following scientific contribution is expected from the proposed research, which arises from the defined research goals and used scientific methods:

- Developed new hybrid model with generic elements for risk analysis and assessment using multicriteria decision-making enables more efficient decision-making on the security posture of a critical IT system, and thus consequently enables a financial institution to better respond to security threats and risks by choosing an adequate IT solution.
- Systematization of knowledge and concepts on multicriteria decision-making methods that are suitable for application in the field of information security together with methods for risk analysis and assessment.

In addition to the expected scientific contribution, the proposed hybrid multicriteria model should be also practically applied in the financial industry for security professionals and especially for decision makers, which actually presents a broader social-economic contribution.

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Software Engineering

Marko Gasparič, Muhamed Turkanović, Marjan Heričko
Towards a Comprehensive Catalog of Architectural and Design Patterns for Blockchain-Based Applications - A Literature Review

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Identification of Reusability Artifacts in Mobile Application Development Process

Towards a Comprehensive Catalog of Architectural and Design Patterns for Blockchain-Based Applications - A Literature Review

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Abstract. *Well structured software architectures usually contain a lot of patterns representing abstract solutions to recurring problems. We performed a preliminary literature review to identify existing catalogs of architectural and design patterns which are applicable in blockchain-based applications. The main contributions of this paper are a summary of 12 existing catalogs and our catalog proposal. Because the blockchain domain lacks a clear categorization of patterns, as well as precise descriptions and corresponding evaluations, we plan to continue working on those issues. Our final goal is to simplify the search for useful blockchain patterns.*

Keywords. Blockchain, smart contracts, software engineering, patterns, design, architecture

1 Introduction

The popularity of blockchain technology and the lack of guidelines on how to design blockchain-based software attracted researchers to explore possibilities for helping practitioners in their engineering endeavors (Destefanis et al., 2018; Porru et al., 2017; Wan, Xia & Hassan, 2019; Xu et al., 2016). In our work, we are focusing on architectural and design patterns that can be used in blockchain-based applications. We are following the definition of Xu et al., who defined blockchain-based applications as applications that make significant use of blockchain, including distributed applications, but not limited to them (Xu, Weber & Staples, 2019).

A blockchain platform is the technology needed to operate a blockchain; it consists of client software for processing nodes, local data storage, and any other clients needed to access the network. The platform can be used as an architectural, storage, or computational element, or as a communication, asset management, or control mechanism (Xu, Weber & Staples, 2019).

Smart contracts are programs that are deployed or executed as a part of a blockchain transaction, and they normally encode agreements between non trusting participants (Alharby, Aldweesh & Moorsel, 2018). If we were to consider a blockchain as a new database type, smart contracts behave similarly to stored procedures, in Structured Query Language (SQL), or classes in Object-Oriented (OO) programming (Rocha & Ducasse, 2018). Like the data, smart contracts become immutable after they are included in a public or private blockchain ledger (Xu, Weber & Staples, 2019). Consequently, blockchains can provide a decentralized secure storage that does not require trust accumulation (Zhang et al, 2020).

Well structured software architectures usually contain a lot of patterns that make them more flexible, reusable and understandable; these patterns represent abstract solutions to recurring problems that can be observed and applied in different settings (Gamma, 1995). Blockchain platforms are fundamental building blocks of the blockchain-based applications' architectures (Xu, Weber & Staples, 2019). They can be integrated with other components, or they can be the only components. Hence, it is worth learning about relevant patterns, to be able to apply them properly, in order to improve the quality of the software development process and product. We aim to simplify the discovery of relevant patterns with a new extensive catalog.

We performed a preliminary review, including white, i.e., peer reviewed, and gray, i.e., non peer reviewed, literature, on architectural and design patterns for blockchain-based systems. We identified 97 patterns.

The remainder of the paper is structured as follows: in Sec. 2, we present the related work; in Sec. 3, we present the research protocol that was pursued in our study; in Sec. 4, we present the results of the study; and in Sec. 5, we present our plans for the future.

2 Related Work

Several literature reviews have been performed in the blockchain domain, but we are not aware of any review that would focus on architectural or design patterns. Existing reviews focus on different topics: Yli-Huumo et al. tried to learn what is the state of the blockchain research, and discovered that the majority

of the papers focus on technical challenges, such as, throughput, latency, and security (Yli-Huumo et al., 2016); Sankar et al. and Zheng et al. surveyed consensus protocols (Sankar, Sindhu & Sethumadhavan, 2017; Zheng et al., 2017); Alharby et al. performed a systematic mapping study of academic research on smart contracts and found 188 relevant papers, out of which almost two-thirds were exploring different applications of smart contracts (Alharby, Aldweesh & Moorsel, 2018); Casino et al. and Zhang et al. performed literature reviews of blockchain-based applications (Casino, Dasaklis & Patsakis, 2019; Zhang et al, 2020). We note that Casino et al. included gray literature in their review, as is the case in our study.

In addition to survey papers, Xu et al. presented a taxonomy that highlights the impact and trade-offs arising from decisions related to blockchain platforms, particularly in respect to performance and quality attributes (Xu et al., 2017). Verdonck demonstrated how unique blockchain characteristics, such as, immutability and visibility, alter the way in which smart contracts are developed, compared to traditional development (Verdonck, 2019).

(Liu et al., 2020) and ("Blockchain Patterns, Mechanisms, Models and Metrics", 2020) represent gray literature that includes pattern catalogs. Liu et al. published their catalog after we performed our search. It contains 12 patterns for blockchain-based self-sovereign identity, which are split into 3 categories, namely, *key management*, *DID management*, and *credential design* patterns. Each pattern is presented in compliance with the standard guidelines suggested in (Meszaros & Doble, 1997), thus, the presentation includes the pattern name, summary, context, problem, forces, solution, consequences, including benefits and drawbacks, related patterns, and known uses.

In our study, we identified one pattern from the Arcitura, the author of ("Blockchain Patterns, Mechanisms, Models and Metrics", 2020). Hence, the entire catalog would have been included if we performed at least one cycle of backward snowballing (Wohlin, 2014), as a part of the protocol. ("Blockchain Patterns, Mechanisms, Models and Metrics", 2020) contains 13 patterns, split into 4 categories, namely, *integrity and validation*, *scalability and reliability*, *security and privacy*, and *utility* patterns. The patterns are presented in a uniform manner, which is not consistent with the standard guidelines. The presentation includes the pattern name, problem, solution, application, and mechanisms.

3 Research Method

In this paper, we focus on the catalogs containing blockchain patterns. We formulated the following research question: *Which architectural and design pattern catalogs for blockchain-based applications exist, and what are their characteristics?*

In software engineering, survey studies often follow the Systematic Literature Review (Kitchenham & Charters, 2007) or Systematic Mapping Study (Petersen, Vakkalanka & Kuzniarz, 2015) protocol. However, these protocols were designed to guide analysis of white literature, and do not provide instructions on how to incorporate gray literature. Thus, we adopted the guidelines for the Multivocal Literature Review, suggested by (Garousi, Felderer & Mantyla, 2019).

Examples of gray literature include reports, theses, specifications, official documents, discussion boards, and blogs (Yasin et al., 2020). Our reasons for including gray literature match the following criteria (Garousi, Felderer & Mantyla, 2019):

- The subject is not solvable by considering only the formal literature (Criterion 1);
- The formal literature lacks volume (Criterion 2);
- Synthesis of insights and evidence from the industrial and academic community would be useful to both communities (Criterion 6); and
- There is a large volume of practitioner sources indicating high interest in the topic (Criterion 7).

It is common to search for gray literature using Google Search and Google Scholar. This is a preliminary study, thus, we used only Google Search. Nevertheless, our results include also white literature content.

Instead of formulating a single search string which could later be validated with a validation set, we used five different strings, namely: "blockchain" "pattern", "blockchain patterns", "blockchain" "design patterns", "blockchain" "security patterns", and "blockchain" "architectural patterns". The reason for our decision is based on the fact that the "blockchain" term limited the results to the investigated topic, while not excluding the results focusing on more specific aspects, such as, smart contracts or patterns for different technologies. On the other hand, "pattern" seems to be too vague, since the number of relevant hits was too low, and additional terms improved the results.

We inspected the first 5 pages of the results returned for each search string, which was either 48 or 49 links per string, and 243 overall. Our stopping criterion was "effort bounded" (Garousi, Felderer & Mantyla, 2019). We detected 31 duplicates with the exact same link.

We performed the search on 6^{th} May 2020, using a clean installation of the Google Chrome browser, via the IP address of the University of Maribor VPN. Relevant sources included white literature and all other publications, including any web-page content that is the main topic of the web-page, such as, blogs, documentation, slides, white-papers, wiki-pages, YouTube videos, and the like. We used nine exclusion criteria:

- Main content is missing,
- Main content is not in English,

- Content is not related to blockchain technology,
- Content is not related to software engineering,
- Content is not *presenting* any architectural or design patterns, i.e., diagrams or pattern name lists are not sufficient without (at least) a description of an issue they are addressing,
- Content is a comment or a Q/A post,
- Content is payable and not included in journal subscriptions, such as, online course,
- Blockchain itself is presented as the only pattern,
- Patterns are presented implicitly, and would need to be extracted, e.g., from a reference architecture or source code.

Based on these criteria, we excluded 154 unique hits, which included 8 duplicates. Hence, exactly one-third of the hits was relevant. However, there was a considerable overlap between the links, pointing to the same content. For example, there were 14 web pages that were referring to (Xu et al., 2018), whether it was an abstract with a link, a preprint version, or an official version. By merging such hits, we reduced the number of unique sources to 35. However, we note that, even in this case, all the lists of patterns are not unique; for example, (Xu et al., 2018) and (Xu, Weber & Staples, 2019) include the same patterns. When one list was the same as another we used the newer source as the reference. When one list contained only a subset of patterns presented in another list, we used the more comprehensive source as the reference. That reduced the number of sources to 28.

We removed 5 sources that contained only one pattern, and an additional 11 sources that did not provide any classification of patterns, i.e., all the patterns were included in one category, nor did they present the patterns in a uniform way, i.e., the authors did not even use a custom template. Ultimately, 12 unique catalogs of patterns remained.

We would also like to stress that, when we found a source that was, in fact, a published peer reviewed publication, we used that as the reference, to allow easier and more reliable tracking of sources. The results are presented in the next section.

4 Results and Discussion

As can be seen in Tab. 1, the types of the sources can be very different, and only five have the form of a research paper. Sources other than blogs, theses, and slides were probably peer reviewed, i.e., we conjecture that they represent white literature. (Chittoda, 2019) and (Xu, Weber & Staples, 2019) were published by prominent international publishers, (Lu et al., 2019) was published in a peer reviewed journal, and another four papers were presented at international conferences.

The number of patterns presented in each catalog is between 2 and 15; the mean average number of patterns in a catalog is 7.5, and the median is 6.5. These numbers are very low compared to the 97 unique patterns identified across 35 relevant sources of patterns obtained in our study. We suspect that the actual number of patterns is even higher, since our study is preliminary, and considerably limited in scope. Consequently, we regard existing catalogs as inadequate. We believe that a comprehensive catalog of patterns would be very useful for practitioners and researchers.

Moreover, (“Getting started with blockchain design patterns”, 2020), (Chittoda, 2019), (“Design Patterns for Decentralization”, 2020), (Lu et al., 2019), (“Four

Table 1: Summary of catalogs

Source	Type	Group	Nr. patterns	Nr. categories	Template
(“Community blockchain interaction patterns”, 2019)	thesis	gray	6	2	none
(“Design Patterns for Decentralization”, 2020)	slides	gray	7	1	custom
(“Four architecture pattern candidates for Blockchain-based decentralized applications”, 2019)	blog	gray	5	1	short standard
(“Getting started with blockchain design patterns”, 2020)	blog	gray	3	1	custom
(“Solidity Patterns”, 2019)	blog	gray	14	4	custom
(Chittoda, 2019)	chapter	white	13	5	custom
(Hibti, Baina & Benatallah, 2019)	paper	white	7	3	custom
(Lin, Liao & Chen, 2020)	paper	white	2	1	long standard
(Liu et al., 2018)	paper	white	8	4	none
(Lu et al., 2019)	paper	white	6	2	short standard
(Xu, Weber & Staples, 2019)	chapter	white	15	4	long standard
(Zhang et al., 2017)	paper	white	4	1	custom

architecture pattern candidates for Blockchain-based decentralized applications", 2019), and (Zhang et al., 2017) do not include any reasoning on why the specific sets of patterns are included in the catalogs, nor do they report on any type of pattern evaluation.

Conversely, Liu et al. report that they implemented five out of eight patterns in a real-life application, which could be considered as some kind of evaluation, but they also do not explain how the catalog was created (Liu et al., 2018). In (Hibti, Baina & Benatallah, 2019) and ("Solidity Patterns", 2019), existing, third-party literature was used to extract the patterns included in the catalogs; the authors also report on known uses of patterns, which could be helpful for assessing whether a specific pattern is indeed a solution to a recurring problem. Similarly, (Lin, Liao & Chen, 2020) and (Xu, Weber & Staples, 2019), the only papers where the patterns were presented according to the standard long template, also report on known uses of patterns, but the inclusion of the patterns is based on the authors' experience only, in the case of Lin et al., while the origins of patterns are unknown in the case of Xu et al. ("Community blockchain interaction patterns", 2019) contains a set of theoretical use cases from which new patterns were derived; they were evaluated by implementation feasibility analysis.

We are aware of only four catalogs where the authors performed some kind of empirical research to obtain a set of patterns, such as, analyzing existing applications or smart contracts. These catalogs are presented in (Bartoletti & Pompianu, 2017), ("Maintenance of Long-Living Smart Contracts", 2020), ("Decoding Smart Contract Design Patterns", 2018), and (Wessling & Gruhn, 2018). However, in those sources, the patterns are not presented in a uniform manner, and no categorization is provided. The presentation of patterns in all four sources is brief, which makes it hard to implement a pattern. Consequently, they were excluded at the last step, as catalogs of low quality.

Two of the included catalogs did not present patterns in a unified format, and another two used a short version of the standard template. Such presentations are largely inadequate in terms of applicability for practitioners. The same is true for sources using a custom template; however, we would like to stress that some of the custom templates are very informative, even when compared to the long standard template. Hence, we can observe some initiative in the community to help developers apply theoretical knowledge in practice.

Finally, an issue that can easily be overlooked when we are dealing with the catalogs that do not contain large sets of patterns, is the problem of pattern classification. In fact, we even find it hard to agree with some categories presented in the catalogs discussed in this paper. However, as the number of patterns grows and different catalogs are overlapping, it becomes increasingly important to split the patterns into suitable categories. For example, the same pattern can be called *embedded permission*, *access restriction*, *restricting access*, *authorization*, and *access verifier*, and it can be classified as *contract structural* pattern, *smart contract design* pattern, *security* pattern, or *design or coding* pattern. The list of categories used in 12 catalogs is presented in Tab. 2.

When we synthesized the 97 patterns obtained from 35 different sources, by performing "term normalization", we noticed that subcategories could be beneficial as well. Consequently, a useful hierarchy of patterns and categories could be several levels deep. As a part of this preliminary study, based on our intuition and expertise, we drafted our first version of categories for architectural and design patterns used in blockchain-based applications. The suggested categories, subcategories, and patterns are visualized in Fig. 1.

Table 2: List of categories of blockchain patterns included in existing catalogs

Source	Category names
("Community blockchain interaction patterns", 2019)	- Trading - Technology
("Design Patterns for Decentralization", 2020)	- Decentralization
("Four architecture pattern candidates for Blockchain-based decentralized applications", 2019)	- Architecture
("Getting started with blockchain design patterns", 2020)	- Blockchain Design
("Solidity Patterns", 2019)	- Behavioral - Security - Upgradeability - Economic
(Chittoda, 2019)	- Security - Creational - Behavioral - Gas Economic - Life-Cycle
(Hibti, Baina & Benatallah, 2019)	- Organisation - Decision-Making - Learning-Flow
(Lin, Liao & Chen, 2020)	- Design
(Liu et al., 2018)	- Creational - Structural - Inter-Behavioral - Intra-Behavioral
(Lu et al., 2019)	- Data Management - Smart Contract
(Xu, Weber & Staples, 2019)	- Interaction with External World - Data Management - Security - Contract Structural
(Zhang et al., 2017)	- Familiar

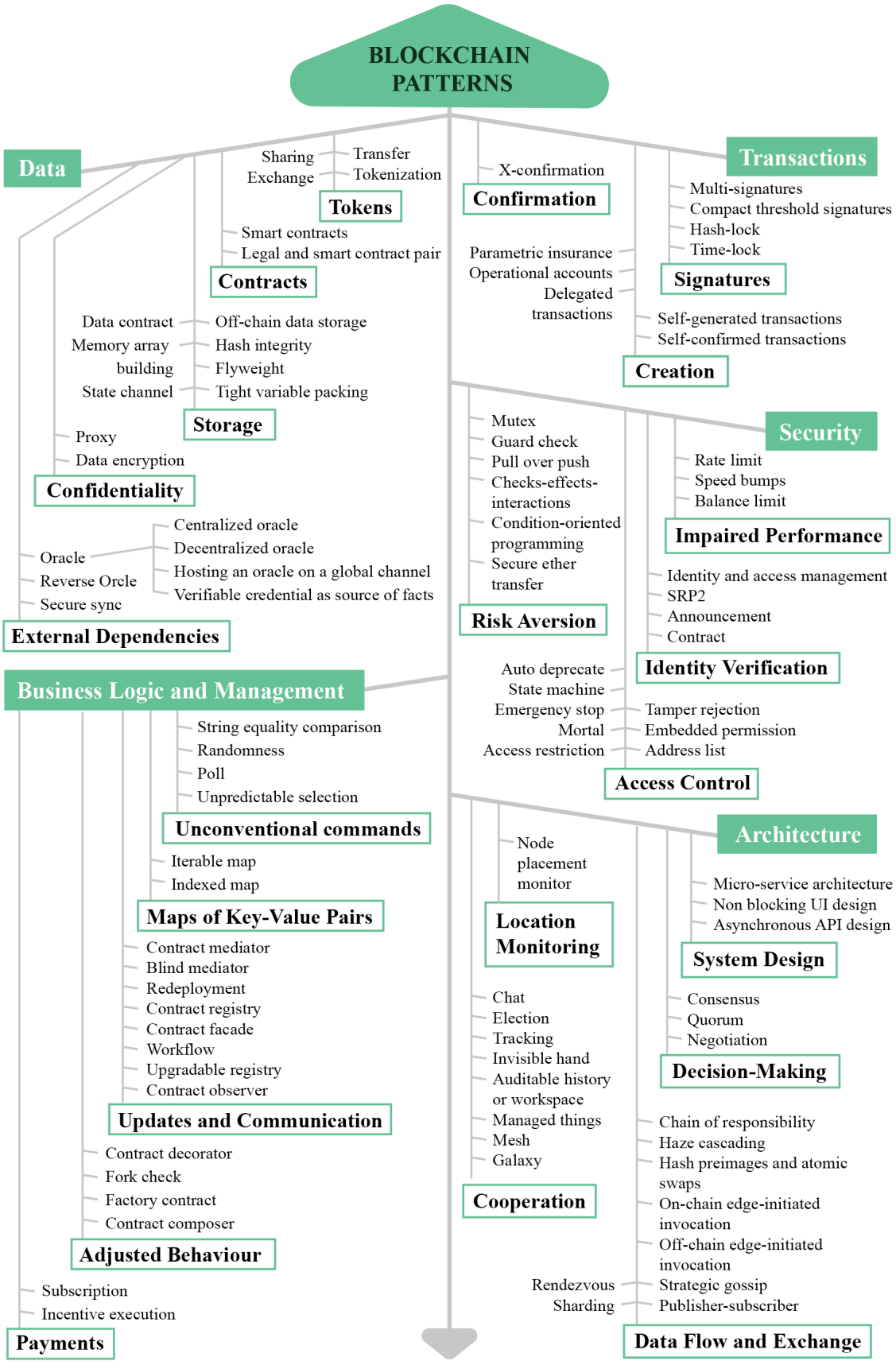


Figure 1: Diagram of categories (marked with green backgrounds), subcategories (marked with green borders), and corresponding patterns (unmarked)

Nevertheless, the categorization of patterns is probably not a unidimensional problem. Thus, we believe that we would need to perform some kind of grounded theory research, such as, open and axial coding (Bryant & Charmaz, 2007), to obtain a comprehensive and sound set of categories.

