E-Schools project - Framework for Digital Competencies of School Principals: Competencies in the Area Digital Infrastructure

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Abstract. *The efficient integration of digital technologies into all facets of school operation is the responsibility of principals of schools undergoing digital transformation in the 21st century. As part of the project "e-Schools: Development of the System of Digitally Mature Schools", which has completed its second phase of implementation in the Republic of Croatia, the Framework for Digital Competencies of School Principals was created.*
The necessity of educational institution (school) principals maintaining suitable digital infrastructure is emphasized in this study, along with some related challenges. The digital skills that the principal must have in order to properly manage the school's digital infrastructure were highlighted in particular. The key steps of the methodology for developing the framework were briefly described in the paper. Particular attention was paid to the presentation of the digital competencies developed within the field of digital infrastructure (a total of five competencies), as well as typical activities (a total of 24 typical activities).

Keywords. school, digital infrastructure, principals, education, digital competence

1 Introduction

The main goal of the research was to define the key digital competencies of principals related to the area of Digital Infrastructure by (1) exploring and reviewing the relevant literature and (2) working with experts in the field of digital competencies and the main stakeholders (principals).

In accordance with the set goal of the research, the authors defined the following research questions:

- What digital competencies should principals acquire in order to successfully manage the area of Digital Infrastructure?

- What typical activities should school principals perform in order to successfully manage the area of Digital Infrastructure?

The responsibility of a school principal in planning and implementing suitable digital infrastructure in schools is covered in the paper. Also, digital competencies of school principals in the area of Digital Infrastructure together with school principals' tasks and activities in the area of efficient use of digital infrastructure have been described. Some challenges related to digital competencies in the area of Digital Infrastructure have been also presented.

2 The Role of a School Principal in Planning and Implementing Adequate Digital Infrastructure in School

Digital infrastructure is prerequisite for the digital transformation of schools, which is required for students (future employees), instructors, and other school personnel, as well as the school principal/management. Digital competencies needed for new workplaces should be acquired throughout early education. Teachers should base their teaching and learning activities for students on digital technologies. All other school business functions should be assisted by digital technologies. This is not practicable in the absence of proper digital infrastructure.

The term digital infrastructure is particularly challenging to define, because much of it represents new and evolving technologies (Glaeser & Poterba, 2021).

According to Tondeur, et al. (2009, as cited in Vermeulen et al., 2017), "an ICT-infrastructure refers to more components than the technical structure (PC, internet connection and the availability of educative programs) alone; it comprises ICT policy, ICT vision,

and sufficient degree of competence by colleagues to use ICT".

School principals as leaders have an important role in fostering, supporting, and assuring each component of the digital/ICT infrastructure. Okeke (2019) discusses technology leadership as "a new concept in school leadership, and it involves school principals creating and sustaining support for effective use of ICT in teaching and learning."

Sheninger (2019) defines digital leadership and its seven pillars as the specific areas embedded in the culture of all schools that can be improved or enhanced through the purposeful use of technology as follows:

1. Student Engagement and Learning
2. Learning Spaces and Environment
3. Professional Learning and Growth
4. Communication
5. Public Relations
6. Branding
7. Opportunity

After conducting a thorough literature review, the following basic publications were chosen to be used in determining the set of required digital competencies:

- Proposal of Strategy for digital maturation of schools and school system in the Republic of Croatia (2018),

- Standards for Principals of Educational Institutions (proposal) (2017),

- ISTE standards for teachers (ISTE, 2008),

- Norwegian Professional digital competence framework for teachers (Kelentrić, Helland & Arstorp, 2017),

- Australian Professional Standard for Principals and the Leadership Profiles (Australian Institute for Teaching and School Leadership, 2014),

- European Framework for Digitally-Competent Educational Organisations: DigCompOrg (Kampylis, Punie & Devine, 2015),

- European Framework for the Digital Competence of Educators: DigCompEdu (Punie, 2017),

- DigComp 2.0: The Digital Competence Framework for Citizens (Vuorikari et al., 2016), and

- laws connected to primary and secondary school education.

The members of the working group employed methods of content analysis, group decision making, brainstorming, brainwriting and panel discussions to identify the elements that made up the mapping of the aforementioned documents as a starting point for the identification of key competencies. This phase's primary contribution may be seen in the list of fundamental areas, the elements that go with them, and the critical competencies for each element. Through five categories and 37 components, this first phase identified eighty-two capabilities.

No improvement or enhancement are possible without adequate digital/ICT (technical) infrastructure and principals are supposed to possess competencies in this area in order to actuate them.

3 Digital Competencies of School Principals in the Area of Digital Infrastructure

Five digital competencies are created for the area Digital Infrastructure. The main steps of the methodology used to construct the framework are briefly discussed in this chapter, along with the created competencies and a simple explanation of each.

