Preliminary Evaluation of a 3D Serious Game in the Context of Entrepreneurship Education

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Abstract. *Under umbrella of the Student Business e-Academy project, a digital start-up game was developed as a complementary material to the entrepreneurship curriculum. The paper brings the preliminary results of the evaluation of two different aspects of this game: usability of the interface and the sense of presence in a 3D virtual environment. The results indicate that, as far as these criteria are concerned, the improvements should be considered and implemented in both aspects. Several specific guidelines for further development of the game are outlined in the paper as well.*

Keywords. Serious games, 3D virtual worlds, Entrepreneurship, Evaluation, Usability, Presence

1 Introduction

New approaches to Technology Enhanced Learning (TEL) often explore the use of virtual, serious games within different areas of learning and with different types of users. There is great evidence (some of it is presented in the following section) that gamification, role playing, simulations, and virtual games have positive effects on a range of perceptual, cognitive, behavioural, affective and motivational impacts and learning outcomes. Still, more research has to be done in order to better understand the tasks, activities, skills and functions that different kinds of games can offer and to explore how these might match desired learning outcomes is apparent (Connolly et al., 2012; Hamari et al., 2016).

The paper presents a study focusing on a couple of less explored aspects, usability and presence, of a serious game used for educating learners on different entrepreneurship topics. After short theoretical context (section 2), the development of a digital game is described (section 3) followed by the evaluation procedure (section 4) and presentation of results (section 5). Discussion of obtained results and outlines for further work are presented in the last part of the paper (section 6).

2 Virtual worlds and 3D games for TEL

Based on 129 papers, a systematic literature review of empirical evidence on computer games and serious games (Connolly et al., 2012) showed that these games have a potential of creating learning environments to better reach the educational and training goals. The use of games (and competition) has a positive influence on motivation and learning process itself (Ercil, Ozcelik & Sahin, 2015). Even in the case of using existing 3D virtual environments such as Second Life, there is evidence that 3D virtual environments could indeed facilitate students in achieving better learning outcomes through constructivist learning (Chau et al., 2013).

Serious games allow learners to develop a range of different skills (analytical and spatial skills, strategic thinking, psychomotor skills etc.). Some of the advantages of using serious games in higher education are: student autonomy, problem recognition, problem solving, decision-making, better short-term and long-term memory etc. (Dragičević, 2016).

Even through there are many benefits to using games and simulations in the classroom, they are underused in practice (Bichsel, 2013); the percentage of games and simulations used in lessons is less than 25%. In addition to lower levels of use (many believe due to their complexity and strict higher education curricula), there are critics emphasising the issues and distrust behind game-based education such as faculty perspective, slowness of innovation adoption, time, costs etc. (Arai, 2005; Shea, Grenier & Boots, 2015). These issues are often times explored and evaluated with users - teachers and learners (see examples further on in the paper).

Games for learning are being used across a wide range of subject disciplines with health the most popular one followed by games about social issues, science and business (Connolly et al., 2012). With regards to entrepreneurship related curricula, majority of the programmes still focus on multimedia content encompassing case studies, self-evaluation exercises

and, recently, traineeships and competitions for both young and adult learners. As in entrepreneurship related curricula, the knowledge and experience of the real-world regulations and business context is very valuable, the educators started exploring with the use of role playing, business simulations and serious games only as of lately (mostly developing the scenarios and games within EU funded projects).

An example of massively multiplayer online role-playing game (MMORPG) is illustrated in Figure 1. Simulations of (macro-/micro-)environments and systems allow participants to experience situations that are impossible in the real world for security reasons, costs, time, etc. The online world provides a virtual learning environment that could faithfully illustrate reality.

Figure 1. Symphony – Macroeconomic MMORPG (http://projectsymphony.eu)

3 Development of digital start-up game

The development of the 3D game and related preliminary study presented in the paper was conducted within the framework of the project Student Business e-Academy (project reference: 2015-1-HR01-KA203-013080) funded through Erasmus+ programme (key action: *Cooperation for innovation and the exchange of good practices*; action type: *Strategic Partnerships for higher education*)[1].