5 Conclusions and Future Work

In this paper, we present the results of a preliminary study on existing blockchain pattern catalogs. We focus on different characteristics of the catalogs, such as, number of patterns and categories, adopted presentation templates, and research that led to the selection of patterns included in a specific catalog.

We noticed that the catalogs are very limited in size, standard templates are rarely used, and empirical evidence supporting the usage of patterns is almost non existent. This is problematic, because it is not enough that some solution is called a pattern by the authors of the papers and blogs. In practice, it is crucial to understand whether the implementation of the pattern is worthwhile. Additionally, it would be beneficial to collect all the relevant patterns in one place, so that the blockchain developers do not need to go through the same search process as is reported in this paper.

In the future, we plan to perform an exhaustive review, which will provide complete information on existing architectural and design patterns for blockchain-based applications. We expect the list of patterns to grow, because we are already aware of different sets of patterns that are missing in this work.

Acknowledgments

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Identification of Reusability Artifacts in Mobile Application Development Process*

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***Abstract**. Development of mobile applications is a challenging task which differs from traditional software development, and needs to address the business and development specific challenges. Our research focuses on development specific challenges. The main goal of this research is to identify reusability artifacts in mobile application development process targeting two or more mobile platforms, and to create the basis for more efficient and interoperable cross-platform mobile development process. After identifying all artifacts in the development process for one target platform, we have performed the reusability analysis for the second platform. We found that 66% of artifacts are completely or partially reusable.*

Keywords. software development, mobile application development, development methodologies, reusability

1 Introduction

Traditional and mobile development differ in several important aspects which makes mobile development a challenging task. There are different classifications, but Hosbond (2005) focuses on the two main sets of challenges that should be addressed in mobile systems development. These are business related and development specific challenges. In this research we will focus on development specific challenges and will give special attention to the usage of methodologies which according to some authors, like Rahimian and Ramsin (2008), Spataru (2010) or La and Kim (2009), should be firstly addressed.

Classic or agile software development methodologies should be adapted for the development of mobile applications as the existing ones do not cover the specific mobile targeted requirements (La & Kim, 2009). There are attempts from several authors to create new methodologies in order to cover the gaps in the domain of mobile applications.

Along with the methodology related problems, the fragmentation problem forces the developers of mobile applications to focus on only specific platforms and versions (Shah et al., 2019), but as the development of mobile applications primarily aims a wide range of users, such approach is not the preferable option and the development teams reach for different solutions of the problem proposed by professional and scientific community. First, worth to mention is the approach that enables the development teams to use a mediatory language or just mediatory transform engine to code for several target platforms. Some of the most influential projects are React Native (Facebook Inc., 2020) and Flutter (Google Inc., 2020). Although, these attempts have some advantages they also have significant drawbacks, like their dependability on the efforts invested in the transform engine, specific APIs and specific domain, the lack of control over generated source code and similar. Another possible solution to the problem could be the introduction of adapter applications (adapters) as native applications for every target platform. According to Agarwal et al. (2009) this is one of the two main techniques for handling fragmentation. As standardization of APIs in mobile world is still not possible, the usage of programming techniques whereby the interface calls are wrapped, i.e. abstracted, in distinct modules which are then ported across the platforms, is left as the other solution. The representatives of this approach are MobiVine (Agarwal et al., 2009), Adobe PhoneGap (PhoneGap, 2020) or Adobe AIR® (Adobe Inc., 2020). Almost all of the drawbacks stated for existing solutions that introduce a transform engine are also present in this solution. Finally, the third approach is to use web technologies and to develop cross-platform web applications, but this approach is out of our scope as it differs in many aspects (which also have their own drawbacks) from the basic assumptions taken in this research.

Therefore, in our research we are focused on finding a solution that would enhance methodological interoperability among teams working on the same application but in different (and native) development environments. In the context of more comprehensive research, we aim to identify what artifacts (required inputs and outputs of methodologically and methodically defined development steps) emerge

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during mobile application development, whether and to what extent there are similarities between these artifacts so they could be reusable during the development process for two or more mobile platforms, and to create the basis for more efficient and interoperable process of multi-platform mobile applications development.

The paper is structured as follows. In section two we bring the methodological context and artifacts analysis setup while in third section we present the identified artifacts and their types. Section four brings the reusability analysis results while the last section concludes the topic and looks forward to the future research.

2 Analysis Setup

In our previous research (Stapic et al., 2016), we performed a literature review in order to identify newly created methodologies targeting the development of mobile applications and we have identified 14 different methodologies. However, only one of these methodologies was reported to be used in practice – Mobile-D.

Mobile-D process, as described in (P Abrahamsson et al., 2004; Supan et al., 2013; VTT Technical Research Centre of Finland, 2006), includes five phases that are executed in partially incremental order (see Fig. 1). The aim of the first phase, called Explore, is to prepare the foundation for future development. The Initialize phase should describe and prepare all components of the application as well as to predict possible critical issues of the project.

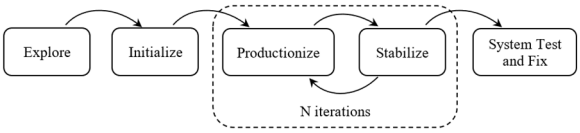


Figure 1. Mobile-D process *(VTT Technical Research Centre of Finland, 2006)*

The Productionize and Stabilize phases are executed iteratively in order to develop all other features of the mobile product. Iterations start with planning day in Productionize phase. The first activity is post-iteration workshop which aims to enhance the development process to better fit the needs of the current software development team. Requirements analysis, iteration planning and acceptance test generation tasks follow and are executed during the planning day. Working day is based on implementation through test driven development, pair programming, continuous integration and refactoring. This day ends with the task of informing the customer on new functionality. Finally, the release day includes the activities of integration and testing. The Stabilize phase has the goal to finalize the implementation along with integrating subsystems if necessary. As this phase can contain additional programming and development, the activities are very similar to the activities in the Productionize phase. The only additional activity concerns documentation wrap-up. Iterations should result in a working piece of functionality at user level. Finally, System Test and Fix phase aims to detect if the produced system correctly implements the customer defined functionality. It also provides the project team feedback on the systems functionality and the defect information for the last fixing iteration of the Mobile-D process. This last iteration is not obligatory, but when fixing is needed it consists of the same activities as other implementation iterations already explained (P Abrahamsson et al., 2004; Supan et al., 2013; VTT Technical Research Centre of Finland, 2006).

Mobile-D strongly suggests the usage of Test Driven Development (TDD) which is connected to all Mobile-D phases . The basics and the state of the art in TDD can be found in (Hammond & Umphress, 2012). The purpose of TDD is to give the developers confidence that the code they produce works, as well as to guide the design of the code towards an easily testable structure. Additionally, the refactoring practice is also based on TDD to ensure that changes made to the code do not break any functionality (P. Abrahamsson et al., 2005).

In order to systematically observe the development process and to identify the artifacts created during it, we developed a prototype application, namely KnowLedge, for Android platform. The application intends to enable users learn and/or share knowledge in an interactive and social manner. Among others, the basic usage included functional requirements like browsing through categories to find existing knowledge on a topic or placing a request for a new explanation, instruction or tutorial, sharing knowledge in groups etc.

The overall system architecture comprises service oriented architecture, mobile application, remote database and usage of the global positioning system. In addition, as it can be seen in Fig. 2, the mobile application architecture is also intended to be multi-layered with three distinct but connected layers. The internal cohesion (see (Miller, 2008)) of the presented modules should be high, and at the same time the external coupling should be kept low.

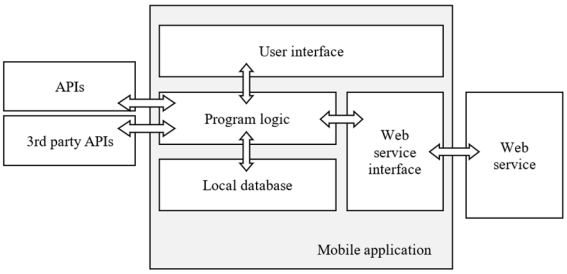


Figure 2. Architecture of KnowLedge application

The Mobile-D process with its clear technical specification was well documented and easy to follow and the overall development process took less time than initially planned. A few screenshots of the created application are visible in Fig. 3.

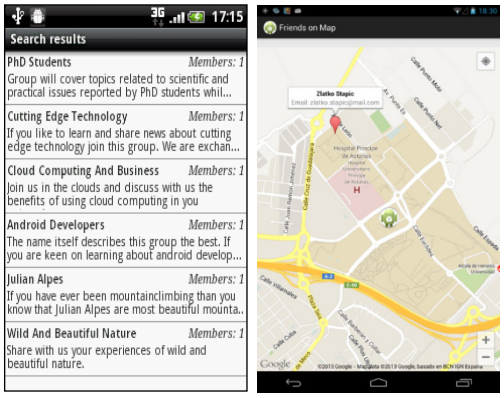


Figure 3. Screenshots of KnowLedge mobile application

3 Identification of Artifacts

As there are many definitions of artifact (e.g. from Hilpinen (2011) or from Parker (2011)), we have adopted the definition from Conradi (2004) who says that artifact is "*any piece of software (i.e. models, descriptions, code) developed and used during software development and maintenance*". As the goal of this research was to analyse only the structural and semantic aspects of the sets of artifacts, we performed an analysis only from the semantic concept view, while other possible views, such as procedural concept view or pragmatic concept view are not covered by it. Thus, we only observed the artifacts and their connection to the activities and tasks as it can be seen in Fig. 4.

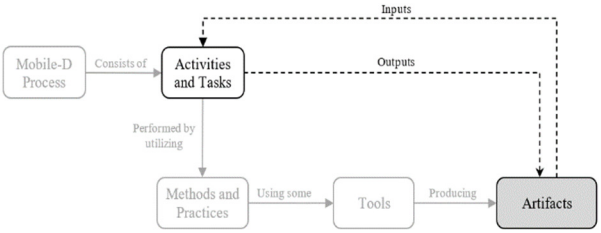


Figure 4. Focusing semantic of artifacts and their origin

We performed the artifacts analysis in two steps. Firstly, we analysed the Mobile-D process library (P. Abrahamsson et al., 2005) and identified the documents and other platform-independent deliverables at a high level of abstraction. Secondly, as the approach of identifying and grouping the artifacts only according to the phases of the origin would not be a good way, and as during the implementation phase we collected the additional data on the artifacts, we systematized and described all identified artifacts using the template presented in Table 1.

Thus, from the conceptual point of view, we created a solid basis for identifying not only the documents that had been created, but also other artifacts that might be hard to identify if the project was performed outside the laboratory.

Table 1 shows a part of the list of the identified artifacts, along with their initial classification, description and connection with the Mobile-D phases. We used standard CRU notation for denoting the artifacts that were created (C), used/read (R) and updated (U).

Table 1. An excerpt from the list of identified artifacts in development process for Android

Artifact name	**Type**	**Description**	**Phases inputs and outputs**									
			I		**II**		**III**		**IV**		**V**	
			Input	**Output**	**Input**	**Output**	**Input**	**Output**	**Input**	**Output**	**Input**	**Output**
Mobile-D process library	Document	Process library describing the Mobile-D methodology in detail. Used as methodology guidelines in every phase. (P. Abrahamsson et al., 2005)	R		R		R		R		R	
Product proposal	Document	Generated before the development process. Describes the initial and general idea on the product.	R									
Project plan	Document	Contains all information on project including definition of customer group, scope, planned activities and their duration, plans on documentation etc. Aligned with agile practices, this document is also updated during the iterations.		C	R	U	R	U				
…	…	…										

The identification process resulted in total of 60 different artifacts for Android development process, which are then analysed in order to see which of these artifacts are potentially reusable in development process for other platform such as iOS. These artifacts are grouped into 12 different categories as presented in the table below. The full list is available in appendix 1.

Table 2. Types of artifacts in Android development

Artifact type	Description
Document	Represents used documents or created artifacts that are published as documents during or at the end of development process.
Embedded document	Represents document that could be observed as stand-alone artifact, but is usually included in some other document.
Template	Represents templates that are used to create some artifacts.
Model	Represents models that are created during the development process. Models could be observed as stand-alone artifacts, but are usually presented as a part of some document.
Model element	Represents the atomic level (i.e. integral) artifact that could be observed as stand-alone and is used to create models.
Code	Represents any artifact created during the implementation and is written in any programming or description language.
3rd party example	Represents code artifacts created by third party and used as examples of implemented functionality or to solve some programming issue.
Software tool	Represents software tools used during the entire project.
License	Represents individual-specific unique key that is obtained or used during the development process.
Standard	Represents document containing formal and internationally recognized description of some concept or element.
Publishing resource	Represents resources that are created during the development process and are used in publishing purposes.
Product	Represents final product as most important project deliverable.

As the application was designed to cover the most common mobile application development use-cases (see Fig.4), it is not expected that the number of artifacts or their types would increase significantly if the general size of the application would be bigger. The KnowLedge application along with belonging tests and backend services has approximately 12.000 lines of code (LOC).

Some documents contain parts (document artifact) that should be observed separately which is why we identified them as a specific (new) type. Similarly, the model element could be observed as a stand-alone artifact used to build more complex models.

4 Reusability Analysis

Mijač (2015) defines reusability as property of a software asset that indicates its probability of reuse, while the reuse is defined as the use of existing software and software knowledge to construct new software. In the context of the following analysis, we have adapted the mentioned definitions.

In the cross-platform reusability analysis we found that 50 artifacts (71.43% of Android identified artifacts) are mutual to both development cases. Additionally, many of these mutual artifacts are platform independent as being products of methodological approach. In total, 20 out of 50 identified mutual artifacts (40%) should be created or obtained only once, as these were identical in both development processes. On the other hand, there are 13 artifacts (26%) that could be partially reused while performing the development process for the second or any other target platform. Finally, we recognized 17 artifacts (34% of all common artifacts) with a very low level of possible reuse. They were classified as ones that should be developed from scratch for every target platform. A preview of results of the cross-platform analysis can be seen in Table 3. All other artifacts were classified as platform dependent artifacts, which also have some reusable semantic or syntactic parts like sequencing, iterations, algorithms etc. The full list of common artifacts, along with their classification is available in appendix 2.

Table 3. An excerpt from the list of mutual artifacts in Android and iOS case

Artifact name	Identical	Partially reusable	Different
Mobile-D process library	X		
Product proposal	X		
Initial requirements document	X		
Project plan		X	
Project plan checklist		X	
Project plan checklist template	X		
Measurement plan		X	
Architecture line description			X
…			

In total, 33 artifacts (66% of the mutual artifacts) are completely or partially reusable which encouraged us and provided a solid basis and motivation for the next phases of our research towards methodological interoperability and artifact reusability.

5 Conclusion

In this research we have presented the results of reusability analysis of methodological (i.e. process related) and development artifacts that arise in development of mobile applications for two or more target platforms. Firstly, we analysed the Mobile-D process library and identified the documents and other platform-independent deliverables at a high level of abstraction. Secondly, we collected the additional data on the artifacts and identified 60 different artifacts for Android development process which are grouped in 12 different categories. In the cross-platform reusability analysis that followed, we found that 71.43% of artifacts are common and present in all development processes in multi-platform development, while 66% of these are completely of partially reusable confirming that artifacts reusability presents solid basis for improvement in multi-platform mobile application development process.

In our further research we would like to semantically describe the methodology driven development process as well as the artifacts which arise in it, with the special focus on the reusable artifacts, in order to create a novel methodological framework for development of multi-platform native mobile applications.

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Appendix

1. Identified artifacts in development process for Android, available at: http://tiny.cc/identified_artifacts
2. Common artifacts in development for different platforms and their reusability classification, available at: http://tiny.cc/common_artifacts

Strategic Planning and Decision Making

Sandro Radovanović, Nikola Zornić, Boris Delibašić, Aleksandar Marković, Milija Suknović
Predicting the Result of a Managerial Game Using a Multi-Label Prediction Models

Lili Nemec Zlatolas, Maja Pušnik, Tina Beranič, Marjan Heričko
Towards a Strategic Approach to Attracting Female Students and Researchers in the ICT Field

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Assessing Digital Transformation Readiness Using Digital Maturity Indices

Predicting the Result of a Managerial Game Using a Multi-Label Prediction Models

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Abstract. *The allocation of human resources in the managerial environment is a hard task to perform and to learn. The cost of a real-life experience is very precious. Therefore, companies develop managerial games to provide near real-life experience for decision-makers. The teaching process could benefit if the outcomes of the managerial game could be predicted. Namely, the teacher could adjust teaching materials according to the expected result. Besides predicting an outcome, one would like to predict the emotions of the decision-maker. Having this in mind, we employed multi-label prediction models for prediction an outcome of the game and emotions of the decision-maker. The AUC ranges 0.62-0.66 for the classification of emotions, and ~0.76 for the outcome of the managerial game.*

Keywords. Managerial games, Multi-agent games, Predictive Modelling, Multi-label Classification.

1 Introduction

A complex business environment requires managers to constantly learn, experiment, and gain new insight into how the team would work under some assumptions and how effective a goal can be achieved with the resources at hand. Effectiveness of the team and efficiency of the manager depends on the complex relationships between the skills of team members, characteristics, time and productivity. Real-life expertise and experience can have a high cost of experimenting, and potential cost in time, financial, and human resources. Therefore, one can employ managerial games where managers can employ different strategies, different compositions of teams and other decision-making strategies that can result in better or worse results. This is seen as a winning strategy for bridging a gap between science and decision-making research (von Winterfeldt, 2013).