The first step specified the areas of school planning and management that matched the Framework for the Digital Maturity of Schools. Five areas in total have been identified: (1) Planning, Management, and Leadership, (2) Digital Technologies in Learning and Teaching, (3) Development of Digital Competencies, (4) Digital Culture and (5) Digital Infrastructure.

After identifying the important principal tasks for each of these areas, a set of digital competencies was determined through an analysis of the relevant literature.

The following step involved a team of experts performing the content validation of competencies. More than twenty digital competency experts were involved in the content validation. In addition to content validation, the experts evaluated the significance of competence for a certain defined area.

In addition to experts in content validation and digital competency clarification, the principals themselves participated in the validation of the principals' digital competencies. Validation was accomplished through focus groups that followed a predetermined process and were facilitated by a competent moderator.

After updating the competencies based on qualitative validation of experts and principals who took part in the research, the final version of the competencies was obtained.

The final phase involved describing each competency and identifying typical actions associated with each competency. The research ultimately produced a total of 25 competencies and more than 170 typical activities in the five previously mentioned areas. A complete description of the methodology development of the Framework for Digital Competencies of School Principals is given in the paper entitled "Methodology for developing a framework for digital competencies of school principals in Croatia" (Žajdela Hrustek, Kirinić, Mekovec, 2022). In the rest of the chapter, the principal's digital competencies related to the area of

Digital Infrastructure are presented together with short descriptions of the competencies.

Competency 5.1 "The principal plans and coordinates upgrades to the school's digital infrastructure according to the needs identified and in collaboration with experts, staff, founders and the Ministry (*of Science and Education*)."

In their development plans, missions and visions, educational institutions (schools) may present different requirements regarding digital infrastructure. In the Republic of Croatia, the Ministry designs and implements a strategy for improving the digital infrastructure of the education system in coordination with the Croatian Academic and Research Network (CARNET). The needs of each individual school may be greater than what the Ministry has foreseen in the budget. In such circumstances, the principal should consider the possibilities of securing additional financial resources in partnership with the Ministry, the founders, the school board and the community of parents, guardians and foster parents.

Competency 5.2 "The principal supports and coordinates the development and upgrades of the school's network infrastructure based on identified needs and capabilities."

The Ministry of Science and Education of the Republic of Croatia, in cooperation with CARNET, is developing a network infrastructure upgrade strategy based on the requirements of educational institutions (schools). Some educational institutions could have greater needs if teachers and students are better motivated and engaged in the use of advanced digital technologies. As a result, a new, more advanced network architecture, higher speeds, with more access points, subnets and requirements for improved network access monitoring may be required.

Competency 5.3 "The principal manages the distribution of digital devices according to the recognized staff and student needs, planned schedule and established criteria."

The principal, together with professional associates, is responsible for determining the conditions and distribution of digital devices in accordance with the monitoring of activities and the requirements of teachers and students. The obsolescence of technology, which is a consequence of the rapid and continuous development of digital technologies, is another key criterion for starting the process of procurement and adequate distribution of digital devices.

Competency 5.4 "In collaboration with the school staff, the principal determines the purpose of using software to support business, learning and teaching processes."

The principal, together with professional associates and all other employees of the educational institution (school) creates software usage models, considering the potential of digital tools as well as unique aspects of teaching and business processes. The principal should be a motivator and initiator of the preparation and implementation of plans to move from simpler to more complex software usage models in order to improve learning and teaching processes as well as business processes.

Competency 5.5 "The principal ensures and coordinates technical support and the school's infrastructure maintenance system."

Nowadays, as educational institutions (schools) use more and more digital equipment, there is an increasing need for technical and program maintenance. However, the end users (teachers, other employees and students) do not have the necessary knowledge to perform such activities. The principal should cooperate with the Ministry and the founders in order to secure additional funds for the employment of experts or the restructuring of the personnel responsible for maintaining the infrastructure in the school or, alternatively, engage specialized economic entities.

4 School Principals' Tasks and Activities in the Area of Efficient Use of Digital Infrastructure

In the "Area of Efficient Use of Digital infrastructure" for five competencies a total of twenty-four typical activities were identified.

For the competence "The principal plans and coordinates upgrades to the school's digital infrastructure according to the needs identified and in collaboration with experts, staff, founders and the Ministry." three key tasks/activities are recognized for modernizing school digital infrastructure. Firstly, the principal's task is to familiarize themselves with the Ministry's adopted plan for a certain period. It is also very important that the principal, in collaboration with other stakeholders, makes a plan for developing the school's digital infrastructure in accordance with the Ministry's plan. The principal should also be responsible for communication with other stakeholders about how to realise the procurement of digital infrastructure that the school requires but is not addressed by the Ministry's plan.