The main goal of the SBeA project (10/2015-10/2017) is to produce a high-quality, personalized e-learning program for young people interested in entrepreneurship in order to provide them with necessary resources to bring their business ideas to life as well as to prepare them for entering the market (SBeA project website, 2015). The blended program, available from a customized virtual platform consists of 6 modules (3 per semester) and 2 training seminars/conferences. SBeA program is developed by three partner institutions: University of Split (Croatia), University of Malaga (Spain) and Middlesex University (United Kingdom).

Digital start-up game was developed as a complementary material to SBeA curriculum (SBeA project proposal, 2015). Since the emphasis was put on developing and piloting the international, innovative entrepreneurship program, not much restriction was put on the type and the functionality of the game. Therefore the partners were free to deliberate on the choices of the technical solution and the underpinning philosophy during the first part of 2016 to ensure:

- the relevance of the game scenario for the project and the wider/international context,
- the links to developed curricula to ensure scaffolding and simulation of real-life business environment adapted to specific needs of the user group,
- the interest and the programme longevity beyond project consortium and the project timeframe.

The scenario was developed by University of Split (Ćukušić, Ugrčić, Paušić, 2016). In September 2016, following the presentation of the solution prototype, due to the complexity of the technical solution and the scenario scope, the partners revised the proposed scenario and decided to develop only one scenario fully (as opposed to developing three scenarios but to a certain extent/phases). The scenario titled Starting a business in Tourism sector (opening and operating a tourist agency) is planned through three main phases (market research, budget estimation and raising funds) as illustrated in Figure 2.

The player is located in Split, CRO. Start of the game is at the city centre. The player takes on a role of entrepreneur. At his/her disposal is a budget of 10.000 euro and then he/she: either raises the rest of the money from the bank or other investors or starts the business using initial budget. The goal is to establish and run a business with a relatively limited budget and simulate one year of operation. Start is in the Mentor's office. The mentor is there to introduce the game (interaction is initiated on approaching the mentor's desk and pressing the E key). After that, the player can move around different stops. He/she is supposed to e.g. define the targeted customer segments, choose a loan package, define the products, sales prices, product costs, employ people etc. The game is successfully completed if at the end of the simulation (12 months) the player has profit.

As of early 2017, the game is fully functional and available for download and installation from the project's website http://e-learning.efst.unist.hr/ upon registration. In addition to an offline version, web access would be offered to all registered users as well. The game is available in three languages (Croatian, English and Spanish).

[1] Details about the project and the funding are also available from the Erasmus+ Project Results database (access to descriptions, results and contact information of all projects funded under the Erasmus+ programme is available from the platform): http://ec.europa.eu/programmes/erasmus-plus/projects/.