Having this in mind, one would like to create a teaching strategy to learn the decision-making frameworks as real as they can be. Another benefit of managerial games is for candidate selection. Namely, as a part of the candidate selection process employer can require candidates to play a managerial game. However, one might want to go one-step further. Instead of evaluating teaching strategies and process selection one can predict whether a person will perform the team composition task and solve the problem at hand (Tavcar et al, 2017). In this paper, we learn the predictive model that can predict whether a person will optimally solve the team composition task knowing decision-making strategies, personal characteristics, and experience. Being able to predict the efficiency of the manager and effectiveness of the team one can optimize business performance. Instead of predicting the performance, we will also predict the response of the manager in terms of results. More specifically, after each game manager responds in terms of happiness, anger, surprise, etc. Since the team effectiveness depends on the manager response (Treffers et al., 2019) one would be motivated to predict this as well.

In this paper, we will utilize multi-label predictive models that predict team efficiency in solving a given set of tasks. The reasoning why multi-label predictive models are selected is the fact that it is expected that emotions after the managerial game are associated with the efficiency of the team. More specifically, we expect that predictive performance will be better if the predictive model utilizes information about the relation between efficiency and emotions.

The contributions of the paper are twofold. We propose a multi-label prediction model, which predicts the effectiveness of the team compared to the satisfactory result. Additionally, we predict the emotions of the decision-maker that are as important as the managerial game itself. The second contribution is the inspection of the effects if there are statistical differences between gender and education in winning the managerial game.

The remainder of the paper is structured as follows. In Section 2, significant background research is presented. A literature review consists of two subsections. The first part will explain common decision-making learning approaches in managerial games. The second part will explain what has already

been done in the field of data analysis in managerial games and motivate the paper. In Section 3, we will propose the methodology. We will explain the data, multi-label classification, and experimental setup. In Section 4, we will present the results and provide a discussion of the results. Finally, in Section 5 we will conclude the paper and provide a plan for future work.

2 Literature Review

Decisions made by a manager are a result of experience, knowledge, intuition, heuristics, etc. In a gaming scenario, one would like a manager to explain the decision-making process and provide reasoning for a decision. From a decision theory perspective, several approaches can be employed (Wang & Ruhe, 2007). The most prominent ones are going to be briefly explained.

One can find frameworks for explaining decisions based on risk, uncertainty, inter-temporal decision-making or complex decisions. Risk is a condition in which the expected values of a decision-maker for one or more criteria are bound to a finite number of states that occur according to some probability distribution (Hollard et al., 2016). Knowing the framework decision-maker can take into account states and recalculate expected utility and, thus, make a better decision.

Sometimes, the decision-maker does not have all the information needed to calculate the expected utility of the decision. In an example, the decision-maker lacks the information about the possible states and, thus, cannot calculate the likelihood of each state and its value. In that case, one needs to invest more resources to obtain enough knowledge and make a better decision. This framework is called decision making under uncertainty (Sproten et al., 2018).

Although these two frameworks are the most important ones in the business teaching and economic theory one can find newer frameworks that take into account the sequence of the decisions as a base for better decision making. This is called inter-temporal decision processes (Namboodiri et al., 2014). The idea is that the reward of action is having a delayed effect. Therefore, one must add time perception to achieve a larger expected reward in a limited period. (Li et al., 2018; Rambaud & Takahashi, 2019)

In a complex decision-making situation (De Bruijn & Ten Heuvelhof, 2010) there is no correct choice. Instead, multiple alternatives warrant further experimentation before committing to a single approach. Decision-makers must use a systematic approach to frame the problem and divide it into simpler ones.

The second part of the literature review presents papers regarding data analysis for managerial games. With the emergence of the big data paradigm, the shift from the behavioural analysis of a decision process to analytical analysis gained strength. Several research areas emerged such as computational social choice (Chang et al., 2014). Computational social choice has many tasks, one of them being understanding the decisions of a person or a group that affect the behaviour of the whole group (i.e. team, organization, or even a country). One of the first efforts to understand the decision-making process is presented in (Yu et al., 2014). Multi-agent game platform *AgileManager* was used to help understand how people delegate tasks to their employees. The platform gave the context of each task and set of resources, i.e. employees with characteristics, such as competence, capacity, skills, and working days and the task was to finish the project with satisfactory results. However, to have a teaching moment every resource has associated uncertainty. This means that the results of the same setup of a team will yield different results that correspond to some known distribution with expected reward (mean reward) and expected deviation. It is stated that this type of experience helps decision-makers make better decisions in real-life settings.

However, having multi-agent managerial games as a learning method for gaining experience of a decision-maker can yield a non-satisfactory result due to the human perception of a game. As a solution, one must set up agents in such a manner that they accurately infer human emotions. Such agents are called affective agents. In paper (Yu et al., 2015; Gebhard et al., 2018) emotions that are identified are happiness, sadness, excitement, bored, surprised, and angry. These are core emotions that can be aroused in decision-makers as a result of a game.

Affective agents do affect the process of managerial game effectiveness. It is shown in the paper (Lin et al., 2015; Jerčić et al., 2018) that can predict a user's emotions are as important as the managerial game itself. The reasoning is that believable interactions in human-agent setup make the teaching method more real-life and trusted. Having the above mentioned in mind for multi-agent managerial games is important to create the game as realistic as it can be, as well as being able to identify emotions from the decision-maker. For the problem, authors are trying to handle this can be mapped as a multi-label prediction problem. Namely, one would like to predict the result of the game based on the characteristics of a decision-maker, and also to predict the emotions from the decision-maker at the same time.

A typical approach to solving managerial games is in the field of reinforcement learning. Namely, it is learned to solve the managerial game though an additional agent that acts as a decision-maker (virtual decision-maker). Virtual decision-maker plays the managerial game and optimizes the decision process instead of real-life decision-maker. To the best of our knowledge, the first effort in learning the resource allocation in managerial games is learning multi-

armed bandits. In a paper (Stone & Kraus, 2010) the goal was to create the best possible two-person team which will optimize reward. This is done in such a manner that one agent observes the other agent and recommends which action the second one should perform. One can find the usage of multi-armed bandits for the problem at hand. In a paper (Zhou et al., 2018) one can find a model for optimal team composition that is based on structural contingency theory. Namely, the team organization is divided into multiple multi-arms bandits problem which learn with some constraints the structure of the team that will solve the problem at hand. An extension of the multi-armed bandits includes the adaptation of the synergy graph team formation algorithm using multi-armed bandits as shown in paper (Liemhetcharat & Veloso, 2017).

Other approaches utilize common reinforcement learning techniques such as the Q learning algorithm (Zhang et al., 2019). This algorithm tries to estimate the set of actions that will lead to the maximization of the reward. Compared to multi-armed bandits, this adds one level of complexity due to estimating the set of actions. Namely, Q learning algorithms must explore a sequence of actions that lead to optimal reward while multi-armed bandits find the best action according to state. The sequence of actions that lead to an optimal managerial game can be solved using metaheuristics as well. Therefore, one can find the application of genetic programming (Li et al., 2015) and particle swarm optimization (Fang et al., 2012). Also, state of the art techniques such as deep reinforcement learning and actor-critic method is used (Barriga et al., 2019).

Our research aims to fill the gap in the area. Namely, we would like to create a prediction model that will allow a decision-maker to compose a team for the problem at hand during a managerial game. The model will report either to a decision-maker or to a teacher what the probability of efficiently solving the task is and at the same time provide to the teacher what the expected emotions of the decision-maker are. This way, the teacher and/or decision-maker can guide the learning process toward solving the problem, for example, some of the decision-making frameworks. Another research question that is lacking in managerial games is the effect of gender and education. To the best of our knowledge, research of that kind from a data analysis point of view is missing in the literature. By answering this question, perhaps a more detailed data-based discussion about the effects of gender and education in team composition could be achieved.

3 Methodology

The Methodology section will consist of two parts. First, we will explain the data at hand. Then we will provide a hypothesis and brief explanation of algorithms used, as well as experimental setup.

3.1 Data

The data used in this research originates from research conducted in the paper (Yu et al., 2017). The data is obtained from the managerial game called Agile Manager, where the task was to coordinate a team of ten workers for a given task. The data was collected from December 2013 to October 2016. Due to clarity, each table will be labelled with italic letter.

There are six tables, which explain the process of the managerial game. First, table *User* explains the demographics of the user of the managerial game, i.e. decision-maker. Besides having demographics attributes, one can find personality survey questions obtained from the Ten-Item Personality Inventory survey and affective-oriented features of the user obtained from the Positive and Negative Affect Schedule survey. There are in total 1,144 users in the database.

Each user has to solve *Game Level* in one instance of the game. There are in total six game levels according to the difficulty of the game. Each game level besides having the difficulty assigned had the focus on either speed or quality of the game. Therefore, the user was given before solving a level a clear sign whether it is more important to perform quickly or with higher quality. Each level contains from 20 to 30 tasks.

Every *Task* has its difficulty, deadline and estimated effort required for solving that task. During a *Game Session*, the user plays a level by assigning *Worker Agents* to a task. Every worker agent has a level that is translated to the probability of solving the given task given the timeframe, the maximum number of units that can be given to that worker agent and speed vs. quality indicator, which is a signal that worker agent can perform quickly or with high quality. There are in total 20 worker agents, from which the user selects 10 for the game session. During the game session, each worker gets a reputation, which helps the decision-maker in the assignment process. Namely, if a worker solves the problem within a given period and with satisfactory speed and quality, reputation improves, otherwise reduces. Assignments of worker agents to tasks are saved in *Decisions*. For each game session, the managerial game saves a result. Namely, one can obtain a user score and compare that score with the score obtained from the adversarial player that was played by the artificial user. If the user score is higher than the artificial user score, one can say that the task was solved satisfactorily. Additionally, the emotion caption system records the emotions of the player during the game. Emotions that are reported are happiness, sadness, excitement, boredom, anger, and surprise.

There are in total 9,854 game sessions and 495,533 decisions in the dataset.

3.2 Experimental Setup

After an examination of the literature review, we derived two hypotheses.

- Are there differences in performance based on gender and based on education?
- Can we predict whether a user will compose a team that will satisfactorily solve the problem at hand while predicting the emotions of the decision-maker?

To answer the first research question we will use traditional statistical analysis. Namely, we will use the Chi-Square test of independence (Sharpe, 2015). More specifically, we will utilize the information available in the table *User* where one can find gender and education of the decision-maker and information in the table *Game Session* where the signal whether a user solved the level with satisfactory results. If needed Benjamini-Hochberg post hoc tests will be performed (Benjamini, 2010).

For the second research question, we will utilize a multi-label classification. The idea of multi-label classification is to predict more than one label in the data using adapted data mining and machine learning algorithms. More specifically, one would like to utilize the potential dependencies between labels to obtain better predictive performance. We will use a binary relevance (BR) approach that does not model label dependency. Modelling label dependency allows predictive models to "see" values of other labels during the learning process and, after, during the prediction process (Montañes et al., 2014). The approach that will be used is called Classifier Chain (CC). This approach introduces partial conditioning in labels. Namely, a list of labels is provided where the next label on the list uses information about the labels that are previous in the list. For base learners of the BR and CC approach, we used the Gradient Boosted Trees classifier (GBT).

Beside classical modelling of labels, we will also use known adaptations of learning algorithms for multi-label. Those are going to be an adaptation of the kNN algorithm (Zhang & Zhou, 2007), a hierarchical ARAM Neural Network (HARAM) (Benites & Sapozhnikova, 2015) and adaptation of SVM algorithm for the multi-label setting called MLTSVM, but will be denoted as MLSVM (Chen et al., 2016).

Our experimental setup assumes that the predictive model is available before the decision-makers' game session. Therefore, our final dataset consists of 9,854 instances where each instance has the features in categories: 1) personal - gender, education, country, age, ten features explaining the personality of the user, twenty features explaining user affectivity, 2) design of the game level – speed or quality indicator, number of rounds, tasks per round, worker productivity rate, 3) user experience – total time spent playing a game, number of games played, and 4) decision-making strategy – task assignment using expected utility theory (decision making under uncertainty), task assignment using inter-temporal decision-making theory, task assignment using complex decision theory and other approaches to task assignment. The labels that are defined are the outcome of the game, i.e. solved the game with satisfactory results, and emotions of the user expressed in happiness, sadness, excitement, boredom, anger, and surprise.

To prevent overfitting, we performed a ten-fold cross-validation procedure. This means that the dataset is divided into ten subsets, called folds. Each fold is used exactly once as a test dataset, while the remaining ones are used for model training. For each fold, we measure the area under the ROC curve (AUC). Finally, performances are aggregated with average and standard deviation presented. It is worth to notice that performances are presented label-wise.

Since every learning algorithm has its parameters, we used inner ten-fold cross-validation for parameter optimization. A similar is done for a sequence of the classifier chain. The results that will be presented are shown for the best performing classifier chain.

4 Results and Discussion

The results and discussion section consists of two subsections, one for each research question.

4.1 Differences in Gender and Education

For the first research question, we will perform a Chi-Square test of solving the task successfully given the gender and education of the user.

For the gender of the user and solving the task successfully, we obtain the contingency table presented in Table 1.

Table 1. Contingency table for the gender of a decision-maker

Gender/Solve	False	True
Female	2,229	945
Male	4,442	2,222

Based on the presented contingency table value of the Chi-Square test statistic is 12.391 (p-value < 0.001). We can conclude that, based on the data at hand, male participants do have a higher percentage of solving the task by team composition.

For education, we obtain a contingency table presented in Table 2.

Table 2. Contingency table for the education of a decision-maker

Education/Solve	False	True
High School	847	395
Diploma	2,383	1,253
Bachelor	2,446	1,080
Master	175	77
Ph.D.	47	8
Other	773	354

It is obtained that the value of the Chi-Square statistic is 21.075 (p = 0.001). Since there are multiple groups and multiple testing, we utilized Benjamini-Hochberg post hoc tests which showed that there are statistical differences between Bachelor and Diploma group (p = 0.008), Bachelor and Ph.D. groups (p = 0.046), Diploma and Ph.D. groups (p = 0.024), and High School and Ph.D. groups (p = 0.046). We can conclude that decision-makers with a Diploma degree solved more problems compared to decision-makers with Bachelor's degrees and Ph.D. degrees and that decision-makers with High School and Bachelor's degrees are better than decision-makers with a Ph.D. degree. Although the results are counter-intuitive, the main reason for such performance is the correlation between education and the complexity of the game. More specifically, Ph.D. participants tend to play games that are more complex. Complexity is observed in multiple sources of uncertainty (team member performance and variability of output of the task). Thus, performances of Ph.D. participant is lower than expected. Also, high school and diploma participants played games that has the lowest complexity (player performance is a constant and output of the task can does not have a variability). Thus, they could easily calculate the expected value of the game. Participants with Bachelor and Master degree played games every type of games regarding complexity (easy, medium and hard). Therefore, their performance is very similar to the others.

4.2 Predicting the Outcome of the Game

As already explained in the experimental setup section, we utilized several strategies for multi-label predictions. Namely, we wanted to predict the outcome of the game (user solved the game on the satisfactory level) and emotions of the user after the game expressed in happiness, sadness, excitement, boredom, anger, and surprise. Learning algorithms were binary relevance (BR), classifier chain (CC), multi-label kNN algorithm (kNN), adaptation of neural network (HARAM), and adaptation of SVM algorithm (MLSVM). The results in terms of average and standard deviation of AUC over folds are presented in Tables 3, 4 and 5.

Table 3. Predictive performance for the outcome of the game

Label	Outcome
BR	**0.760±0.001**
CC	**0.760±0.001**
kNN	0.619±0.019
HARAM	0.754±0.027
MLSVM	0.697±0.021

As can be seen from the results, predicting the outcome of the managerial game is difficult. Namely, BR and CC that use GBT performed the best. Adaptation of existing algorithms for multi-label prediction, kNN, HARAM, and MLTSVM performed worse compared to GBT.

Table 4. Predictive performance for emotions happiness, sadness, and excitement

Label	Happiness	Sadness	Excitement
BR	0.589±0.018	0.607±0.016	0.616±0.023
CC	**0.624±0.025**	**0.623±0.021**	**0.659±0.015**
kNN	0.554±0.016	0.553±0.017	0.559±0.026
HARAM	0.614±0.021	0.604±0.016	0.657±0.019
MLSVM	0.604±0.019	0.602±0.012	0.644±0.023

We can observe that emotions are hard to predict. Namely, AUC is worse compared to the prediction of the outcome. The emotion of happiness and sadness have AUC ~0.62, which means that the predictive model barely recognizes differences between emotions. The situation with excitement is better in terms that AUC is ~0.66. Again, the best performing algorithm is the classifier chain with GBT.

Table 5. Predictive performance for emotions boredom, anger, and surprise

Label	Boredom	Anger	Surprise
BR	0.589±0.020	0.560±0.023	0.613±0.023
CC	0.624±0.025	0.626±0.021	**0.653±0.019**
kNN	0.548±0.024	0.551±0.030	0.558±0.021
HARAM	**0.627±0.031**	**0.631±0.035**	0.644±0.027
MLSVM	0.612±0.024	0.622±0.027	0.639±0.024

A similar conclusion can be drawn for the emotions boredom, anger, and surprise. It is very hard to predict emotions from the data at hand. However, emotions boredom and anger were best predicted by adaptation of neural network for multi-label called HARAM, while surprise was best predicted using classifier chain and GBT.

By observing the results, one might conclude that usability of the result is questionable. To the best of our knowledge, this is the first attempt in trying to

predict both results and emotions in advance. Predictions of winning the game are at satisfactory level, while emotions are very hard to predict. This is due to complexity of recognizing the emotions.

5 Conclusion

In this paper, we tried to answer two research questions. The main goal was to try to predict the outcome of the managerial game, i.e. whether a decision-maker will manage to organize a team that will solve the problem at hand. Besides predicting the outcome, an additional level of complexity is the possibility to predict the emotions of the decision-maker. It has been shown that emotions influence employee happiness and proper emotions have to be shown. Our approach for the given task was using multi-label prediction models. This methodology is suitable for the problem at hand because we try to predict multiple labels that do have some dependency, i.e. emotions depend on the outcome of the game. The results suggest that the outcome of the game can be predicted at a satisfactory level. Namely, the best performing multi-label model had AUC ~0.76. This means that for a random satisfactory result and random non-satisfactory result our model can differentiate in 76% of the cases which one is a satisfactory result. On the other hand, emotions are hard to predict with AUC ranging from 0.62 to 0.66.

Another research question was to inspect gender and education on the outcome of the managerial game. For that purpose, we performed the statistical analysis. More specifically, we performed the Chi-square test of independence. We showed that male decision-makers tend to perform better compared to female decision-makers. Besides, we tested the effect of education on the outcome of the game. We can conclude that decision-makers with a Diploma degree solved more problems compared to decision-makers with Bachelor's degrees and Ph.D. degrees and those decision-makers with High School and Bachelor's degrees are better than decision-makers with a Ph.D. degree are.

As a plan for future work, we would like to gain more insight into what are the key points based on which prediction model made a decision, i.e. explain the predictions. This type of analytical insight could give better feedback to the teacher and decision-maker about why the effect is going to be achieved. Additionally, we would like to perform a more detailed prediction model with a model for each decision in the managerial game process, not only for the game itself.