Four typical tasks/activities related to the second competency of the Digital infrastructure area were identified, "The principal supports and coordinates the development and upgrade of the school's network infrastructure based on identified needs and capabilities." As a starting point, the principal must become acquainted with the Ministry's strategy for improving the schools' network infrastructure. The principal of the school should be ready for constant cooperation with other stakeholders in order to be able to adequately develop a plan for the development of the school's network infrastructure in accordance with the plan of the Ministry. Furthermore, the principal should actively interact with other stakeholders on how to

achieve the procurement of network infrastructure that the school requires, which is not included in the Ministry's plan. The principal should be prepared to arrange individualized access to specific online resources for certain teachers and students to foster increased involvement, understanding, and faster development.

"The principal manages the distribution of digital devices according to the recognised staff and student needs, planned schedule and established criteria." is the third competency in the area of digital infrastructure. Five key tasks/activities were recognized. Principals must manage the tracking of digital devices in classrooms and labs, devices retained by teachers, other staff, and students, and monitor their obsolescence with teachers and professional assistants. Principals must, also organize the observation of various preparation and teaching activities, as well as horizontal and vertical communication to determine the necessity for new or specific digital gadgets (advanced use of technology). It is also important that the principal constantly checks teacher and student evaluation results using digital devices. Principals must participate in defining the criteria for distributing digital devices. A further very important task of the principal is to continuously oversee the process of distributing digital devices and authorisations based on identified forms of use.

There are six tasks/activities defined regarding the fourth competence "In collaboration with the staff, the principal determines the purpose of using software to support business, learning and teaching processes." One of the principal's primary responsibilities is to stay current on specific software features that assist business, learning, and teaching activities. It is crucial that the principal familiarizes oneself with the standards for software use set forth by the relevant Ministry. The principal is responsible for, in collaboration with the teachers and other staff, identifying how and what types of software is used and also developing software use models as support for business, learning and teaching processes. An educational institution's principal, with a vision for a successful digital transition, determines and provides the prerequisites for making a transition to more complex software use models with the aim of increasing the quality of business, learning and teaching processes and continuously motivates the staff to apply more complex software use models.

For the last competency within the area of Digital infrastructure "The principal ensures and coordinates technical support and the school's infrastructure maintenance system." six tasks/activities are defined. The principal's task should be to ensure and to coordinate technical maintenance of digital devices. The principal should communicate with the founders and the Ministry in order to provide additional funds for financial compensation to employees with appropriate competencies for the time spent on maintenance work, as well as, if such employees do not

exist, obtain permission to enter into technical support contracts with companies specialized in the maintenance of digital infrastructure. The principal is also responsible for communication with the Ministry to obtain permission to hire a person (professional assistant) with the necessary competencies for performing maintenance tasks in schools that use many digital devices. In collaboration with experts, the principal should make a protocol for fulfilling technical maintenance requirements. One of the principal's top responsibilities should be to stay current on technical maintenance requirements in order to provide extra training for digital device users. (Kirinić, et al., 2022).

An overview of the principal's digital competencies along with typical activities in the area of Digital Infrastructure is also shown in Table 1.

5 Challenges Related to Digital Competencies in the Area of Digital Infrastructure

Five focus groups were held, with the main purpose of examining the proposed framework's clarity and comprehensibility and determining how it could be improved. The focus groups comprised representatives from five distinct types of schools. The first focus group was with primary school representatives. The second focus group included high school representatives. The third focus group included members from art schools, and the fourth included representatives from vocational schools. The fifth focus group was held with representatives of the centre for upbringing and education, that is, institutions for the upbringing and education of students with greater difficulties.

The principals in the focus group examined the framework and revealed some of the challenges they confront in their everyday administrative activities. Challenges in Area Digital infrastructure are as follows:

- Procurement of ICT equipment (as well as network infrastructure) is an important skill, but it is dependent on the founder and is not practiced uniformly throughout Croatia. The practice varies and is dependent on new funding sources. It is debatable how much it reflects the scope of the principal's work; an ICT expert should be included; the principal may coordinate it, but using an expert to assist.

- In order to keep up with trends, it is necessary to seek funding sources. The principal should be aware of equipment insurance calls/tenders and be able to apply for them.