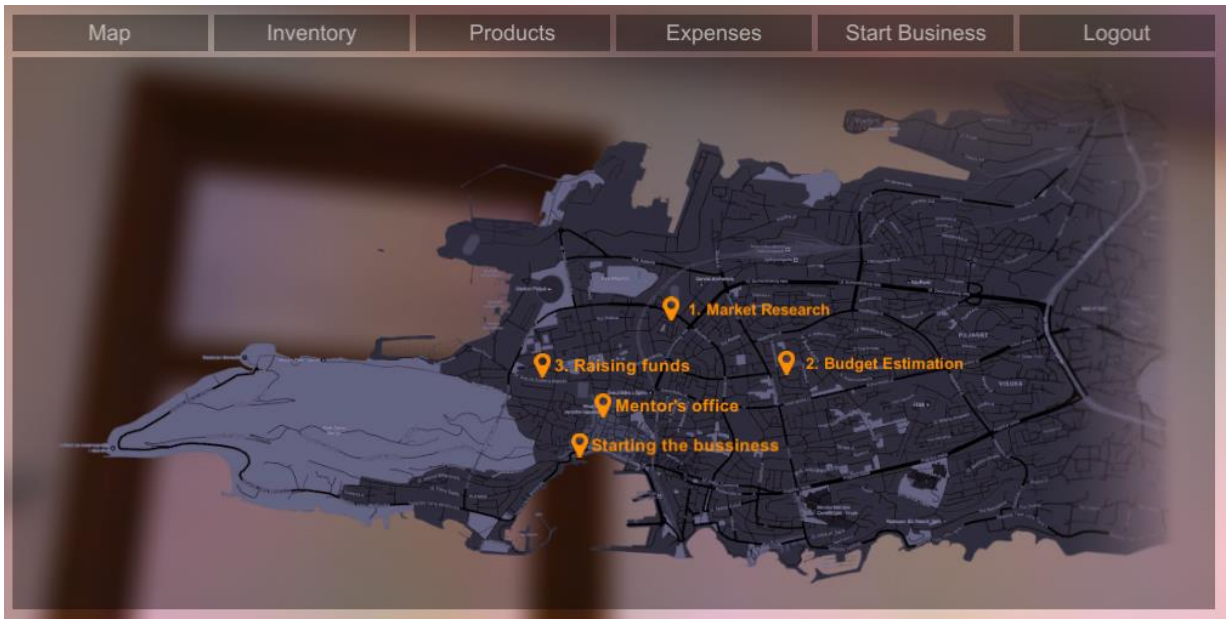

Figure 2. SBeA game dashboard (screenshot)

Technologies used for game development are: Grails framework, Java, C# and Unity game development platform. The choice of the game development platform was based on the experiences from earlier project – V-ALERT (V-ALERT, 2016) and the report on 3D virtual worlds platforms and technologies (Maratou & Xenos, 2014) and the popularity of the Unity platform. Unity plays an important part in a booming global games market. More games are made with Unity than with any other game technology. The proportion of developers relying on Unity as their primary development tool and using Unity is growing all the time[2].

The great advantage of developed solution is that it does not require any additional software to be installed on the client computer for playing the game. Hardware requirements of the game are also commonly met on personal computers with average performances. These features ensure the availability of the game to a wide range of potential users and the longevity of the game as a significant project outcome.

4 Preliminary evaluation of digital start-up game

Evaluation of the game covers two aspects: usability of the interface and the sense of presence in 3D virtual environment. Currently, the preliminary evaluation is completed in order to briefly assess the levels of usability and presence and to develop guidelines for further improvements of the game.

In preliminary evaluation, several empirical methods were employed: two attitude questionnaires and semi-structured interviews along with evaluator's observations for acquisition of additional feedback. Thus quantitative and qualitative measures were acquired.

The pilot study was conducted at University of Split, Faculty of Economy, in May 2017. Eight students from graduate study of Information technology management applied to participate in the study. Two of them were female and six male students, aged between 22 and 24.

The students were given an entry questionnaire (in Croatian) through which they have provided certain personal information, level of study, experience in using computers and Internet, gaming in general and playing 3D games, as well as information about their prior knowledge on entrepreneurship. According to the obtained data, all participants have basic knowledge on setting up a company and one student declared that he already started his own business. All students use computer and Internet on daily basis. Six students play computer games, with frequency ranged from few times a month to few times a week, while two students do not play computer games at all. With regards to prior experience in playing 3D games, answers are almost equally distributed from "not experienced at all" to "somewhat experienced". It is evident that none of the students have significant prior experience in using 3D games.

After completing the entry questionnaire, the students were directed to download the game form the project website and to run the game on a personal computer. All students completed the registration process successfully and started to follow in-world scenario tasks without requiring any kind of assistance from the supervisor of the evaluation study.

[2] The statistics are available from the official website (https://unity3d.com/). For illustration, 5 billion downloads of 'Made with Unity' games are made in Q3 2016; 34% of top 1000 free mobile games are 'Made with Unity'.