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Towards a Strategic Approach to Attracting Female Students and Researchers in the ICT Field

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Abstract. *Attracting female professionals, researchers and students in the STEM fields has been a growing topic in recent years. By comprehending the importance of diverse teams in all areas, the emerging challenges are also addressed by the Institute of Informatics at the University of Maribor. Therefore, strategic monitoring of actions was introduced in order to attract females in the field of Informatics. In this paper, we address the importance that the academic organisations and Institutions create action plans and follow the guidelines for attracting potential female staff, who can ameliorate the teams at Universities. We present an example of how the action plans are being monitored and extended actively, based on trending guidelines.*

Keywords. Gender equality, ICT, Informatics, actions, STEM, strategic monitoring.

1 Introduction

In 2018, 17% of ICT students and 16.5% of employed ICT specialists were women (Eurostat, 2018, 2020). In response to repetitively small numbers, the European parliament has started to support empowering women in the digital world strategically ("More women in ICT: empowering women in the digital world," 2018). Many benefits are anticipated from this effort, as Phillips et al. (2014) have found that diverse groups are better at solving problems than the homogeneous groups. Diversity on the other hand also generates more revenue and inspires future generations ("Top Three Reasons We Need More Women In Tech," 2020; "Why We Need More Women In Tech In 2020," 2020). There is a similar mentality at the Institute of Informatics at the Faculty of Electrical Engineering and Computer Science.

Since its establishment in 1993, the Institute of Informatics, which operates at the Faculty of Electrical Engineering and Computer Science at the University of Maribor, has employed and supported female members. The number of female employees has increased by 129% in the last ten years, due to careful career planning support and a healthy and supportive work environment at the Institute, as well as the creation of strong collaborations and following actions to attract female researchers. To formalise the existing orientations aimed at providing an equal environment, the *Ladies in Informatics initiative* was founded in 2018 ("Ladies in Informatics," 2020). The initiative pursues to unite female scientists with related research interests in the ICT domain. It is growing by welcoming new female researchers and student members, as this is an important focus of the initiative. The initiative's website is presented in Figure 1, and the work and activities within the initiative, which include several key goals (advocate, collaborate, promote, motivate, support and encourage), are presented in Figure 2.

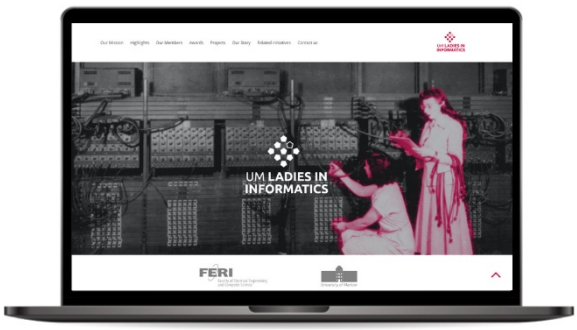


Figure 1. Website of the *Ladies in Informatics initiative.*

Many similar initiatives can be detected, formed to connect women in STEM, and promote actions to improve gender balance because of the underrepresentation of women in these fields. For example, the publication by Informatics Europe presents an excellent groundwork for following actions of bringing more women into the STEM fields (*More Women in Informatics Research and Education*, 2016). We will continue this paper with a review of related initiatives, as well as listed actions to attract more

female scientists. We will continue with the presentation of the indicators, identifying the level of female inclusion possibilities, as well as support in STEM fields. The discussion on how to improve the current status and best practices will also be reported.



Figure 2. Goals of the *Ladies in Informatics initiative.*

2 Related Initiatives

Some initiatives have created actions that could be followed to attract female scientists to higher positions or attract more female students into ICT studies. Initiatives like *IEEE WIE, Women in Informatics Research and Education, ACM-W, Women in Cyber, ECSO Women4Cyber, and Girls who Code* are formed to increase gender equality in STEM fields and connect females working in these fields ("ACM-W," 2020; "Girls Who Code," 2020; "IEEE Women in Engineering," 2020; "Women4Cyber," 2020; "Women in Cyber – a Manifesto for TODAY," 2019; "Women in Informatics Research and Education ", 2020).

A project funded by the European Commission called *genSET* was carried out, aimed at improving the excellence of European science through the gender dimension in research. Recommendations extracted from this project outcomes included gender diversity in teams, and providing more visibility of women at Institutions ("Increasing Capacity for Implementing Gender Action Plans in Science," 2019; Vasilaki, 2013). One of the recommendations coming from this project was also to create action plans to follow the gender strategies of scientific Institutions.

A guide to improving gender equality in research organisations by Science Europe presents ways of monitoring gender equality, such as defining explicit objectives for gender equality, mandatory actions being taken to meet the objectives, and gender equality data should be collected and made public (*Practical Guide to Improving Gender Equality in Research Organisations*, 2017). Further on, in a publication by Informatics Europe, 48 actions divided into six sections have been proposed to attract more women into Informatics (*More Women in Informatics Research and Education*, 2016). This publication is also used by the Institute of Informatics to measure the actions and monitor the improvement strategically in attracting female researchers and students. The actions from the publication will be presented in the next section.

3 Monitoring Actions

A checklist of actions from the Informatics Europe publication has been developed at the Institute of Informatics (*More Women in Informatics Research and Education*, 2016). This allows strategical following of actions that are already being carried out, or could potentially be carried out. Brainstorming sessions are organised to discuss possible improvements and provide ideas on how to achieve the proposed actions. In Figure 3, percentages of the achieved levels of suggested actions from the six sections are presented for the Institute of Informatics. Some of the actions are already being carried out, due to the Regulations that need to be followed, and some are being evaluated, planned and performed.

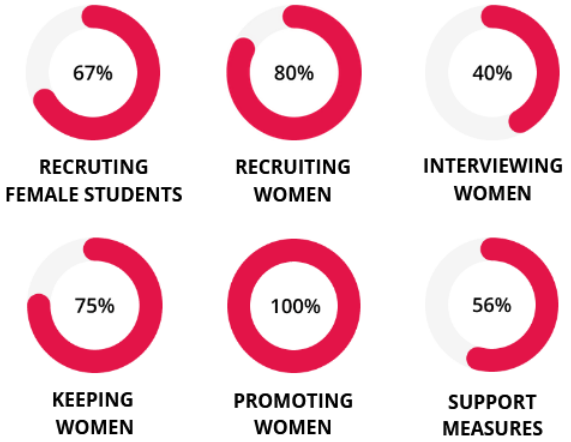


Figure 3. Achieved level of proposed actions by Informatics Europe at the Institute of Informatics.

Examples of how the measures are being achieved at the Institute of Informatics will be presented next. The Institute promotes success stories of their female researchers and teachers on various channels. One of the members of the Institute won the IEEE Slovenia and IEEE Region-8 student paper contest award as the *first-ever female contestant to win both competitions over nearly thirty years* (News, 2017). This was presented in promotional materials for High School students entering their studies. The effect of the promotion of a female winner has shown an increment

in the percentage of female students at the Informatics and Communication Technologies Study Programme. Another member of the Institute was awarded the prestigious title of *Female Engineer of the year 2019* in Slovenia, and her story was covered broadly in both national and international media (Office, 2020). The promotion of such success stories encourages female candidates to apply for job positions in ICT and creates opportunities for sharing best practices.

The educational and scientific responsibilities show the high success of Researchers or Professors holding a PhD, with numerous publications, excellent scores for pedagogical work from students and a high percentage of leading international projects at the Institute. Further on, the number of female employees has increased at the Institute in the last ten years as they are provided with numerous advantages, one of them being the maternity leave for women in Slovenia (average 12 months), which is always considered when women candidates are being evaluated for success criteria.

Also, there has been a higher percentage of female candidates achieving permanent Assistant Professor positions in 2019 at the Institute in comparison to male candidates. This shows excellent support of the management to achieve higher percentages of female employees in all positions. Joint sporting events are also often organised for staff at the Institute, and support for a personal development plan for researchers is being carried out. These are some of the actions being carried out at the Institute of Informatics. All listed actions are being monitored strategically, based on the publication by Informatics Europe, which has been a foundation for measuring actions attracting females at the Institute of Informatics (*More Women in Informatics Research and Education*, 2016). The actions are divided into six sections:

- Recruiting female students;
- Recruiting women;
- Interviewing women;
- Keeping women;
- Promoting women; and
- Support measures.

In Table 1, six actions present the working ground for **attracting female students** to enrol in the IT studies by using social media, presenting role models and success stories to prospective young students.

Table 1. Recruiting female students actions (*More Women in Informatics Research and Education*, 2016)

1.	**RECRUITING FEMALE STUDENTS**
1.	Use multiple social media channels to promote events and reach a high number of prospective students.
2.	Work with undergraduate open-day coordinators to recruit female student ambassadors and speakers from the department and industry. While female faculty may choose to volunteer as role models, this costs women their study/research time.
3.	Present example stories about women with successful careers in Informatics in recruitment materials and on the departmental website, encouraging female candidates to apply and reducing the stereo - type that Informatics related jobs are for "nerds".
4.	Offer courses and guest lectures on topics that are popular with undergraduate and graduate students and present new opportunities for researchers, such as human-computer interaction, multimedia, lifestyle Informatics, health Informatics or computational linguistics.
5.	Include in course descriptions aspects of creativity in tech education and work, such as information and communication design, user interface design or participatory design.
6.	Emphasise good prospects for employment in the IT sector for skilled workers and that salaries are above average.

In Table 2, ten actions for **recruiting women** are presented, and the actions point out that women should be broadly welcomed and invited for open job positions.

Table 2. Recruiting female students actions (*More Women in Informatics Research and Education*, 2016)

2.	**RECRUITING WOMEN**
1.	Advertise openly for all positions, stating that you are an equal opportunity employer.
2.	Describe positions in a broad way. State job criteria objectively.
3.	State in the recruiting materials and job descriptions that the university/department/institute is committed to facilitating the combination of work and childcare.
4.	Emphasise that jobs in Informatics allow for more opportunities for tele-commuting and tele-working, compared to other fields.
5.	State that flexible terms of employment are possible, such as working part-time and flexible working hours.
6.	Distribute advertisements across a number of channels. For example, send them to women's networks' email lists, such as national women in tech networks or networks of female professors.
7.	Approach candidates directly. For example, send the advertisement personally to (at least) three women you would like to see in the position. Ask them to apply, or ask them to send it to three other women who they think would be suitable.

8.	Allow 3 months for applications to be submitted. Time is needed for the advertisement to reach the right women, and they need time to respond.
9.	Take action if too few suitable women apply. For example, extend the deadline for applications and re-advertise the position (inter)nationally.
10.	Re-examine the applications and consider re-advertising if the initial list of candidates selected for interview does not include any women.

In Table 3, five actions are presented regarding **interviews** for open job positions.

Table 3. Interviewing women actions (*More Women in Informatics Research and Education*, 2016)

3.	**INTERVIEWING WOMEN**
1.	Ensure that the composition of the hiring committee is as balanced as possible. For example, ensure that at least 30% of the committee consists of women, with a minimum of two female members.
2.	Invite women to the interview not only to see whether they are best for the position, but also to give them experience of being interviewed and increase their status at their own institution.
3.	Raise the issue of increasing the representation of women in the department when interviewing women and men and ask how they would approach it. This provides extra tips and also shows the department is serious about the issue.
4.	Provide help with solving the "two body problem", that is helping to find a position for the applicant's partner.
5.	Consider 18 months per child since PhD completion for mothers when comparing candidates for any success criterion, thus reducing the time used to judge the achievements.

In Table 4, sixteen actions are presented for **keeping women**. Supporting females with children, and creating a development plan, as well as maintaining high women`s quotas are significant actions in this section.

Table 4. Keeping women actions (*More Women in Informatics Research and Education*, 2016)

4.	**KEEPING WOMEN**
1.	Schedule meetings only between 09:30 and 16:30, so carers of young children are able to deal with commuting and childcare.
2.	Overcompensate the imbalance of women in the institute by their overrepresentation at institute colloquia. For example, if 15% of the department is female, then make sure women give at least 25% of the talks. Invite external female speakers as well.
3.	Organise a course for all senior staff members on unconscious bias. These can cover all diversity issues not just gender equality issues.
4.	Provide support for the creation of a women's network within the department/institute, including secretarial support and a budget for holding events such as lunches.
5.	Distribute welcome packages with a booklet that lists childcare options as well as other useful info provided by faculty/institute members.
6.	Hold annual discussions with representatives of the women's network and the head of the HR department.
7.	Encourage senior members of staff in the department to act as mentors. This will create a community where knowledge is passed on to new members, keeping women interested in the department/organisation and in the field.
8.	Count the hours spent on female support and network issues in the same way as all other departmental commitments and duties. Do not assume that female employees can deal with this extra load in their "spare" time.
9.	Fund childcare as part of conference travel expenses for participating faculty and researchers with young children.
10.	Fund travel expenses for a partner to go to the conference location during the breastfeeding period.
11.	Inquire if conference venues have childcare facilities and personnel, and request organisers to provide attendees with childcare and breastfeeding options. Ensure that conferences organised by your department provide such facilities.
12.	Balance the didactic and scientific responsibilities of all staff and make explicit the priorities for evaluating an individual's performance (e.g., research excellence, students' satisfaction with courses, contribution to departmental duties).
13.	Create an "ambassador" program, or a personal development plan for researchers with high potential. Ensure that at least 30% are women.
14.	Upgrade a postdoc position to a tenure track position when there is an excellent female candidate and she meets the criteria specified. Include a mid-term review of progress against the criteria.
15.	Provide visibility and self-promotion training for female researchers in temporary as well as permanent employment.

16.	Provide coaching and mentoring to female researchers to make them more aware of their attitudes and concerns, for example, how to combine work and family demands and how to deal with the competition for permanent positions.

In Table 5, two actions are presented for **promoting** successful **women**.

Table 5. Promoting women actions (*More Women in Informatics Research and Education*, 2016)

5.	**PROMOTING WOMEN**
1.	Ensure a reasonable representation of women in departmental or external committees, whilst also being careful not to unduly overload female members of staff with committee membership.
2.	Look for and propose suitable women when asked to nominate candidates for prizes, awards or prestigious tasks (e.g. for reviewing, representing the department internally or externally). Strive for equal numbers of highly qualified women and men on the short list.

Nine **support measures** actions are presented in Table 6. Connection with other females is crucial in succeeding in the ICT field.

Table 6. Support measures actions (*More Women in Informatics Research and Education*, 2016)

6.	**SUPPORT MEASURES**
1.	Consult the women in your department. For example, organise lunch once a month with a different woman, at a different level, and ask her how she views the organisation, her role and her career ambitions and prospects.
2.	Scout for and follow talented female researchers that could be called upon at some future point in time to complete diverse tasks.
3.	Anticipate the retirement of (male) professors by making an inventory of, and initiate training of potential female successors.
4.	Keep track of national and international networks for female researchers. Encourage women to take part in networks.
5.	Find successful role models and create opportunities for both men and women to share best practices.
6.	Monitor the percentage of women at all levels in the organisation. Create specific but realistic targets and action plans. Make the figures public in annual reports and departmental evaluations.
7.	Assign gender representation as a responsibility to a member of the management team, as well as ensuring it is in the HR department's portfolio. Encourage gender diversity to be championed by both men and women in the whole organisation.
8.	Support the creation of departmental and institutional policy that takes into account the number of children when comparing CVs in all instances related to hiring and promotions.
9.	Develop a special program for extra tenure-track positions for high potential talent, where the recruitment criteria are based on excellence rather than topic. Consider at least an equal number of female candidates for these positions.

4 Conclusion

The *initiative Ladies in Informatics* was founded to follow the current trends and best practices detected in other related associations. By connecting with initiatives with similar goals, we are also presenting a story and the actions taken to improve the position of women among researchers and students in STEM fields. The checklist of possible actions is monitored and evaluated continuously. Many important milestones were already achieved; however, we expect that development in the forthcoming years will strengthen the measured criteria even further. The list of actions from the publication (*More Women in Informatics Research and Education*, 2016), presented in Tables 1-6, can be used by related initiatives as a checklist to monitor the actions for attracting female Researchers and students. However, since the trends in the domain are changing rapidly, lists of actions will evolve over time, with the first step of extending a list with new actions extracted from the recommended guidelines followed by the related initiatives.

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Analysis Of Strategic Planning Assistance Tools

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Abstract. *Strategic Planning is an important part of an organisation's success, and since this presents an Achilles heel for many companies, appropriate tools can provide much needed assistance. In this paper, we address the field of Supporting Information Solutions in Strategic Planning. Analysis and presentation of tools to assist in Strategic Planning is included, and the main goal of the paper is to determine, which of the given tools is the most suitable. In order to make a comparison, we selected six tools, chosen based on the frequency of presence in the forums. We analysed the functionalities of the tools and, finally, compared their core properties, providing guidelines for future Strategic Planning activities.*

Keywords. Strategic Planning, performance indicators, strategic tools, control panel, organisation monitoring

1. Introduction

The goal of every organisation is to increase its profits, enhance the company's performance, and ensure customer satisfaction, as well as provide an employee-friendly work environment (Rozman & Stare, 2008). The paper's focus addresses the field of Strategic Planning and activities related to its creation, supporting the organisation's goals. Since the effort of an organisation is to stay competitive in the market, the appropriate Strategic Planning is very important, and many organisations are not aware of, or do not have enough knowledge to create an effective and appropriate strategic plan for their needs. Another problem is the failure to follow the outlined strategic plan, and organisations spend a lot of time obtaining a report in which they will gain insight if they follow the set paths and monitor their own performance. According to the listed problems, Information Technology (IT) solutions are a welcome and necessary addition to Strategic Planning activities.

A Strategic Plan is a formal definition of the business direction in which the company or organisation will focus (Janškovec, 2004). Different organisations have diverse goals while they strive for business success, which opens several questions, e.g. how to support them while achieving defined goals. One of research interests in this paper is how to evaluate when an organisation is actually successful within its business activities. Since the situations in organisations change rapidly, they consequently need to react quickly and correctly, be flexible and responsive. It is important to check performance on an ongoing basis, while they must also set realistic goals and check the compliance of operations with the set goals. Since rapid and unexpected market changes bring many problems to unprepared organisations that hinder the achievement of strategic goals, these obsticales empower the companies' goals of efficient strategic planning and following the set plan. Organisations which have regulated control systems and take timely action, are more likely to be successful in the business world. Figure 1 presents a simplified example of the road to a mountain in the case of a good strategy plan (right) and an unappropriated one (left).

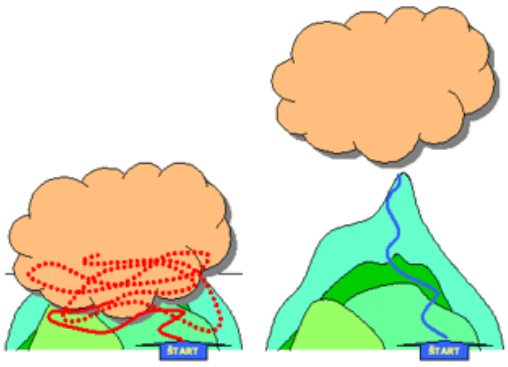


Figure 1. Example of a good and a bad strategy

In the following sections, the importance of Strategic Planning while supporting organisations needs will be presented, followed by strategic elements in section three. In Section four, the tools supporting organisations will be presented and compared in Section five. A conclusion and future work will be defined in Section 6.