Table 1. Competencies and typical activities of school principals in the Area of Digital Infrastructure

5.1. The principal plans and coordinates upgrade to the school's digital infrastructure according to the needs identified and in collaboration with experts, staff, founders and the Ministry.	5.2. The principal supports and coordinates the development and upgrade of the school's network infrastructure based on identified needs and capabilities.	5.3. The principal manages the distribution of digital devices according to the recognised staff and student needs, planned schedule and established criteria.	5.4. In collaboration with the staff, the principal determines the purpose of using software to support business, learning, and teaching processes.	5.5. The principal ensures and coordinates technical support and the school's infrastructure maintenance system.
The principal: - familiarises himself/herself with the Ministry's plan for upgrading the digital infrastructure of schools adopted for a certain period; - in collaboration with other stakeholders, makes a plan for developing the school's digital infrastructure in accordance with the Ministry's plan; - communicates with other stakeholders about how to realise the procurement of digital infrastructure that the school requires, but is not addressed by the Ministry's plan.	The principal: - familiarises himself/herself with the Ministry's plan for upgrading the schools' network infrastructure adopted for a certain period; - in collaboration with other stakeholders, makes a plan for developing the school's network infrastructure in accordance with the Ministry's plan; - communicates with other stakeholders about how to realise the procurement of network infrastructure that the school requires, but is not addressed by the Ministry's plan; - organises an individualised approach to individual network resources for particular teachers and students due to greater engagement, knowledge and faster development.	The principal: - coordinates recordkeeping of digital devices in the classrooms and labs, devices kept by the teachers, other staff and students, and also monitors their obsolescence; - coordinates the monitoring of various types of activities for preparing and holding classes, as well as vertical and horizontal communication for the purpose of identifying the needs for specific/new digital devices (advanced use of technology); - checks teacher and student evaluation results using digital devices; - participates in defining the criteria for distributing digital devices; - oversees the process of distributing digital devices and authorisations based on identified forms of use.	The principal: - keeps up with particular software features for supporting business, learning and teaching processes; - familiarises himself/herself with the competent Ministry's requirements regarding the standard form of software use; - in collaboration with the teachers and other staff, identifies how and what types of software is used; - in collaboration with the teachers and other staff, develops software use models as support for business, learning and teaching processes; - determines and provides the prerequisites for making a transition to more complex software use models with the aim of increasing the quality of business, learning and teaching processes; - motivates the staff to apply more complex software use models.	The principal: - ensures and coordinates technical maintenance of digital devices; - communicates with the founders and the Ministry to ensure additional funds to compensate the employees with adequate competencies for the time spent performing maintenance tasks; - communicates with the Ministry to obtain permission to hire a person (professional assistant) with the necessary competencies for performing maintenance tasks in schools that use many digital devices; - communicates with the founders and the Ministry to obtain permission for concluding a technical support contract with specialised business operators; - in collaboration with experts, makes a protocol for fulfilling technical maintenance requirements; - keeps up with technical maintenance requirements for the purpose of organising additional training courses for digital device users

- If the principle does not have sufficient financial resources, he will struggle to manage technical support. The founders have ultimate authority, whereas the principals can merely collaborate. There are no conventional answers; it differs between each school and per principal.

- Some principals have attempted to find financial resources to establish their own repository (central storage), but due to limited financial resources, this is not feasible for all schools. They should have an IT specialist on staff at least part-time.

- The principals lack the necessary expertise to manage an information security system. Because both teachers and students are involved in a large system, the principal faces challenges if he does not have the support of competent colleagues. Licenses exist, as do persons who renew and maintain them. Is there a legal procedure in place? Who gives technical assistance? A principal appears to be overburdened. Seminars are essential for the principal's preparation. If they acquire a procedure from someone, it won't be a problem.

6 Conclusion

As the leaders of educational institutions, principals have a significant role in the development, maintenance, and quality assurance of their digital and information technology (ICT) infrastructure.

The primary purpose of the research that is presented in this paper was to define the key digital competencies of principals related to the field of digital infrastructure. This was accomplished by searching for and studying the relevant literature, as well as enlisting the assistance of specialists in the field of digital competencies and the primary stakeholders (principals).

In this paper, the function of a school principal in the formulation and execution of an appropriate digital infrastructure in educational institutions is analysed and explored. In addition, descriptions have been provided of digital competencies held by school principals in the domain of digital infrastructure, as well as of the responsibilities and actions held by school leaders in the domain of making effective use of digital infrastructure.

The main steps of the methodology used to construct the framework are briefly discussed along with the created competencies and a simple explanation of each.

In addition to specialists in content validation and digital competency clarity, the principals themselves took part in the process of validating their own digital skills as part of the validation of the principals' digital competencies. Focus groups that followed a predetermined protocol and were conducted by an experienced moderator were used to carry out the validation process. The final version of the competencies was achieved after the competencies were updated based on qualitative validation by the experts and principals who participated in the research. This was done in order to obtain the final version of the competencies.

The key limitation of the research described in this paper is that it is restricted to establishing the input guidelines for developing the Framework. The framework was established with a focus on specific documents that should be considered, hence the full opus of needed skills and knowledge was not included in some components. Furthermore, only Croatian experts and principals participated in the validation, so the framework itself reflects only the situation in Croatia.

Future study should include updating the framework in light of ongoing changes in the development of digital technologies and digital competencies.

Acknowledgments

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