Some students played the game in English while others choosed to play in Croatian.

The students were asked to take a screenshot of the final screen that contains the information about their income at the end of the game. An example of a student's final screen is given in Figure 3. Playing the game, including the registration process, took approximately 30 minutes.

Upon finishing the game, the students were asked to complete the exit questionnaire. This four-part survey obtained users' subjective perception about (i) personal success in the game and relation between prior knowledge on entrepreneurship and the score in the game, (ii) usability of the interface, (iii) presence in the virtual environment and (iv) general likes, dislikes and possible comments. The first three parts of the survey are designed as quantitative instruments while the fourth set of questions allowed acquiring the answers in open form.

Following the perception of the participants on their success in the game, the second part of the exit survey is the SUS questionnaire (Brooke, 2013), a well-established instrument for quick usability assessment of an interactive system from end-user perspective. Usability is the general concept that describes how user interfaces are easy and pleasant to use. According to ISO standard (ISO 9241-11, 1998), usability of an application is strongly related to the specified users, their goals and context of use. SUS questionnaire is integrated into our exit survey in its original form which uses 5-point Likert scale to annotate users' answers. To keep participants' engagement in the context of the study, the word "system" is replaced by "game" in all questions. The whole list of questions in the SUS questionnaire will be presented further on in the paper (Table 1).

The third part of the exit survey is the extract from Presence Questionnaire, PQ (Witmer, Jerome & Singer, 2005). Presence is the user's subjective experience that includes two dimensions: first, the involvement in virtual environment, i.e. the ability to focus his/her attention and energy on stimuli in virtual environment and second, the sense of immersion, i.e. perceiving him/her as a part of the virtual environment sensory inputs, events and activities (Witmer & Singer, 1998).

Considering the nature of the user experience in digital start-up game, we have extracted an applicable set of questions from the PQ, version 3.0 (Witmer, Jerome & Singer, 2005). For example, our game does not include any sound options so all the questions related to sound or a combination of sound and other stimuli in virtual world are excluded from the study instrument. Consequently, the selected set of 23 applicable questions for this study out of 32 questions in the PQ version 3.0 covers the factors of Involvement, Adaptation/Immersion, Interface Quality and Distraction. None of the questions addressing the factor of Sensory Fidelity were applied in the study. The selected set of questions is presented in Table 3 along with the results obtained by the 7-point Likert scale.

The SUS and PQ questionnaires are given to Croatian students in English since the English versions of these questionnaires are validated measuring instruments. In addition, SBeA curriculum and training modules are also in English, as described in Section 3, so the use of English versions of evaluation instruments was appropriate. All students reported that they are fluent in English and none of them asked for translation in any of the proposed questions.

After completing the exit survey the students were free to comment their experience in the form of a semi-structured interview with the supervisor of the study.