2. Strategic Planning

Strategic Planning is organisational management. It sets priorities, focuses energy and resources, strengthens the organisation, and ensures that employees and other stakeholders work towards common goals by achieving a response to the intended results, evaluating, and adapting the organisation's direction in response to the changing environment. It is a disciplined effort that produces fundamental decisions and actions to shape and lead what an organisation is, who serves the organisation, what and why the organisation does it, and, above all, with a focus on the future. Strategic Planning that is effective, not only determines where the organisation is going, but also covers the actions needed to progress, and, at the same time, includes criteria for the organisation to know if it is at all successful (Taylor, 2020).

Strategic plan is a document used to communicate with the organisation regarding the goals, the measures needed to achieve the set goals, and all the elements that are crucial and were developed during the preparation of the strategic plan (Musek-Lešnik & Lešnik-Musek, 2016). The strategic plan generally covers the following sections:

- a summary, usually written at the end of the entire strategic planning process,
- description of the organization,
- the mission of the organisation, its vision and statements of value,
- strategic analysis, which can take the form of a SWOT analysis (covering strengths, weaknesses, opportunities and potential threats),
- explanation of the strategy and tactics for the organization,
- an action plan,
- organisation budget and operational plans,
- methods of monitoring and evaluating the performance of the organisation.

Creating a strategic plan depends largely on the very nature of the organisation. In the event that an organisation operates in a rapidly changing business environment, strategic planning is essential to the organisation's existence and usefulness, so that the organisation remains effective. The strategy planning or renewal is suggested in the following cases (Musek-Lešnik & Lešnik-Musek, 2016):

- when the organisation renews goals,
- when an organisation begins operations,
- in case the organisation is preparing for a new venture (example, a product launch),
- when markets begin to alternate and the business environment changes (business practices, regulations, laws).

By renewing Strategic plans, following the guidelines and the pyramid of concepts (Figure 2), higher quality and support is provided for an organisation.



Figure 2. Pyramid of concepts for higher quality of organisation (Taylor, 2020)

3. Supporting Organizations

Companies need to design and define what they want to become and how they will achieve their goals. For this purpose, they have to define several strategic elements:

1. The **vision** of an organisation is a general description of the projected future of the organization, and represents idealised future images. It predicts on what the organisation should focus in the future.
2. The **mission** of the organisation defines the meaning of existence or the purpose of the organisation itself. The centre of the organisation is its mission, and from this follows the companies' conduct. The mission, drawn up in the form of a generalised statement, should include all the basic concepts that describe the organisation concisely, its services, market, goals, philosophy (responsibilities of the organisation to its employees, users, society and, of course, the founders).
3. For organisations that want to be efficient and successful, they need not only a great product, but also a great **story** that adds value to products and services and attracts attention.
4. **Methods of** the vision **realisation**. The strategic underlying tool is a well thought out and clearly set goal that is integrated into a strategic plan (Musek-Lešnik & Lešnik-Musek, 2016).
5. **Tangible and measurable tasks** are set by organisations. The organisation must set goals so that they can be measured easily and quickly. In this way, the organisation determines its success in achieving its goals quickly. Effective goals are based on defined values, the mission and vision of the organisation. The purpose of the goals is to summarise the mission and vision and, thus, define the actions and procedures more on how to carry out both aspects successfully (Musek-Lešnik & Lešnik-Musek, 2016).

Support of tools while creating strategic plans and addressing strategic elements benefits organisations while performing their daily tasks and achieving their set goals.

4. Tools for Strategic Planning Support

Based on a literature review, focusing also on commercial forums and business recommendations, the following tools for strategic planning were chosen:

- Cascade Strategy,
- Envisio,
- On Strategy,
- Planview,
- Bitrix24 and
- KPI Fire.

More details about the tools are provided in the following sections.

4.1 Cascade Strategy

The organisation was created in 2012 (the logo is presented in Figure 3) and the first version of the tool was created a year later. It is a strategic management platform, allowing the creation of a plan. The implementation of the plan in the company can then be monitored by using the control panel. In the event of a strategy change, the tool allows changes to be made at any time. The tool covers the central management of individual projects, objectives and key performance indicators - KPIs (Cascade, 2020).

Figure 3. Logo of the Cascade Strategic tool

The tool covers strategic planning, goal and project management, includes dashboards, reports, performance management, and human capital management. Cascade Strategy also contains a strategy-planning wizard and various visualisation templates that can be customised to the needs of the projects. Users can create and customise strategies and assign projects to individuals and set goals for them. Cascade Strategy Software has the ability to track various parts of projects, such as risks, issues, goals, and engagement.

4.2 Envisio

The Envisio tool was founded in 2012. The tool (the logo is presented in Figure 4) is designed to manage strategies in educational and governmental organisations. It offers a transparent interface for easy use. The interface includes data about the company's performance, additionally enables the creation of reports for Boards of Directors or other leading services in organisations, so that the including parties can communicate about the progress. It allows the organisation to work with their team to customise the tool as much as possible for the needs of the organisation (Envisio, 2020).

Envisio is an online solution. For learning, it includes documentation and a so-called online classroom (Envisio, 2020). It also provides online support.

Figure 4. Logo of the Envisio strategic tool

4.3 On Strategy

OnStrategy Company was established in 2003 in the United States (the logo is presented in Figure 5). OnStrategy's biggest competitor right now is Envisio (OnStrategy, 2020). The main feature is communication with the client. They also advise the client and adapt the tool for the client with common ideas. The information solution covers the entire process of Strategic Planning, enables directing tasks to specific departments, transparent reports and tracking performance with the help of the control panel. It is an online solution, and covers training in the form of documentation, live online and personal support.

Figure 5. Logo of the OnStrategy strategic tool

4.4 Planview

Planview is an online solution that helps with Strategic Planning (Figure 6). The solution is intended primarily for industrial companies, where it covers functionalities for easier, faster and more efficient operation of the company. It is a flexible tool for a changing work environment. It includes a control panel so that leaders in the organisation or company can see the results quickly and easily, and take timely and correct action, thus avoiding possible inconveniences (Planview, 2020).

Figure 6. Logo of the Planview strategic tool

It is work and resource management software and covers comprehensive solutions for Strategic Planning, resource and product collection, capacity and technology management, and collaborative management. Software can help organisations create timelines, optimise funding, and allocate resources through strategic scenario planning. Also included are tools for financial and capital planning, analytics, and a control panel for an easier and faster overview of events.

The company's goal is to achieve the set strategy of the organisation with the service of all people, resources and business capabilities. The service includes:

- Strategic Planning,
- Portfolio and resource management,
- Product portfolio management,
- Capacity and technology management,
- Management of joint work.

4.5 Bitrix24

Bitrix 24 (Figure 7) is a freely available tool for Strategic Planning, business intelligence and a project management platform. Tasks can be assigned to company employees through the tool. The chart can review the tasks and their status, the responsible person and the chronological relationship. This gives the user a complete picture of the projects (Bitrix, 2020).



Figure 7. Logo of the Bitrix24 strategic tool

Bitrix24 has various offers in terms of price range. These classes include various functionalities, such as number of users, online storage capacity, CRM functionality capture, marketing automation, options over tasks and projects, communications, websites and a contact centre.

4.6 KPI Fire

KPI Fire was founded by Cedro Toro as a solution to a problem he had been facing for more than 15 years as an expert and consultant for Lean / Continuous Improvement. He found that most companies strive to communicate their strategic priorities with outdated x-metric spreadsheets, PDF documents, and slideshows. Cedro noted that strategic plans are often well-designed, but the organisation has not yet recognised them.

The solution is designed for a top-down strategy by generating bottom-up ideas. In the middle are selected and activated projects for the implementation of strategic priorities.



Figure 8. Logo of the KPIFire strategic tool

It is a cloud-based tool, and suitable for all types of groups in manufacturing, service industries, healthcare and other organisations. KPI Fire is designed to help organisations align its teams, and achieve their goals in such a way that it provides users with the tools to enter their annual goals, strategic plans. The entered goals are then broken down into departmental goals, team goals, and projects.

KPI Fire project management allows users to plan and implement continuous project improvements, create workflows, perform tasks, and allows users to set up a workflow template for repetitive project types - automation.

It allows the user to create standardised workflows that help team members visualise their strategy, and ensure that all people are involved in achieving the same goal. Strategic goals can be created and defined with the help of KPI Fire, and then all users in the organisation get access or visibility of these goals in real time on the control panels. The custom forms contained in the tool enable the management of organisations to obtain ideas and suggestions from employees. Ideas can be prioritised, and later converted into feasible projects. All new projects and ideas that are created and implemented can be linked to the goals and easily measured regarding their effectiveness and significance. The logo is presented in Figure 8.

To compare all listed tools, a simple experiment was conducted, testing all tools and comparing their functionality, which is presented in the following Section.

5 Experiment

To compare all listed tools and provide a guide for potential users, we conducted a simple laboratory experiment. The experiment included testing the tools and comparing their functionalities. The experiment was performed in a laboratory environment (on a personal computer).

The idea of the experiment was to test the functionalities covered by the tools, and to determine the extent to which they cover Strategic Planning and plan implementation. Table 1 shows a comparison between the tools. The main functionalities were chosen based on the tools' functionalities and what is

perceived to be desirable for creating and implementing a Strategic Plan and they include:

- Idea generator,
- Strategy planning,
- Vision definition,
- Enter organisational value,
- Enter organisational goals,
- Entering of new projects,
- Project charter,
- Indicators of success,
- Dashboard,
- Creating reports,
- Exporting reports,
- A guide to using the tool,
- An open source solution,
- Free tool testing,
- Cloud storage and
- Possibility of integration (Box, Dropbox, Google Drive, Microsoft One Drive).

The more detailed comparison of tools regarding their functionality is presented in Table 1.

Table 1. Comparison of tools

Tool / Functionalities	*Cascade Strategy*	*Envisio*	*On Strategy*	*Planview*	*Bitrix 24*	*KPI Fire*
Idea generator	✗	✗	✓	✗	✗	✓
Strategy planning	✓	✗	✓	✗	✗	✓
Vision definition	✓	✗	✓	✗	✗	✗
Entering organisational value	✓	✗	✓	✗	✗	✗
Entering organisational goals	✓	✗	✓	✗	✗	✓
Entering of new projects	✓	✓	✓	✓	✓	✓
Project charter	✗	✗	✗	✗	✗	✓
Indicators of success	✓	✓	✓	✓	✓	✓
Dashboard	✓	✓	✓	✓	✓	✓
Creating reports	✓	✓	✓	✓	✓	✓
Exporting reports	✓	✓	✓	✓	✓	✓
A guide to using the tool	✓	✗	✗	✓	✗	✓
An open source solution	✗	✗	✗	✗	✗	✗
Free tool testing	✓	✓	✓	✓	✓	✓
Cloud storage	✗	✗	✗	✗	✓	✗
Possibility of integration	✗	✗	✗	✗	✓	✗

The vision, goals and values of the organisations were created in the tools that made it possible. This was followed by the creation of activities, which were carried out after the workflow until their completion. Reports, dashboards and performance indicators were also tested based on these activities. When entering the vision, organisational value and goals, the main difference between the tools were shown. Only KPI Fire, Cascade Strategy and On Strategy tools can enter the mentioned elements.

In the next steps, the activities were entered into the tools, which turned out to be very similar for all tools. All tools enable the entry of these activities, the implementation of certain works on these activities (at what stage the activity is, how much time is provided for completion, who is in charge of the activity, which persons are involved in the activity and how). Based on these settings over the activities, it is possible to create a control panel in the tools that will display important data for the responsible individuals. Based on the reports provided by the tools, the Planview tool stands out, which has a large set of reports.

Of all the tools analysed, the Bitrix24 tool brings the most functionality to organisations. It is clear from the presentation that it is not only a tool that would allow real-time monitoring of the company's path, but also includes a Human Resources module, where they can use the tool to manage employee data, recorded hours and communication between employees. The tools do not allow the definition of a Strategic Plan, as it is a document that records the data planned by those responsible for planning in organisations. The tools presented are intended primarily to follow the Strategic Plan once it has been created, and are not to aid in planning, but to support in the implementation of the Strategic Plan.

Cascade Strategy and On Strategy are the best tools after conducting the experiment. The tools support a lot of functionality, and, at the same time, are easy to work with. Their great advantage is that the tools are very well documented, as they enable users to work easier, simpler and faster.

Second place belongs to the KPI Fire tool. It is a tool that has a lot of functionality. The problem with the tool, however, is the documentation, as the steps for using certain functionalities are not recorded exactly.

Third place is occupied by the Planview tool. A great advantage of the tool are the reports, as they cover a wide range of different views of the data.

The Bitrix24 tool is in fourth place. It is a tool that places more emphasis on running a business and managing Human Resources, less on following a Strategic Plan. It is a great tool for smaller businesses, with which an organisation can engage its employees.

The Envisio tool occupies the last place. According to the obtained data, it is a tool that helps in the implementation of the Strategic Plan. A problem arose during testing because the tool was requested to gain access to the test environment, which was not obtained.

6 Conclusion

Strategic Planning and implementation of a Strategic Plan is an important component for organisations, therefore the purpose of the paper was to explore the tools that could provide support while creating a Strategic Plan and monitoring its success.

Based on the literature, information was gathered on the tools that are most common within scientific papers and forums and cover as much functionality as possible. The aim of the task was to obtain information about what functionalities the tools provide. An experiment was performed according to the obtained data. The tools had many elements in common however differed in the number of functionality and therefore provided different support.

A comparison of the tools` functionalities, and their usefulness is presented in Figure 9, revealing that the best tools are Cascade Strategy and On Strategy.

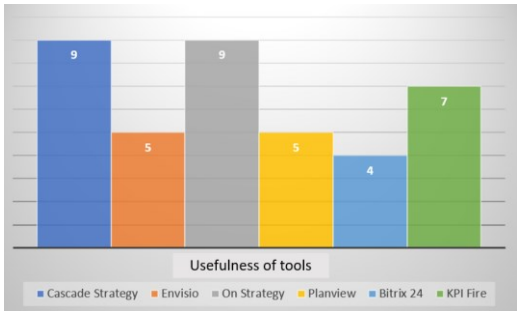


Figure 9. Comparison of strategic tools based on the number of functionalities

The future work will include an interview with the individuals in charge of creating and implementing a Strategic Plan in the companies. The aim of the interview will be to gain as much information as possible from these individuals, and their opinions on how this could be improved. According to the data obtained we will evaluate how much of Excel type of management is still present and how many of the listed tools are actually applied in organisations, since the main identified problem is monitoring the implementation of the plan. Future work will also include a survey on a larger set of organisations

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National Research Funders' Collaboration - Strengthening the Regional Research Landscape

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Abstract. *Research funding is a process based on thorough and rigorous research evaluation performed by international experts, organised and managed by the independent national research funding organisations. In the European Union, the majority of research funds still originate from the budgets of the Member Countries. It is nearly a decade since the national research funders started to cooperate, aiming to improve their expertise, encourage the cooperation of scientists and make the research potentials ready to compete in the demanding calls within European research framework programmes, with special attention on prestigious projects of the European Research Council. In this paper self-organisation of research funders is shown at the European, global and regional levels, stressing the goals, instruments and challenges of the latest. The comparable evaluation system, independence of the funders and sound handling of the possible conflicts of interests is the prerequisite for the cooperation of research funders at any level. A case of CEUS (Central European Union of Science funders) is used in the discussion.*

Keywords. research funding, evaluation expert system, management of regional cooperation, research landscape

1 Introduction

Research funding at the national level is of the utmost importance to assure the needed scientific potentials for international cooperation, competitiveness, and to provide the scientific advice for decision-makers at all levels. The scientific fields to be covered are usually stated by the national policy documents, although, regardless on the size of the country, most of them are struggling to cover the majority of the scientific fields and the consecutive specific areas (the accurate classification of scientific fields used by research funders is the FORD (Fields of Research and Development), published by *The Organisation for Economic Co-operation and Development* (OECD, 2015, page 59). Variations of funding coverage for scientific fields and areas are often in place due to a legacy, or other reasons, as discussed later in this paper. The concept of independence/autonomy and the cooperation of research funding organisations is stressed in this paper. The role of the Science Europe Organisation is introduced for the purpose of setting the scene for the regional cooperation. Evaluation systems in most countries differ in details; however, the basic structure of the widely used system comprehending internationally renewed independent experts and panellists makes the approaches comparable, offering a corresponding platform for cooperation, both on bilateral and multilateral levels.

In society there is no doubt of the importance of scientific progress at the declarative level. The awareness is related mostly to the new knowledge leading to new products and new jobs, which brings us to the conventional cyclic thinking supporting research. Long-term, the state provided funding of science is the overall accepted way of institutionalisation of the care for science, in the long term aimed to originate benefit for the economy and society at large. The importance of basic research is not always well accepted, and, learning from the economic crisis a decade ago, often not treated as a sustainable way of growth and prosperity in the future. The work of Venavier Bush, the Director of the Office of Scientific Research and Development in the USA, and published by the National Science Foundation (Bush, 1945) was crucial for the recognition of the integrative approach to science and the public welfare worldwide, and even nowadays this publication is still used as a textbook by scholars. Indeed, it is supposed to be consulted by policy makers. Ziman's (Ziman, 2000) discussion on pure science can also serve as introductory reading, including the clarifications on academic science, and of the science base and observations of its impact, and leads us eloquently to the background of the national funding, regardless of the present economic welfare: "Although academic science requires a very sophisticated social environment, it is cultivated variously in tiny plots in the poorest and least developed countries." (Pages 24-25)

In this paper, those research funding organisations are mentioned that address predominantly the basic research and the applied research, with no direct industrial application. They are funders of the new knowledge and talents. Using the language of the NASA Technology Readiness Levels (TRL), also adopted by the European Commission in 2014 research framework programme (EU Horizon 2020, 2014), the research funding observed in this paper is involved in sustainable supports to TRL's form sone to three, (basic principles observed, technology concept formulated, experimental proof of concept).

2 The Structure and Prerequisites for Research Funding Organisations

In the last two decades, different types of Associations and Organisations aimed to bind the national research funding systems, struggling for both administrative cooperation and mutuality in experience exchange for the complex, at domestic level often criticised evaluation processes. Mentioning just two of them – in many ways predecessors of Science Europe, an active association of research performing and research funding organisations – gives us an insight to the collective effort of National Agencies/Organisations for improvement, and to boost the excellence of researchers through evaluation and funding mechanisms: EUROHORCS (European Heads of Research Councils) and ESF (European Science Foundation). Almost a decade ago tough discussions and opposite views (illustrative article: Sattary, 2011) were confronted by national funders, and the new association, called Science Europe, was formed in 2011 after the rejected merger of EUROHORCS and ESF.