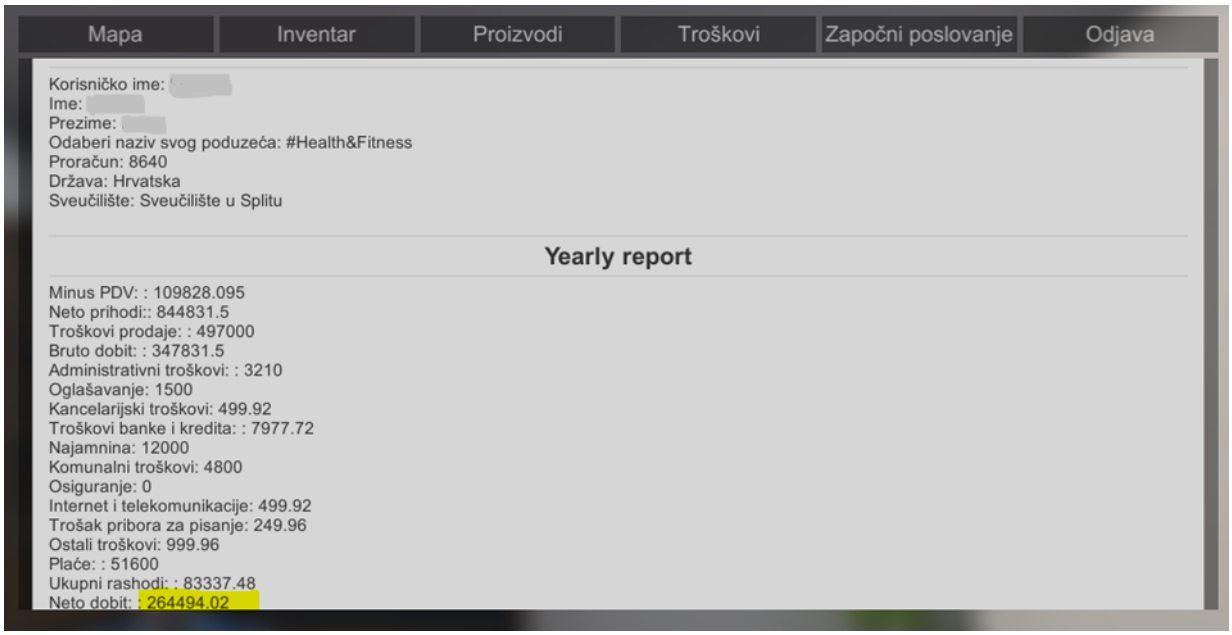

Figure 3. SBeA game final screen with highlighted income at the end of the game (screenshot)

5 Results of the study

In the first part of the exit survey the participants reported their subjective satisfaction about their personal achievement in the game. Two students did not finish the game, three of them reported unsatisfying income, one student was satisfied and three students were extremely satisfied with their incomes.

The answers in the SUS questionnaire are analysed as follows. For odd numbered questions the score is calculated as the scale position of the answer minus 1. Even numbered questions have reversed polarity and their score is calculated as 5 minus scale position of the answer. All questions along with calculated scores (means scores ranged 0 to 4) and standard deviations per question are presented in Table 1. For even numbered questions the higher score means the less agreement of the participants with the statement. Thus for all questions the higher score represents the higher level of participants' satisfaction with the game. The total SUS score of each participant is the sum of his/her scores in all questions. Multiplying the total score by 2.5 we get the scores ranged from 0 to 100. An average of obtained scores by all participants is considered as a SUS result of the study.

Table 1. Results of SUS questionnaire per question

SUS questions	Mean	SD
1. I think that I would like to use this game frequently	0.88	0.83
2. I found the game unnecessarily complex	2.38	1.30
3. I thought the game was easy to use	2.38	1.30
4. I think that I would need the support of a technical person to be able to play this game	3.38	1.06
5. I found the various functions in this game were well integrated	2.00	1.07
6. I thought there was too much inconsistency in this game	1.38	0.92
7. I would imagine that most people would learn to use this game very quickly	2.38	1.30
8. I found the game very cumbersome to use	1.75	1.16
9. I felt very confident using the game	2.25	1.04
10. I needed to learn a lot of things before I could get going with this game	3.38	0.74

Table 2 presents the overall value of the pilot study along with related descriptive statistics.

Table 2. Summary of SUS questionnaire

N	Mean	SD	Min	Max
8	55.31	11.37	42.50	72.50

Analysis of the PQ questionnaire follows the previously explained method for calculating the score of SUS questionnaire. Questions 11, 14, 15, 18 and 19 have reversed polarity and their score is calculated as 7 minus scale position of the answer. For all other questions, the scores are calculated as scale position of the answer minus 1. Thus the total scores of all participants range from 0 to 138.

However, our current analysis showed that one participant regularly chose the first answer (21 answers are "1" and two answers are "2"). We can assume that this participant did not make an effort to complete the PQ seriously/carefully therefore this extreme score is eliminated from the study. Presence measurement with the rest of the sample (N=7) reaches the scores from 46 to 94 with the mean of 69 and standard deviation of 16.02. These values are considered reliable and further analysis of PQ is based on the related sample. It is important to note here that the repeated analysis of the SUS on this 7-participant sample did not reveal considerably different results in descriptive statistics. The SUS score of the 8th participant is 42.5 which is the minimum in the sample (as shown in Table 2). However, another participant achieved the same score, thus the minimum value remains unchanged. Compared to Table 2, the mean SUS score of the new sample is slightly higher (57.14) and the standard deviation is slightly lower (10.94). With this rationale, and bearing in mind that the main purpose of this preliminary study is to get users' feedback to be employed for improvement of the game, we decided to accept the SUS score of the 8th participant as valid. Since qualitative feedback is more important than quantitative scores in this phase of our research, it is possible that contribution of the 8th participant is valuable to us in all other segments except the presence evaluation.

Table 3 presents selected questions of PQ for the study (as explained in previous section) along with mean scores (ranged 0 to 6) and standard deviation values per question, considering the 7-participant sample as discussed above.

Similar to SUS scores, the total PQ score of each participant is the sum of his/her scores in all questions. These sums are pondered to get the scores in percentage and the average of obtained scores is considered as the overall result of PQ for this study i.e. the level of presence in the game. This result is presented in Table 4.

Table 3. Results of PQ questionnaire per question

PQ questions	Mean	SD
1. How much were you able to control events?	3.57	1.99
2. How responsive was the environment to actions that you initiated (or performed)?	2.86	1.95
3. How natural did your interactions with the environment seem?	2.00	0.82
4. How much did the visual aspects of the environment involve you?	2.29	1.25
5. How natural was the mechanism which controlled movement through the environment?	2.43	0.79
6. How much did your experiences in the virtual environment seem consistent with your real world experiences?	2.57	0.79
7. Were you able to anticipate what would happen next in response to the actions that you performed?	3.57	1.51
8. How completely were you able to actively survey or search the environment using vision?	3.14	1.77
9. How compelling was your sense of moving around inside the virtual environment?	2.86	1.95
10. How involved were you in the virtual environment experience?	2.86	1.57
11. How much delay did you experience between your actions and expected outcomes?	2.14	1.46
12. How quickly did you adjust to the virtual environment experience?	3.57	1.62
13. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?	3.00	2.16
14. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?	3.86	1.07
15. How much did the control devices interfere with the performance of assigned tasks or with other activities?	3.29	0.95
16. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?	2.86	1.07
17. How completely were your senses engaged in this experience?	2.43	1.90
18. To what extent did events occurring outside the virtual environment distract from your experience in the virtual environment?	3.57	1.27
19. Overall, how much did you focus on using the display and control devices instead of the virtual experience and experimental tasks?	3.29	1.38
20. Were you involved in the experimental task to the extent that you lost track of time?	2.43	1.62
21. How easy was it to identify objects through physical interaction, like touching an object, walking over a surface, or bumping into a wall or object?	3.71	1.70
22. Were there moments during the virtual environment experience when you felt completely focused on the task or environment?	3.00	1.29
23. How easily did you adjust to the control devices used to interact with the virtual environment?	3.71	1.60

Table 4. Summary of PQ questionnaire

N	Mean	SD	Min	Max
7	50,00	15,19	30,43	71,01

The fourth part of exit survey allowed students to note in open form what aspects of the game they liked the most, what they did not like and what changes they propose for the next version of the game. The most liked feature of the game was the fact that the virtual environment included the map of the virtual world, as reported by 5 students. They also added that they had the high level of understanding the real situations in virtual environment. Three students appreciated the simulation of the investments, the possibility to control their budget and the very clear relationship between causes and consequences, i.e. *"I liked the virtual perception of possible state and future occurrences."* On the contrary, two students reported that they did not like the game. In the second

question, related to dislikes, 6 students reported several bugs in the game and 2 students stated the game was confusing in some steps of the process. In the third open form, asked for improvements suggestion, 2 students proposed more frequent guidelines for running a business instead of general directions at the beginning of the game (i.e. proposed smaller chunks and context, phase related guides). In addition, one student suggested that meeting more people in the hallways and offices would be much more realistic.