2.1 Science Europe - The Association of National Organisations

Science Europe is the European Association representing the interests of major public research performing and research funding organisations. The association was founded on 21 October, 2011, and is established as an International Non-profit Organisation under Belgian law, with its office in Brussels. The Slovenian Research Agency (ARRS) was a founding member.

The vision of this Association is to contribute to a strong European research ecosystem that, in turn, will help create better science. The Association acts as a forum, where its Member Organisations join forces and collaborate to shape the future of research in Europe in a way that no single organisation would be able to achieve on their own. This declarative description of the vision (Science Europe, 2013) is illustrated by two overarching missions, the *Active Advocacy* (to be a recognised and respected voice in the European Research Area, alongside national governments and the European Commission, and contribute to improving the political, legislative, and financial conditions of scientific research in Europe), and *Collaboration* (to promote exchange and cooperation between our Member Organisations in terms of both policy and activities, with the aim of improving performance and the impact of Science Europe and its Member Organisations nationally and at the European level). In the last few years, the focus was moved from scientific advice, being in the forefront of the mission (Science Europe, 2013), and organised in the complex structure of Scientific Advisory Committees (SACs). Advice from active researchers is still an essential input to sound policy making. Today, the Association engages directly with the scientific experts and researchers, who advise and lead its Member Organisations, and continues to gather independent opinions and advice adapted to the diversity of its activities (Science Europe, 2020a). For illustration, Science Europe has also been instrumental in developing and promoting Plan S, an international and inter-institutional effort to make full and immediate open access to scientific publications and research data a reality. Many of the Science Europe member organisations are funders and/or members of cOAlition S, so they have endorsed Plan S and are jointly working on its implementation (cOAlition S, 2020), which is of the utmost importance, since the majority of audacious national strategies on open access have a lack of implementation-level insight. Today, cOAlition S is recognised globally and is a highly influential Association of public and private research funders embracing implementation models for open access that would change the existing often rigid business models for scientific publications, such as Article Processing Charges (Eve, 2007). Launching guidelines, requirements for price transparency frameworks and exploring non-commercial publishing models for open science, raise the international position and visibility of cOAlition S.

2.2 National Research Funding Organisations

National Research Funding Organisations commonly have their legal background in statutory and implementing Acts. In the case of the Republic of Slovenia, it is the Act on Research and Development adopted by the National Assembly and the governmental Decision on establishing the Public Research Agency of the Republic of Slovenia. In general, the research funding organisations, as stated by their European Association (Science Europe, 2020a), Science Europe member organisations should:

(a) Have a substantial and significant impact on their national research system and budget,
(b) Be funded primarily through national public funding,

(c) Have substantial operating independence from their national government.

Each of the listed attributes can be analysed and discussed further in relation to the specific legal and governing structures, notwithstanding that the concept of substantial operating independence from the national government is discussed and mostly (mis)understood. Being funded from the national budget, the National Research Funding Organisations are, at the same time, obliged to maintain their operating independence through impartiality of the research proposal evaluation, transparency of procedures and decisions based on these evaluations, appropriate addressing of conflict of interest of all involved experts, and their need to display efficiency, meaning the appropriate speed of operating procedures.

The operating structure of research funders is anticipated as predictable in all countries, and involves three parallel structures, each performing its powers and competences: (a) The administration, full time highly skilled administrators chaired by a Director, President, or wider leadership structure, (b) The Scientific Council, in its structure assembling the highest-level scientist covering all fields of sciences and the funding mechanisms of the Institution; their responsibility is to advise, conceptualise and to act as decision-makers at different levels of research assessment processes not being directly involved in evaluations (may vary), and (c) The governing/managerial body, deciding on the operational activities of the Institution and having the power of nominating the Chair of the Institution, to be appointed by the national government or other highest-level National Institution.

The importance of National Research Funders, the waste amount of annual funds from national budget and their importance for the research community, can be illustrated well by the quote from Science Europe (Science Europe, 2020a), stating that »36 member organisations from 27 European countries are highly recognised nationally and internationally. Together, they contribute approx. €18 billion to research per year. They joined forces in Science Europe to support the best conditions for research. «

3 Regional Alliances – Active Cooperation for Bridging the Gaps

The variety for the need for regional Associations spans from learning societies to the funders. All these subjects have joined interests, and have the power that contributes to the widening of the expertise and increased visibility in the research community. Research funders have similar challenges in the unbalanced European research landscape of 28 (27) countries with very different attributes regarding economic development, scientific culture and tradition.

"Widening participation" is used to describe the need for a more balanced contribution of scientists in European research projects, both in the application and success. Indeed, the expression might be treated as a euphemism, since its message is clear: Get the involvement of those Member Countries whose performance and investment in research is below average, and they are faced with extensive brain drain instead of brain circulation. With outstanding attention, the topic of widening was addressed by the European Research Council (ERC) by the Chair of the ERC Scientific Council Working Group on Widening European Participation, Eva Kondorosi (Kondorosi, 2015). The effort of ERC led to the establishment of a "visiting Fellowship" scheme for researchers from weak participating regions to organise visits to ERC teams for a short period of time, aiming at supporting them strengthening their research ideas before applying to the ERC. The scheme was also introduced by ARRS, evidently contributing to the improved performance of researchers from Slovenia (ARRS, 2019).

3.1 The CEUS initiative - Central European Science Partnership

In 2018 a Letter of Intent was signed by CEUS (Central European Science Partnership) in which members/partners agreed to develop jointly concrete measures to stimulate and support the further cooperation and integration of research activities among the partner countries: "To do so, the partners agree to organise meetings of both the Heads of Research Councils (HORCs), as well as of office staff members, to develop and advance joint research activities among the partners." At the time of signing the Letter of Intent, possible foreseen actions included the "exchange of information on current developments in the respective national research systems, the discussion of science policy issues that are of common interest, the exchange of best practices, as well as the joint development of specific funding instruments to promote the scientific cooperation and integration among the partner countries."

The Memorandum stated the basic principle, that all actions within the partnership will be "taken on the basis of mutual consent, aiming to maximise the benefit of the co-operation for the individual partners, as well as for the scientific communities within the partner countries."

The CEUS Memorandum (CEUS, 2019), signed in Vienna in 2019 right after positioning of operative and administrative details, was much more than just an Act protocol of the Chairs of the research funders involved. Four partners agreed on high level mutuality and trust with the use of a unilateral evaluation procedure for bi- or multilateral research projects among partners: "The results of the evaluation procedure shall, subsequently, be accepted by the respective other partner

organisations, presupposed that the decision body of the partner organisation approves of the result." In ten points the memorandum offers an operative-level platform acceptable for all partners not to interfere with different national legal and other related bases (CEUS, 2019):

(1) The joint project application is submitted to one of the partners, which, as a consequence, acts as the Lead Agency. The partners agree on the principle that a partner acts as the Lead Agency for a Joint Research Project only if a substantial financial contribution to the Project is requested from this partner by the applicants. Further details will be specified separately by the partners in mutually agreed guidelines. The application must follow the application guidelines of the Lead Agency;

(2) The application consists of a joint scientific description of the project, delineating the scientific contributions of the respective partners. Cost calculations must be stated separately for each national part of the project, and must follow the guidelines of the respective National Funding Agency;

(3) Once the application is submitted, the Lead Agency informs the partner organisation of the application, and asks for a formal check of the respective national project part. If the formal criteria of one of the funding agencies are not met, the application is considered as being rejected by all funding agencies involved;

(4) The Lead Agency administers the evaluation process in accordance with its standard procedures that apply for the respective funding programme. The partner agencies agree on an international peer review procedure;

(5) The Lead Agency forwards the result of the review process to the partner organisation(s) (funding/rejection), including complete reviews and/or any other documents and information relevant to decision-making. The partner organisation(s) assure(s) the confidential treatment of this information;

(6) The partner organisation(s) present(s) the result of the review process to its decision body, and asks for the confirmation of the Lead Agency's decision. Should the decision of the Lead Agency not be followed, an explanation for this must be provided to the Lead Agency;

(7) If no agreement can be reached between the partner organisations, the application is considered as being rejected;

(8) After a decision has been reached, the involved agencies inform the applicants of the outcome;

(9) In the case of approval, project parts will be financed by the respective funding agency in accordance with its standard practices;

(10) Intermediary and final reports will be carried out in accordance with national guidelines."

3.2 CEUS Partners Profile

Regional partnerships are aimed to provide a joined platform for successful cooperation, (mostly) neighbouring countries, and to leverage the differences in size, performance and research potentials of research funders from these countries. Let us mention the well-established Nordic partnership, that works at different areas (e. g. Nordic EMBL Partnership for Molecular Medicine), the D-A-CH collaboration, the well-established lead – agency type of cross-border cooperation in the field of (also) German speaking countries (Germany, Austria, Switzerland), nonetheless, also the European Commission supported regional research infrastructure consortia like the CERIC (Central European Research Infrastructure Consortium).

The profile of CEUS partners is built by the research funding organisations from countries: Austria, the Czech Republic, Poland and Slovenia. In the preparation the Hungarian partner was involved, but due to the statuary changes and organisational positioning of that Institution, it is not involved in the membership yet. Research funders from Croatia and Switzerland also expressed an interest to participate; thus, we might experience widening of the partnership in the coming years.

CEUS partners are listed below, and the hyperlink to their latest Annual Reports for 2018 are given in the footnote. However, with differences in format and editorial approach, the Annual Reports of research funders are the most relevant and comparable documents, displaying the mechanisms, instruments and funding methods:

Austria (Austrian Science Fund (Fonds zur Förderung der wissenschafltichen Forschung, FWF));

Czech Republic (Czech Science Foundation (Grantová Agentura České Republiky, GA ČR));

Poland (National Science Centre of Poland (Narodowe Centrum Nauki, NCN));

Slovenia (Slovenian Research Agency (Javna agencija za raziskovalno dejavnost; ARRS).[1]

In 2019 the listed research funding organisations started their activities in the form of a *bilateral and/or multilateral Lead Agency* manner. (Zubascu, 2020)

[1] Hyperlings to on annual reports (2018) of research funding organisations:

FWF (Austria): https://www.fwf.ac.at/

GA ČR (Czech Republic): https://gacr.cz/en/types-of-grant-projects/

NCN (Poland): http://www.ncn.gov.pl/finansowanie-nauki/konkursy/typy?language=en

ARRS (Slovenia): https://www.arrs.si/en/obvestila/19/objava-letno-porocilo-18.asp

4 Evaluation

Evaluation of the project proposals is undoubtedly the main requisite for research funders, to build such a priority list of project proposals that demonstrate *excellence* (assessment is performed by targeted international experts, and they are selected according to documented criteria of their research funders, set predominantly by Scientific Councils; the experts follow the procedures, and must avoid bias and manage conflicts of interest; *impartiality* (proposals submitted must be treated equally, in a single blind procedure they are evaluated on their sole merits, irrespective of their origin or the identity of the applicants): *transparency* (decisions are based on clearly described rules and procedures that are published prior to the start of the process; applicants have access to adequate feedback on the outcome of the evaluation of their proposal), *appropriateness for purpose* - the evaluation processes are appropriate to the nature of the call and the research area. The evaluation process is in proportion to the investment and complexity of the work, and, *efficiency and speed* – (the evaluation process is as rapid as possible from start to finish, while maintaining the quality of the evaluation and respecting any legal framework).

Due to the imbalance and different treatment of prestige, widening of the EU and competitiveness too often measured through performances on European projects, the number of proposals and eligibility criteria becomes increasingly important.

One of the key messages of the Horizon 2020 Interim Evaluation Report (Horizon 2020, 20) says: "The large number of European research and innovation funding instruments is difficult to understand for potential applicants, and may lead to overlaps." Regional partnerships could at least partially answer this dilemma with a contribution to the distribution of target calls, and build long-lasting excellency and mutual interest research groups.

Bases of initiatives, like the already more than ten years effectual DORA (San Francisco Declaration on Research Assessment), nowadays, one of the main discussions on evaluation processes is related to the fairness and accuracy, that should not be over-reliant on publication metrics. New impact indicators are under development for the measuring success with, e. g., excluding cash incentives for publishing papers (Watson, 2020).

In July 2020 Science Europe published the Position Statement and Recommendations on Research Assessment Processes (Science Europe, 2020), empowering the research community with content in three chapters reflecting the evaluation criteria already listed above in this chapter:

(1) Approaches used to assess and select proposals and researchers

(2) Transparency of research assessment processes

(3) Discrimination, bias, and unfair treatment in research assessment practices. An important observation from the survey as a part of the of the position statement is related to the reviewers, the pivotal element on which the expert system of research funders could fall, or at least be exposed to the critical public responses: "Reviewers are generally selected based on their knowledge of the research discipline relevant to the assessment. The potential reviewer pool is reduced further by subject-specificity, multi-/inter-/trans-disciplinarily, required level of seniority (Full Professors are often required), and submission language." Furthermore, the expectations of/on researchers include peer review of publications, editorial positions, and mentoring. "This challenge is further exacerbated by a concentration of such reviewing requests targeting the most high-profile research nations and institutions."

Research funders often discuss the *reviewer challenge*. Availability of high ranking and simultaneously on-topic reviewers is rarely influenced by reimbursement of cost and scope of payment (or non-payment at all to the reviewer). Empirical evidence shows that availability is the key decision element in acceptance of the duty of reviewer.

5 Conclusion

National Research Funding Organisations have a crucial role in predictable funding of research. Their cooperation endeavour stands for continuous and internationally comparable improvements of evaluation processes, contributing to trust in the domestic research landscape, and to mutuality with other national funders, resulting in truly international research, and widening the participation and success in transnational projects and schemes.

Observations and discussions on selected cooperation schemas of national research funders joined in Science Europe demonstrate a remarkable opportunity in categories as follows:

Learning: The continuous learning for research funding organisations is a prerequisite of improvements of mechanisms and instruments; the long-term processes are not easy to change, or even modify, and when possible, must be followed by public consultations with the research community, though the new principles must be built on the continuous learning of the experts and administration, and even of the research-policy decision-makers. All this needs to be carried out in parallel with ongoing planning, evaluation and all the formal follow-up processes.

Trust: Research Funding Institutions have a certain trust at national level due, to their statutory position given by the legal background. The independence in performing the evaluations is an unavoidable prerequisite for trust at national level and in international cooperation. Government should manoeuvre transparently and in dialogue with the research community in applying their given power

(in)directly evident in nominating Chairs, Members of the Research Councils or the governing Board.

Ability to respond: Lessons learned from COVID-19 demonstrate the need for more flexibility by Research Funding Organisations. Annual and multiannual work programmes are, however, inevitable, and incorporated in the legal base of these organisations among those with the foundation-like structure and have more flexibility according to those tied directly to the national budgets.

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Using Lean Principles in IT Project Management as a Response to Market Needs – Case Study of Croatian IT Companies

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Abstract. *The dynamic and challenging market in which IT companies are operating requires continuous improvements in processes, in order to adequately respond to market needs. When it comes to IT projects, traditional project management methods are being rapidly changed with lean and agile methods that enables more flexible and customer-oriented approach to project management. This paper brings overview of main characteristics of traditional and lean project management methods, with the emphasis on using lean methods to respond to market needs. Theoretical assumptions are then applied to a case study of two Croatian IT companies that applies lean methods in their project management practices. Finally, the paper summarizes main benefits of applying lean principles in IT project management and stresses the main challenges companies are facing.*

Keywords. IT project management, lean principles, market needs

1 Introduction

In today's business and project environment, companies face a number of obstacles. Turbulent environment, high speed of technology change, time limits are becoming shorter, budgets are becoming more complex and other external factors pose daunting challenges to businesses. (Wysocki, 2009, p. Xli; PMBoK, 2013, p. 10). Project management enables companies to implement a specific project in an efficient and effective way in order to meet the set goals. With the help of appropriate project management methods and techniques, companies can create added value for their customers or clients, achieve various benefits, but also become more competitive in the market. Therefore, it can be said that projects and project management are one of the important assets to a company's success (PMBoK, 2017, p. 10).

The project environment is becoming more dynamic. New technologies are emerging, customer requirements are more numerous and demanding, companies are under constant pressure to deliver final results, taking into account the highest possible level of quality with minimal use of resources, competition is growing etc. (Salameh, 2014, pp. 52 and 71). In such a dynamic and turbulent environment, IT project management practices are experiencing a shift from traditional to agile and lean.

Agile project management (hereinafter: APM) is a dynamic approach to project management, software development and implementation. This approach has gained in popularity due to its adaptive nature and orientation to all participants in the project cycle. APM allows changes and modifications to be incorporated into the overall project plan at multiple points. (SCRUMstudy, 2013a) In APM, project features are formed according to its requirements using numerous iterations in the form of reducing and removing uncertainty. Therefore, this approach to project management is more prone to higher risk compared to traditional projects. However, the agile approach has more flexibility, so it is easier to adapt to all project changes (Fernandez, Fernandez, 2008, p. 15).

This paper put focus on a specific form of modern approaches to project management called lean management. Lean project management characteristics, principles and ecosystem elements are explained in chapter 2. Chapter 3 brings case study on the implementation of lean project management practices in two Croatian IT companies, followed with the discussion and conclusion.

2 Lean Project Management

There are numerous projects that were not implemented on time or within the budget or according to client requirements, which required additional investment of various resources. Furthermore, the oscillations resulting from the constant changes in the

requirements of clients and other project participants also have a significant impact on the project process. Additional costs are created, deliveries of final results are delayed, which greatly affects the quality and safety of the project (Locatelli, Mancini, Gastaldo, Mazza, 2013, p. 776; van Assen, 2018, p. 1312-1314). To avoid the aforementioned problems, the lean methodology is used in practice.

When it comes to the lean methodology, it describes a synchronized system that contains key elements for providing products and services, at minimal cost, in order to meet precisely defined customer wishes. When it comes to customer wishes, it includes high quality products and services, a specific quantity of the same with delivery at the time and place that the customer wants (Slack, Brandon-Jones, Johnston, 2013, p. 465). According to the previous definition, lean management is defined as a just-in-time philosophy. In other words, the customer is delivered the required quantity of product or service at the required time and the required location. The main feature of the just-in-time philosophy is that it is based on reducing everything that does not create added value for the client for which he is willing to pay (Reid. Sanders, 2013, p. 231)

2.1 Lean Management Characteristics

To avoid the aforementioned potential problems, the lean methodology is used in practice. The main feature of lean is to identify and minimize obstacles through the four main elements (Locatelli et al., 2013, p. 776):

- A focus on quality in a way that minimizes alterations by creating a good business plan
- Customer focus which is achieved by eliminating those activities that do not create added value for the customer.
- Reducing waiting times, as an element, takes into account the involvement of suppliers in planning and delivery. Specifically, this approach makes great efforts to involve suppliers in project planning and process in order to minimize variability. According to lean reasoning, supplier involvement is crucial to deliver materials on time with minimum cost and maximum value to the customer.
- The last element, the creation of a continuous flow, refers to the availability of the necessary resources and components, when and where they are needed.

According to Žvorc (2013, p. 697) lean methodology, compared to the traditional one, is more dynamic, its procedures are simplified and more adaptable. Its most important feature is that quality is sought to be ensured from the very beginning, i.e. in advance in every process and design of a product or service in accordance with the needs of customers. Furthermore, the foundation of this method is teamwork. According to lean thinking, employees are the greatest value of a company that is not guided by a strict hierarchical structure or a rigid division of tasks but their potential is stimulated in a number of ways. It is also interesting that any mistakes are not seen as a problem but as the next step towards finding possible solutions. Lean management is project-oriented, which means that new solutions can be realized by forming a new team by implementing a new project.

Furthermore, Ballard and Howell (2003, p. 122) state that the characteristics of the lean approach are a focus on the production system, transformations, the flow of information, and the achievement of goals. It is important to mention that the lean approach is characterized by teamwork, but also the involvement of a larger number of people and the level of organization in the decision-making process. Likewise, the production process and the final result depend on each other and are therefore defined together just like all phases of the product life cycle. Activities are performed at the agreed time, systematic efforts are made to reduce delivery time in the chain, the emphasis is on continuous learning. In the end, stakeholder interests are aligned.

In essence, the lean methodology seeks to minimize the large variability that affects projects. Reducing variability using lean thinking is achieved through a pre-defined planning system to ensure the most reliable flow of work with materials, information, equipment and people. This reduces the overall risk, especially in the case of interconnected projects, where the delay of one project affects another. Furthermore, one of the features of lean thinking is the cooperation of all parties and quality control in the construction phase. In conclusion, the lean approach aims to optimize the overall project process taking into account how each individual activity affects the next. Using this approach, it is possible to achieve better projects (Locatelli et al., 2013, p. 776).

2.2 Lean Management Principles

The principles of lean thinking are closely related to the definition and characteristics of lean methodology itself. Accordingly, lean management is guided by five basic principles, which are (Thangarajoo, Smith, 2015, p. 2; O'Rourke, 2005, p. 9):

- Precisely defining the value of a particular product or service,
- Identifying the value flow of each product or service,
- Uniform and continuous flow of values (production, materials and information),
- "Pull" approach by customers, i.e. withdrawal of the value of the product or service throughout the production process and at the very end
- Striving for perfection through the elimination of "waste".

In the form of the principle of lean thinking, attention should also be paid to the approach of 8Ps.

The "8P's Lean Business System" approach should overcome the shortcomings of classical principles and mitigate or even eliminate the problems faced by each principle: purpose, people, process, pull, prevention, partnering, planet and perfection (Hinesu, 2010, p. 4).

2.3 Lean Ecosystem Elements

According to E. Gabriel (1997, p. 209), the basic elements of the lean approach to project management come from two sides, namely the clients and the project team. Clients represent a third-party sponsor or agent who expects the requirements or expectations to be met on the basis of the contract. The client should be present, along with the project team, throughout the project implementation process, and should have a certain level of power when deciding on future activities and steps. On the other hand, the project team consists of a group of professionals who define, plan, implement and control project processes in the form of meeting customer requirements at the lowest possible cost.

3. Case Study of IT Companies in Croatia

The research aimed to gain insight into the practice of lean project management and how its application affects the final result. In other words, the research aims to provide answers to how companies deal with the obstacles that project implementation brings, using lean approaches in IT companies. This chapter brings results of two case studies from Croatian IT companies.

3.1 Case Study Methodology

The participants in the research were project managers of two Croatian IT companies. The case study was conducted using a semi-structured interview where all questions were open-ended (Brinkmann, Kvale, 2015). The interviews were conducted during July 2020. Before the interview, participants were presented with a "Research Participation Consent Form" which included all information about the research.

The interview consisted of three blocks of questions:

- The first block were questions related to basic information about the respondents' companies and their position,
- The second block included questions related to project management in these companies, and
- The third block were questions related to the realized and/or actual project according to the selection of respondents with the purpose of a more detailed understanding of the agile and lean principles.

3.2 Project Management in IT Companies

In the companies that participated in this study, project manager (further: PM) was the one who was at the head of the project. For a project to be realised successfully, the PM needs to work with the project team. From the interviews with PMs, the structure of the project team is almost the same in all cases. Basically, the main roles are chief consultant/PM and lead developer. Other roles depend on the type of the project at hand. Accordingly, there could be designers, testers, system architects, etc. In one company PM explained that cooperation depends on strategic importance of the project and its impact on the organization. In practice, that means there are situations in which PM works more with a technical account manager (TAM), key account manager (KAM) and a sponsor in the case there are more active projects for a strategic partner.

In project management, most used methods are hybrid methods. Specifically, the method used depends on the project. When it's the small or core projects/solutions in question, where all or almost all requirements are known, then traditional methods such as the waterfall method are used. In projects/solutions that are more creative, innovative and custom, the agile methods are mostly used.

Considering the project management ecosystem, fulfilling the project purpose and achieving partnership are the most considered elements. It is extremely important to have a purpose that is found by answering the questions like "why is this solution being developed" and "in which way will it fulfil clients and company's needs". Partnership is another interesting aspect to which great consideration is given, because companies are not looking to provide a one-time solution, rather they aim to become a reliable partner in which the client can have confidence for future cooperation. Beyond these two elements, during project management it is important to keep track of human resources, i.e. the project team as well as preventing redundant tools and processes.

The biggest obstacle to adequate project management is a fast-paced environment. For a company to stay competitive on the market, top management needs to ensure either online or internal employee education. Additionally, planning resources with limited budgets and project specifications make project management more challenging. To mitigate the impact that these things have on business, companies use many different tools such as Azure DevOps, Jira, DataStudio etc.

Furthermore, it is important to point out how crucial the transparency in project management really is. Top management have to be informed all the time and oversee all project activities on the organizational level from the commercial or internal project aspect, as well as provide support and inspire initiative for the collective benefit. Besides top management, clients also need to be informed about all processes at all times

so there aren't any unnecessary expenses and resource usage.

3.3 Project Implementation According to Agile and Lean Approach

During project initiation, economic, legal, operative and technical aspects of the project are first considered. In the pre-sales phase, all named aspects are considered and graded, and a decision about further steps is made (ideal solution, work assessment, offer). In the project planning phase, it is important to define the way in which the project will be managed and its sustainability. Project scope combines defining project scale, length and depth. Project length and scale are decided with regard to deadlines and resource availability, while project depth depends on many different parameters, what makes it the most challenging part in the first phase. In the next phase, companies define and identify project goals and participants. It is of the essence to define the project team, stakeholders, specifications, activities and deadlines, which are the prerequisites for a successful project realisation.

In practice, it is important for project goals to be specific, measurable, achievable, relevant and timely (SMART). Additionally, goals need to be formed in a way so that they encourage collaboration. In other words, project goal needs to be formed in a way that benefits not only clients, but all participants. After the project goals are set, the project plan can be created. It contains details on all important parts of the project - goals, linked documents, project organization (roles, change, quality and risk management, communication, resource planning, metrics for success measurement ...), project phases, activities etc. PMs have said that employee suggestions on processes, tasks and activities during project realisation are always welcome and that cooperation is very important.

During project development, companies stand by the idea that the project must be aligned with company strategies. Most important factors in project development are control, oversight, communication, reporting and timely interventions.

Progress oversight and control of project performance is a key step in every project. It encompasses employee schedule monitoring, capacity availability and time constraints. By usage of many different tools and metrics (such as MS Project, Azure DevOps, DataStudio) that work is greatly diminished. Also, the project lead must inform all superiors about projects progress during the entire project lifecycle. This phase spans the entire project, so if there should be some obstacle, it can be eliminated with no unnecessary overhead.

By the end of the project, the project's *post mortem* recapitulation is done, with the goal of recognising the mistakes that were made and learning from them as well as promoting the opportunities that were shown as impactful on the project realisation and have impacted its efficiency and quality. The results are presented to all participants. After the presentation, user satisfaction is measured, because it is the basis for further decision-making with the goal of continuous product or service improvement. One of the most important steps in the end is creating the historic data database, with the goal of keeping track of mistakes, so that they aren't repeated in the future.

4 Discussion

Project-oriented companies face numerous obstacles - the specificity of the project, unrealistic customer requests, redundant processes ... In this case, lean management, more precisely lean thinking is often used in companies. To meet customer requirements, the focus is on minimizing alterations by creating a detailed business plan. Also, great emphasis is placed on the continuity of the process and the minimization of the unnecessary ones. An important element are project teams whose task is not only to do a good job and create added value for the client but also to propose changes to processes and activities in case they are irrelevant.

The principles of a lean approach are present in practice although most companies are not aware of it. Continuity related to the detailed definition of the final result through value or processes is the foundation of everyday business. Likewise, companies pay great attention to removing unnecessary processes and tools that do not create added value.

Considering the lean project management ecosystem, the case study shows that third parties are an important element of project management. To meet the expected requirements and make appropriate decisions, their presence throughout the process is greatly required.

5 Conclusion

This paper presents the idea that lean methodologies are used in practice as more of a philosophy then a set of rules. It is in companies' interest to satisfy the needs of their clients as well as preventing additional costs that can emerge from redundant processes. In the interview with the PMs, it can be discerned that lean thinking is very much present in today's business. Great measures are taken to satisfy all participants, and aspiration for perfectionism is seen in usage of special tools, metrics and techniques to reduce redundant processes that bring no value to the client. Although tools are important, the main factor is considered to be partnership, as one of the principles of lean thinking which is not represented as much in other methodologies. Finally, lean methodology is a philosophy through which companies get a good

foothold for satisfying the market's needs. Because of its simple structure, lean methodology can be made to fit any project.

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Assessing Digital Transformation Readiness Using Digital Maturity Indices*

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***Abstract**: Digital transformation and continuous scientific and technological progress allows for increased efficiency in agriculture, animal husbandry, as well as faster and safer food distribution. Monitoring digital maturity is important. It allows us to understand the current state and outcomes of digital transformation. It also facilitates the creation of future steps towards digital progress. This paper explores the notion of digital maturity of countries and the indices used for it with a focus on agriculture. The paper seeks to identify indices by which countries can view their digital maturity, with the aim of further creating adequate policies. Given the importance of the transformation process, the structure of the index was considered in order to determine connections with the main determinants of digital transformation, especially concerning agriculture.*

Keywords. Digital transformation, digital maturity, digital maturity index, agriculture

1 Introduction

Growing competition, which is the result of meeting the growing and more complex market needs, requires new ways of working and creating new value for end users. At the same time, entities consider technological solutions that facilitate communication and that enable the inevitable connection of supply and demand in the market. The sequence of market events and the transition to the fourth industrial revolution (Industry 4.0) has resulted in the emergence of a new paradigm called digital transformation (DT).

It is slowly affecting all industrial areas. Progress in DT is also being made in the agricultural sector through the application of technologies such as the Internet of Things (IoT), Big Data, Cloud Computing and Artificial Intelligence (López-Morales, Martínez & Skarmeta, 2020). The mentioned technological changes require a certain commitment from countries in creating a basis for digital investments and for improving the business climate.

The process of digital transformation is permeated by multidisciplinary activities and requirements (Colli et al., 2018) that include the application of digital technologies to business processes, organizational assets and end products (Jovanović, Dlačić & Okanović, 2018). DT represents significant changes in the current way of doing business such that it changes the form of current business models. In line with the above, the importance of a strategic approach to digital transformation that requires the involvement of various stakeholders inside and outside the organization (de Carolis et al., 2017), which will timely and successfully face current market changes, has been emphasized. Consequently, countries are expected to digitize public administration through web services and other digital services for citizens and entrepreneurs (Tomičić Furjan, Žajdela Hrustek & Pihir, 2018). This in turn creates a stimulating climate for the development of the digital skills necessary to overcome the challenges and barriers in digital transformation (Kutnjak & Pihir, 2019) and establishes a dynamic ecosystem that stimulates quickly adaptable, agile and innovative organizations. The level of digital maturity of a country can be examined by an index. It indicates the readiness of a country to support the digital transformation of companies that operate in it. Namely, if public policies/services are at a high level of maturity, then the transformation is being facilitated and it is more likely that organizations, and consequently the countries in which they operate, will digitally transform more easily.

The complexity of integrating new business models into the established business processes of an individual organization depends on the industry the organization operates in, as well as on the readiness to apply the transformation process in the same industries (Kutnjak, Pihir & Tomičić Furjan). In order for the DT strategy to be adequately and optimally defined, it is possible to see at what stage individual organizations and countries are in terms of their level of maturity.

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Maturity models provide an overview of the situation within an individual entity, and point out areas where additional efforts need to be directed in order for the result of the transformation to be as effective as possible (Schwere et al., 2018).

The aim of this paper is to identify the importance of digital maturity of countries; therefore, the following research questions are asked: RQ1 = What digital maturity indices globally are considered relevant at the country/national level and to their national economies? RQ2 = Can a country's digital maturity index adequately indicate readiness for the digital transformation of organizations in that country? RQ3 = Are there digital maturity indices that indicate the maturity or readiness of a country for the digital transformation of agriculture?

This paper is structured as follows. The introductory part is followed by a presentation of the methodology. The concept of digital maturity is generally presented in the third section. In the fourth chapter, digital maturity in agriculture is highlighted. Chapter five provides an overview of the digital maturity of countries and of the digital maturity index. The connection of the index with the determinants of digital transformation is shown in section six and the findings related to the researched topic are given at the end of the paper in the conclusion.

2 Research Methodology

The process of obtaining answers to the research questions began with a literature review of published scientific papers. Papers were searched for in the relevant databases including Web of Science (WoS), Scopus and Google Scholar for better coverage. The search was made based on two sets of queries: 1) related to research question RQ1 and partly RQ2 with the aim of learning about digital maturity and competitiveness ("digital maturity" OR "digital competitiveness"); 2) related to research question RQ2 and RQ3 aiming to find research about digital maturity, agriculture, Industry 4.0 and digital transformation ("digital maturity" AND "agriculture" AND "industry 4.0"), and ("digital transformation" OR "digital maturity" AND "agriculture"). The research structure and the numbers of selected papers from individual sources, are given in Table 1.

Table 1. Research structure

Source	Search method	Selected papers
WoS	"digital maturity" OR "digital competitiveness"	5
Scopus		6
Scholar		8
WoS	"digital transformation" OR "digital maturity" AND agriculture	6
Scholar	"digital maturity" AND agriculture AND "Industry 4.0"	7
Total		32

In accordance with the above, the literature review is based on the analysis of the selected 32 papers that are relevant to the topic of digital maturity in general, digital maturity of organizations, digital maturity of countries, and the digital maturity of agriculture. In addition to the research shown above, an analysis and review of available indices that examine digital maturity in general and the digital maturity of the agricultural sector were performed.

3 Digital Maturity – Literature Review

The era of digital transformation requires measuring the success of digital performance by organizations and countries in order to see their maturity in dealing with this paradigm. In defining maturity, the literature (Remane et al., 2017) cites two significant concepts: digital impact, which denotes the impact of DT on an organization or country; and digital readiness, which indicates the readiness of an organization or country to overcome upcoming changes. The effects of investing in digital transformation are considered under different methodologies that assess the digital maturity of entities (Pihir, Tomičić-Pupek & Tomičić Furjan, 2018). In general, maturity represents to which degree of completion the desired transformation has been achieved, i.e. the way to achieve certain progress that is of interest and in accordance with the previously set goal (Remane et al., 2017). Digital maturity in turn represents the ability of an entity to respond properly and adapt to a changing digital ecosystem. Entities mature with varying intensity by implementing different transition activities from one stage of maturity to another, up to the moment of full utilization of the digital environment (Mettler & Pinto, 2018). Inevitable technological changes and an increasing amount of knowledge are considered to be the drivers of economic growth. Given that the changes brought about by DT reflect on society as a whole, the task of the manager is to network the organization and society in order to respond to customers' needs (Colli et al., 2018). The diversity of organizations, in terms of their way of doing business, requirements and goals, influences how a transformation plan is defined. It is adapted to the context in which the organization operates (Schwere et al., 2018) and is characterized by uniqueness with respect to the area of implementation (Valdez-de-Leon, 2016). In line with this, we can talk about differential ways of perceiving digital maturity within different organizations and defining their maturity model. The authors (Valdez-de-Leon, 2016) state that there is insufficient readiness and an unclear

path of transformation within telecommunications service providers. Therefore, they have access to maturity models that allow them to position themselves within the current level of maturity, and also to define a plan to advance to a higher level. Production organizations digitize functions within their processes (Colli et al., 2018), (Schumacher, Erol & Sihn, 2016) and introduce innovative services based on collected and analysed data (de Carolis et al., 2017). The health sector looks at ways in which patients can be involved in health service planning and delivery (Meinert et al., 2018) and analyses the extent to which health facilities use technology to improve the patient experience (Mettler & Pinto, 2018). This allows organizations to acquire a certain level of maturity. Educational institutions promote more flexible and creative ways of learning and teaching. They strengthen teachers' digital skills and competencies (Sotiriou et al., 2016) by creating virtual teaching materials whose accessibility extends beyond classical classrooms (Towndrow & Fareed, 2015). In addition, digital maturity is reflected in the readiness to adopt information and communications technology - ICT (Đurek, Begičević Ređep & Divjak, 2017) in areas relevant to the overall business (Đurek, Kadoić & Begičević Ređep, 2018). Organizations whose business is in the field of water services and supply place emphasis on the adoption of new business practices, i.e. virtual offices, conferences and new ways of marketing products to end users (Heinze et al., 2018). Furthermore, public institutions (Pavaloaia, 2019) show a high degree of maturity for the acceptance of ICT. The application of ICT leads to the strengthening of knowledge, skills and abilities of employees, and consequently to an increase in economic productivity. The need for a high level of maturity is also emphasized in the IT departments within organizations (Isaev, Korovkina & Tabakova, 2018) so that they are optimized and ready to provide adequate support to other sectors within organizations. Digital technologies affect all economic spheres and society as a whole and affect changes in the way of life and work of individuals. The availability of technologies enables the transformation of individuals, organizations and the economy (Stoica & Bogoslov, 2018). Within the framework of the fourth industrial revolution, emphasis has been placed on the notion of countries' technological competitiveness and their success in advocating and applying digital technologies with the aim of achieving economic prosperity and general progress (Weresa, 2019). The importance of establishing strategies for the integration of new technologies in the domains of economics and civil society is increasingly emphasized in developed countries (Đurek, Begičević Ređep & Divjak, 2017), which shows willingness to participate in the digital economy. Over the last few years, the literature has provided an overview of various measures of national performance based on indices intended to measure the economic development of a country (Jovanović, Dlačić & Okanović, 2018), and that measure a country's competitiveness, innovation and readiness to accept digital technologies and new ways of thinking and action. The importance of social inclusion in the digital economy and gaining appropriate knowledge and skills to support the use of digital technologies has been emphasized (Stoica & Bogoslov, 2018).