In the semi-structured interview at the very end of the evaluation session, the students explained that the most of the bugs are related to opening the door of the offices which is possible only from a small range of distances and directions in front of the door. All other aspects of navigation and orientation in the space were well accepted. We have noticed during the session that 6 students used the default English interface although the game is also available with Croatian interface. Discussing this issue, we have concluded that he drop-down list for the language selection should be more visible and accessible to students (only one student has deliberately chosen to play in English).

6 Discussion and conclusion

When discussing results of the exit survey we have to place each student' answers in the context of his/her experience reported in the exit questionnaire as well as in relation with his/her objective result obtained in the game. For example, it happens that a student who rated his/her success in the game as intermediate achieved twice as higher income than the student who rated his success as excellent.

Reviewing the overall SUS result (55.31) we can conclude that it is below average and that there are several usability issues that need to be resolved. Most of the SUS questions need to be considered for improvement of the game interface, particularly the questions numbered 6 and 8. In addition to students' answers in open forms of the exit survey along with the feedback obtained in the interview, the technical issues of moving through the virtual environment are the priorities to improve.

The best rated SUS questions are statements numbered 4 and 10 (it is worth noting that the smallest standard deviation is observed for statement numbered 10). This means that students mainly do not need technical assistance to play the game and also that their progress through the scenario does not depend on their prior knowledge. Since the game is intended to be used by students who are finishing the Student Business e-Academy taking place fully online, it means the game will be used also completely online as the entire program, without a mentor or supervisor. Therefore, this aspect is very important. The game has to be fully playable without any technical assistance from another person. This means that in-world situations and events need to provide implicit guidance for the user to successfully complete the scenario. In case of the need for explicit directions, respective instructions have to be provided at the right time and place, i.e. they should be offered as small chunks of information integrated into respective steps of the scenario. This allows the player to act immediately and decreases the need for memorizing the directions which is important aspect of usability of any interactive system.

The results of the PQ are in-line with the SUS results and the qualitative feedback from the users. According to presence evaluation, it seems that interaction with the environment should be more natural (question number 3) and that players have experienced unexpected delays between their action and outcomes (question number 11). Both issues are strongly related to the graphics processor power thus we have to consider suggesting the use of more powerful computer or graphics card to play the game. On the other hand, the question number 14 which is related to visual display quality scored the maximum value in PQ, which means that the level of interactivity in the game was not decreased by the quality of the interface. In addition, high scores were achieved for identification of objects through physical interaction (question number 21), which is also confirmed in the interview with the participants, and for using control devices (question number 23). The last outcome is expected because the interaction is achieved simply by the common peripherals (mouse and keyboard). We can conclude that simplicity of the interaction is very important factor for the sense of "being there" and it should be kept in the next version of the game. The shortcomings of the interaction, which are detected by the PQ as well as by other instruments used in the study, are results of already reported bugs and will be treated in the same way.

Although the study has provided a number of quantitative data, due to the small number of participants we cannot rely on the obtained results as objective measures thus. On the contrary, the intention of this preliminary evaluation is not to generalize obtained results but to observe developed game from different perspectives and to identify aspects that should be improved for reaching better user experience.

As the next step of the research, the full evaluation of the game will be conducted. Along with empirical methods (user testing as conducted in pilot study but with significantly larger sample of users), we plan to apply analytical methods, such as heuristic evaluation with a number of usability experts. Since analytical methods regularly provide complementary set of usability issues of evaluated application, we expect that using both empirical and analytical methods will provide full perspective of developed serious game as well as valuable conclusions and implications for practitioners.

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