4 Digital Maturity – The Current State in Agriculture

Given the lack of papers related to the digital maturity of agriculture, additional research was conducted to identify the current state of maturity in the sector. Namely, one of the ways to improve the digital progress of the country and achieve a higher level of maturity is certainly the creation of policies that will be suitable and stimulating for the agricultural sector (Trivelli et al., 2019), (López-Morales, Martínez & Skarmeta, 2020). For example, the United States publishes publicly available agricultural datasets (Nolet, 2018) that can further benefit entrepreneurs in developing technologies and adapting their business to climate conditions. Australian policies (Nolet, 2018) are aimed at strengthening the agricultural sector by advocating for the application of digital technologies (Cho, 2018), and at providing financial assistance to agricultural start-ups. In the maturity model of the agricultural sector predictive and prescriptive analytics are emphasised as important aspects (Nolet, 2018). The application of such analytics enables big data management, the implementation of ERP systems in farms, the integration and analysis of data (Soosay & Kannusamy, 2018), the use of artificial intelligence, and integration and the exchange of data among farmers. All of this ultimately leads to learning and innovation in agriculture (Ingram & Maye, 2020). Although countries recognize the importance of investing in digital agriculture (Karacay & Aydın, 2018) to increase digital maturity in general, there are barriers (Cho, 2018) that result in agriculture and other industries lagging behind (Zhang et al., 2019). Some of the main barriers include the lack of access to telecommunications and internet infrastructure (Nolet, 2018), (Ciruela-Lorenzo et al., 2020), slow internet connectivity, lack of publicly available data that is usable (e.g. on climate change, soil, environment) (Brohm & Klein, 2019), (Soosay & Kannusamy, 2018), low level of digital literacy among farmers for the adoption of digital technologies (Trivelli et al., 2019), high representation of the elderly population in the mentioned sector, lack and aversion to apply decision support tools (Ingram & Maye, 2020), etc. These barriers certainly are reasons for the low level of maturity of the agricultural sector (Cho, 2018) and reasons for the inequality relating to agricultural activities in agricultural organizations. Although at early stages countries have recognized the importance

of investing in agriculture and are beginning to see the opportunities (Karacay & Aydın, 2018), (Assante et al, 2018) provided by digital technologies to make the agricultural sector more successful and economically viable (Ciruela-Lorenzo et al., 2020), (Triantafyllou et al, 2019), (Triantafyllou, Sarigiannidis & Bibi 2019), it can be concluded that concrete measures for monitoring good practices and the development of countries are necessary for monitoring their digital performance (Jovanović, Dlačić & Okanović, 2018). Given the still relatively small number of comparable parameters for measuring countries' performance and achievements (Weresa, 2019), various stakeholders have created indices that measure precisely their ability to adopt digital technologies, or their willingness to accept them in general. Several relevant and currently available indices have been developed and are described later in this paper. They are guided by the idea that ICT "is not just a separate economic sector, but the infrastructure of all modern economic systems" (Stoica & Bogoslov, 2018), which certainly positively affects a country's performance. In addition to indices that measure the digital maturity of countries in general, the paper also investigates the existence of a digital maturity index for the agricultural sector within a particular country.

5 Results – The Digital Maturity of a Country (Digital Maturity Indexes)

Digital transformation is a generally accepted paradigm that is rapidly, and under changing market conditions, taking root in the lives of all stakeholders. Digital technology and its possibilities have been used by individuals in everyday life; in the operations of organizations, in creating new values for end users, and it does not bypass the highest state/national bodies. National policies and the connected bodies are those who must ensure the smooth utilization of their capacities in the context of the fourth industrial revolution, i.e. they occupy the market and affect stakeholders on the supply and demand sides. Measuring digital performance by countries and their governments is important to assess their current position and determine the level of digital maturity. It also contributes to defining future policies that will focus on improvements in poorly covered areas. The developed metrics, that measure technological factors, macroeconomic factors and institutional environment for the purpose of monitoring the economic progress of countries correspond to the indices. Some of the identified digital measurement indices are presented later in this paper. The systematization of results allows for a review of eight selected digital indices. Seven of them monitor the digital maturity of countries in general and one index monitors the digital maturity of the agricultural sector within a country. For each index, the description and scope are provided, as well as information on its creator. This in turn provides the answer to the RQ1 related to the identification of relevant indices of digital maturity of states. In addition, an analysis of the coverage of the indices in line with the determinants of digital transformation was conducted (Pihir, Tomičić-Pupek & Tomičić Furjan, 2018) in order to see to what extent a certain index satisfies the basic concepts of DT.

5.1 Digital Economy and Society Index (DESI)

DESI (European Commission, 2019) is a composite index that summarizes indicators of European digital efficiency and competitiveness. It includes 30 relevant digital performance indicators measured from **five areas (dimensions)**: connectivity, human capital, use of Internet services, integration of digital technologies and digital public services.

5.2 Networked Readiness Index (NRI)

NRI (Portulans Institute, 2019) is a holistic framework that allows for the assessment of the multiple impacts of ICT on society and on the development of national economies. It considers the application of ICT and how to use it for the development and competitiveness of countries. The NRI was renewed in 2019 and is based on **four pillars**: technology, people, governance and impact. The NRI framework states that the ability to integrate people and technology into governance structures is a necessary condition for a collective prosperous future.

5.3 Digital Adoption Index (DAI)

DAI (World Bank, 2016) is a composite index created to measure the speed of technology adoption and technological solutions by global countries. It enables the assessment of the digital and technological maturity of countries and looks at the extent to which technologies have been adopted in the following **three segments**: people, business/companies and government.

5.4 Digital Readiness Index (DRI)

DRI (Cisco Systems, 2019) looks at how individual countries are reaping the benefits of digitalization and how a country has progressed in terms of its digital maturity. It enables the identification of strategic forces affecting countries and directs them to improve the overall digital readiness. The index identifies key investments that as such help countries on the path to progress towards better digital readiness. It is a holistic approach that looks at **seven components** of digital readiness: basic needs, human capital, ease of doing business, business and government investment, the start-up environment, technology infrastructure, and technology adoption.

5.5 The Digitization Index (DiGiX)

DiGiX (BBVA Research, 2019) summarizes indicators regarding the degree of digitization and the digital impact on observed countries. It analyses the factors, and the behaviour of economic stakeholders and institutions in order to observe the use of ICT and their direction towards achieving competitiveness and overall well-being. It is based on **six dimensions**: infrastructure, adoption of ICT by users, adoption of ICT by the organization, adoption of ICT by the government, costs and regulations.

5.6 Global Competitiveness Index (GCI)

The GCI (World Economic Forum, 2019) is an indicator of total factor productivity and the portion of economic growth regarding the drivers of productivity, growth and human development in the era of Industry 4.0. It analyses the way in which labor and capital are successfully combined in order for countries to achieve prosperous results. It consists of a total of 103 indicators. These indicators are divided into **twelve pillars**: institutions, infrastructure, ICT adoption, macroeconomic stability, health, skills, product market, labor market, financial system, market size, business dynamics, and innovation.

5.7 Doing Business (DB)

DB (World Bank, 2019) is a set of quantitative indicators on business regulation and the protection of property rights. It considers regulations that affect the improvement of business activity or that limit it. The relevant regulations for the index are organized in the following **eleven domains**: starting an organization, obtaining building permits, obtaining electricity, registering property, obtaining a loan, protecting minority investors, paying taxes and levies, cross-border trade, enforcing contracts, insolvency resolution and labor market regulation. The indicators are used to analyse economic outcomes and to identify necessary reforms within the business environment.

5.8 Digital Maturity Index and Assessment Tool for the Agricultural Industry

The mentioned global digital maturity index is focused on agriculture (Zhang et al, 2019). It includes the following **five pillars**: strategy and culture, capability, data rules, data & analytics, and technology. The index enables the agricultural sector and its participants to assess the current level of digital maturity, to examine their own strengths and weaknesses, and serves as a kind of assistance tool in creating initiatives aimed at improving digital efficiency in the sector. In addition, it provides the agricultural industry with a basis for a systematic review and for the development of a digital strategy in order to make agriculture purposeful and influential in a competitive market.

6. Results - Assessment of maturity in relation to the determinants of digital transformation

As basic determinants of DT, the authors (Pihir, Tomičić-Pupek & Tomičić Furjan, 2018) state:

a) Strategy orientation (guided by a defined vision, leadership and adequate management)
b) Customer centricity (monitoring and forecasting customers' needs)
c) ICT and process infrastructure (adequacy of resources and business process management)
d) Talent, capability and capacity strengthening (investment advocacy with a focus on improving the knowledge and skills of human capital)
e) Innovation culture and organizational commitment (advocacy and application of innovation culture)

The mentioned DT determinants were placed in the context of connecting the identified indices of digital maturity of countries. In this way, an assessment was made on the extent to which each index describes the basic determinants of digital transformation. It was found that digital maturity indices can indicate readiness for digital transformation in organizations in a given country. This in turn answers the RQ2.

It can be concluded that the Networked Readiness Index and the Digital Readiness Index fully cover the domain of DT and its determinants because they overlap in key areas regarding the assessment of the digital maturity of countries with DT determinants. The Global Competitiveness Index covers four of the five determinants of DT without considering the strategic orientation of organizations. The Digital Adoption Index and the Digitization Index each cover three determinants, and it can be seen that none of the mentioned indices in their measurements look at the talents, knowledge and skills in promoting DT within organizations. The Digital Economy and Society Index is fully oriented towards the user's use of digital technologies and considers the technological aspects of countries, while Doing Business is a strategic indicator whose orientation is focused on the organization and legal regulations that enables entities to conduct business activities. Finally, the Digital Maturity Index and Assessment Tool for the Agricultural Industry covers three determinants of DT. It is not customer-oriented and does not follow the area of innovation. Instead, it focuses on data and on the adequate management and use of knowledge concerning data (shown in Table 2). By identifying and evaluating an index focused on the digital transformation of agriculture, the answer to the RQ3 was determined.

Table 2. Systematization of indices aimed at measuring the digital effects on countries

Index	Index creator	Key DT determinants
DESI (European Commission, 2019)	European Commission	
NRI (Portulans Institute, 2019)	World Economic Forum	
DAI (World Bank, 2016)	Microsoft & World Bank	
DRI (Cisco Systems, 2019)	Cisco Systems, Inc.	
DiGiX (BBVA Research, 2019)	Banco Bilbao Vizcaya Argentaria	
GCI (World Economic Forum, 2019)	World Economic Forum	
DB (World Bank, 2019)	World Bank	
Digital Maturity Index and Assessment Tool for the Agricultural Industry (Zhang et al., 2019)	CSIRO	

From the above it can be concluded that the defined digital strategies of a country represent the starting points for ensuring the equal participation of organizations in the digital world. This enables a set of policies whose direction should ultimately contribute to the growth of digital maturity in the economy. This set of policies would contribute to the general spread and availability of the Internet, the availability of infrastructure for partially or fully online business of organizations, and the climate for promoting the development of citizens' digital literacy. Therefore, the backbone of the digital strategy of a country would allow for a democratic system of equal participation where all entities are able to take part in a ubiquitous digital world.

7 Conclusion

The speed of technological change has a significant impact on society as a whole and on the creation of new trends. New technologies are becoming more accessible than ever, and organizations are realizing their importance in business. The fourth industrial revolution and the emergence of digital transformation pose new challenges to organizations, and to the entire ecosystem in which they operate.

In this paper, emphasis is placed on the importance of perceiving DT and new technological changes in countries. A literature review identified eight relevant indices, by which countries can measure their maturity in dealing with new market trends. The identified indices define areas of particular emphasis in which efforts need to be focused on in order to make a country's final results as competitive as possible, depending on the domain to which the indices relate. Furthermore, the paper examines the structure of indices and their compliance with the main determinants of DT. Apart from considering indices that look at digital maturity in general, an index aimed at measuring the maturity of the agricultural industry has been established. The mentioned industry is in the initial phase of digital maturity, which signifies that it is recognized for its potential in digital development. Although there are currently a number of barriers to initiating transformation, an adequate national policy aimed at the development of the agricultural sector would enable a culture of advocating innovation, and accordingly, transformation. Certainly, digitally mature countries (i.e. those that are ready to adapt their policies to current market trends) create opportunities in order to achieve their own global competitiveness, which facilitates the path to their own economic development and competitiveness.

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- References

All printed material, including text and figures, must be kept within a print area of 16 cm (6.3") wide by 24.7 (9.7") high. Do not write or print anything outside the print area. Paper size is A4: 21x29.7 cm (8.3x11.7"). Margins (top, bottom, left, right) are 2.5 cm (1"). All *text* must be in a two-column format. Columns are to be 7.7 cm (3") wide, with a 0.6 cm (0.24") space between them. Text must be fully justified. Indent each paragraph by 0.5 cm (0.2").

The final submission has to be submitted in a single PDF file with all fonts that are used embedded, and also the source file (Microsoft Word, LaTeX - zip original files and images).

4 Main Title

The main title (on the first page) should begin 3,5 cm from the top edge of the page, centred, and in Times 18-point, bold face. Capitalize the first letter of nouns, pronouns, verbs, adjectives, and adverbs; do not capitalize articles, coordinate conjunctions, or prepositions (unless the title begins with such a word). Leave a blank line after the title.

5 Author Name(s) and Affiliation(s)

Author names and affiliations are to be centred beneath the title and printed in Times 10-point type. Author names should be in bold face. Multiple authors shall be grouped by affiliation as shown in the title above. Include also e-mail addresses in 9-point `Courier/Typewriter` face. Follow the author information by two blank lines before main text.

6 Type-style and Fonts

Wherever Times is specified, Times Roman or Times New Roman may be used. If neither is available on your word processor, please use the font closest in appearance to Times that you have access to. Please avoid using bit-mapped fonts if possible. True-Type 1 fonts are preferred.

Also make sure that all fonts in the final PDF file are embedded. Thus we strongly encourage the use of Latex especially if you use non-standard fonts for formulas for your examples. You can make sure that your fonts are embedded by opening the PDF file in some PDF viewing program and taking a look at the properties of the document.

7 First-order Headings (May Extend to the Next Line)

For example, “1 Introduction”, should be Times 14-point boldface, initially capitalized, flush left, with two blank lines before, and one blank line after.

Don't use periods (“.”) after the heading number, use them only in lower order headings to separate them from higher order headings. For *long* headings use *a hanging indent* aligning the text to the right of the heading number as shown above.

All paragraphs in the text should be indented except for the first paragraph in a section.

7.1 Second-order Headings (May Extend to the Next Line)

As in this heading, they should be Times 12-point boldface, initially capitalized, flush left, with one blank line before, and one after. Use a hanging indent for long headings.

7.1.1 Third-order Headings (May Extend to the Next Line)

Third-order headings, as in this paragraph, are discouraged. However, if you must use them, use 10-point Times, boldface, initially capitalized, flush left, with one blank line before, and one after. Use a hanging indent for long headings.

8 Main Text

Type your main text in 10-point Times, single-spaced. Do not use double-spacing. All paragraphs should be indented 0.5 cm (0.2") except for the first paragraph in a section.

Be sure your text is fully justified—that is, flush left and flush right. Please do not place any additional blank lines between paragraphs.

8.1 Figures

All figures are to be included within the text. **Figure captions** are to be *below* the figures, in 10-point

Times (or a similar serif font), normal face. Initially capitalize only the first word of each figure caption.

Figures are to be numbered consecutively with Arabic numerals throughout the paper, for example: "Figure 1. Database contexts", and are referred to in the text as Fig. 1, Fig. 2, etc.

8.1.1 Illustrations, Photographs and Graphs

Illustrations, photographs and graphs are considered as figures. All graphics should be centred. Your artwork must be in place in the article (preferably printed as part of the text rather than pasted up). If you are using photographs and are able to have halftones made at a print shop, use a 100- or 110-line screen. Supply the best quality photographs and illustrations possible.

Pencilled lines and very fine lines do not reproduce well. Remember, the quality of the book cannot be better than the originals provided. The conference proceedings will be printed in grey scale, but you can provide images in colour since the papers will also be published on the web site of the conference.

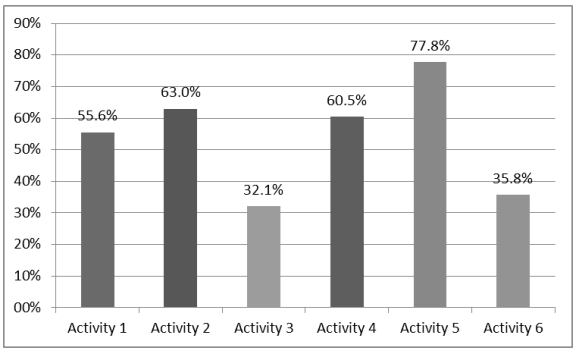


Figure 1. Times, 10 points, normal face

8.2 Tables

All tables are to be included within the text. **Table titles** are to be *above* the tables, in 10-point Times (or a similar serif font), normal face. Initially capitalize only the first word of each table title. Tables are to be numbered consecutively with Arabic numerals throughout the paper, for example: "Table 1. Input data", and are referred to in the text as Table 1, Table 2, etc. Column headings should be as brief as possible.

Table 1. Times, 10 points, normal face

	Column 1	Column 2	Column 3
Row 1	1	2	3
Row 2	4	5	6
Row 3	3	4	7
Row 4	2	6	4
Row 5	2	2	4

8.3 Equations

Equations should be numbered serially on the right-hand side by Arabic numerals in parentheses, and referred to in the text by eq. 1, eq. 2 etc.

$$3x^2 + 3x - 23 = 0 \quad (1)$$

8.4 Footnotes

Use footnotes sparingly (or not at all!) and place them at the bottom of the column on the page on which they are referenced.[1]

9 In-text Citations and Referencing

In-text citation must be used to denote all text used from another author(s) work or from authors previously published own work. When referenced in the text, enclose the author surname(s) and the publication year in brackets, for example (Surname, year) or (Surname, year, p. x) where x is the page number of the cited reference. When referenced paper has more than three authors, cite the paper as (Surname et al., year).

List and number all bibliographical references, alphabetically sorted, in 10-point Times, single-spaced, with a hanging indent, at the end of your paper. Use 6-point paragraph spacing after each reference. References should be distributed evenly in both columns as much as possible, so use a column break where appropriate.

In the References section below you will find examples of common types of bibliographical items: book (Mayer, 2009, p. 52), journal paper (Bule & Peer, 2014), journal paper with more than three authors (Shukor et al., 2014), conference proceedings paper (Steingartner & Novitzká, 2015), report or standard (*ISO/IEC 25010: Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - System and software quality models*, 2011) and web page ("Web Content Accessibility Guidelines (WCAG) 2.0," 2008). For other types of bibliographical items refer the **APA style guidelines**. It should be ensured that every reference cited in the text is also listed in the References section (and vice versa).

Acknowledgments

Acknowledgments, if necessary, should appear in a separate paragraph preceding the references.

[1] Use Times 8-point type, single-spaced. Avoid using footnotes altogether and include necessary peripheral observations in the text (within parentheses, if you prefer, as in this sentence).

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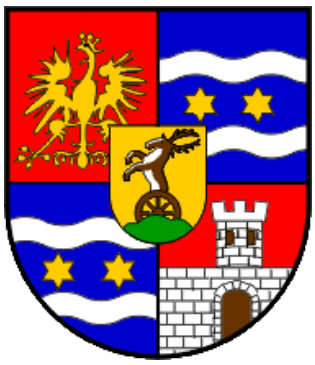
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