Serious computer games in computer science education

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Abstract

The role and importance of serious computer games in contemporary educational practice is presented in this paper as well as the theoretical fundamentals that justify their use in different forms of education. We present a project for designing and developing serious games that take place within the curriculum for computer science teachers' education as an independent project work in teams. In this project work students have to use their knowledge in the field of didactics and computer science to develop games. The developed game is tested and evaluated in schools in the framework of their practical training. The results of the evaluation can help students improve their games and verify to which extent specified learning goals have been achieved.

1. Introduction

A shift from traditional didactic transmission model of teaching to student-oriented forms of active learning, where the teacher's role radically changes, is needed in modern education. Instead of transmitting knowledge, a teacher prepares a suitable environment and tasks as well as other challenges for independent student learning, directs them, and gives them appropriate feedback. Learning objectives should move from lower taxonomic levels, dominated by retrieving various information and facts, to higher taxonomic levels, where there is an emphasis on the search for, evaluation and application of knowledge. Information and communication technologies (ICTs), which have a very limited role in traditional forms of teaching, can very effectively improve the efficiency and quality of learning when these changes happen [1]. ICTs' potential in finding, processing, transmitting, storing and displaying data in various forms (i.e. multimedia) is well-known, but in the traditional forms of teaching and learning their usefulness is limited [2] [3]. This is also valid for communication support, support for collaboration, as well as for the opportunities for easy distribution of learning materials and results of the

work of all those who are involved in the educational process [4], [5], [6]. Only in the last decade did experts discover new opportunities that can contribute for the learner's cognitive processes by interactivity and by the meaningful and purposeful use of multimedia [7], [8].

Games have always represented an important form of learning, but very rarely were they used in formal education. If they are somehow tolerated in the earliest development stages, they cannot be found in the selection of appropriate methods in the more "mature" periods of life, as many teachers believe that teaching and learning is too serious matter to allow the presence of play in these processes. Therefore, games were marginalized for a long time. Significant changes brought more massive introduction of information and communication technologies into education. ICTs do not change teaching methods, but they often encourage teachers and other professionals in the field of education to start thinking about new approaches. Thus, with the advent of ICT, teachers have often started thinking about collaborative forms of learning, even though this could be implemented in the classroom where students sit next to each other also without technology. Even the emergence of computer games teaching has led experts to think more about games

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at school, and they found that high quality games always include construction, synthesis and application of knowledge. This means that by playing games, the player actually performs activities that are essential in constructivist theories of learning [9], [10].

2. Research methodology

As research method we have chosen the method of DBR (Design-Based Research) [11], [12], [13]. The method is concerned with the design of the learning process, taking into account the complexity involved, different levels of education and different contexts in educational institutions [14]. The DBR method is especially useful when the teacher is involved in research as a performer and is actually included in the experiment. Van den Akker et al. mention three main reasons for the use of DBR in the field of educational sciences [12]:

(i) To increase the importance of research for educational policy and practice;
(ii) To develop empirically grounded theory based on combined study of learning processes and learning technologies that support this process;
(iii) To increase the robustness of design practice.

Research on the basis of DBR begins with a thorough analysis of the learning problem under study, which leads to specific ideas for change and improvement. Designers then conceive and develop a system that uses ICT to produce learning materials and methods for the implementation of improvements, which were announced by theory and previous research. If the theoretical analysis is correct, these interventions should give significantly more effective results [15].

This method was used in the Department of Computer Science and Didactics of Computer Science at the Faculty of Education, University of Ljubljana. It involved the members of the Department and students of the Computer Science Teacher study program in two courses in the 4th year of study.

The starting point represented the ADDIE model. This is a framework which lists generic processes that instructional designers and training developers use, and represents a guideline for building effective training and performance support tools in five phases. We have upgraded and refined this model with some theoretical principles from the field of cognitive psychology and special didactics in the framework of our research. The resulting new model is called SADDIE.

3. The characteristics of games

Games accompany humans at all stages of their development, but they are used most intensively in the early stages when the intensity of learning is maximal. Games have their own specific characteristics that affect their popularity, and have largely positive impact on their usefulness in learning. Prensky has identified seven key elements of the game [16]:

(i) The game is based on the story, which provides a framework and connects the parts of the game into a recognizable whole.
(ii) Players in the game try to meet the objectives related to the story and challenges,
(iii) While observing the rules that give the game a structure, and add the game some additional challenges.
(iv) The player participates in the game through active interaction with other persons who appear in the game or with the game environment.
(v) They are usually in a conflict relationship, or compete with them.
(vi) The interaction in the game gives the player a sense of control over events and over opportunities to influence the course of the game.
(vii) The environment of a game usually responds the player with the outcome or another type of feedback that at any time permits him to verify the appropriateness of his actions and effectiveness of his progression towards the goals in the game.

An important aspect of playing games is the intensity of player's involvement in the game. Good game may cause the state of ecstasy that was called "flow" by American psychologist Csikszentmihalyi [17]. Such state of ecstasy is well known from sporting activities, while some others experience it when reading a good book. It causes loss of sense of place and time and complete devotion to the current activity. The author has found that the state "flow" in general represents:

- Optimal level of capacity to act;
- A feeling of pleasure and control;
- Matched player's skills with the challenges of the current activities;
- Clear objectives;
- Feedback (response);
- Ecstasy with a loss of sense of time.

To achieve such state of ecstasy, certain conditions must be fulfilled. Malone defined 5 conditions for achieving "flow" [18]:

(i) The activity must be designed so that the player can continuously adjust the level of challenge to his abilities.
(ii) The activity must be organized in such a way that it can be "isolated" from other stimuli that could affect the player during the game.
(iii) There should be clear criteria for success.
(iv) The activity should provide feedback to the player, which tells him how successful he is in the game.
(v) The activity must have a wide variety of challenges, so that the player can obtain information about various aspects of his performance.

4. Games and learning

In a game, a player can create an environment within the zone of proximal development (ZPD) in cognitive and socio-emotional sense by selecting the complexity. This concept was defined by Vygotsky and represents the difference between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers. Learning is most effective when it takes place within the ZPD.

Serious computer games are an example of the use of technology to effectively achieve the learning objectives taking into account these requirements. Of course, not every game is didactic and meets the above mentioned conditions. The game is educational only when it "hides" some learning objectives. It is important, however, that despite the learning objectives the game remains funny and keeps all the other attractive features of the game.

4.1. Games on the basis of behavioural theories of learning

In the beginning, the majority of computer games was based on the behavioural learning theory. In fact, this was the teaching material with some "playful" accessories. Thus, the stimulus, which is the basic element of the learning process in this context, is the question the game addresses the player. His response to this stimulus is the answer, which may be right or wrong. Whenever there is a correct answer, a positive response should be given, which acts as an amplifier of the connection between the question and the correct answer. In a game, it can be "happy tune" or the emergence of figures, which stimulates positive emotions. In the case of a wrong response, the reaction must be negative. It can be "a sad melody" and/or graphic element, which has a similar effect and weakens the connection. Typically, a series of correct answers followed by any additional "reward" for the player's achievements in the form of mini game or animation. These games are based on the "drill and practice" principle and use game techniques such as quizzes, point and click, or practicing basic arithmetic operations. Such games are suitable for implementation with the use of ICT and are relatively simple to develop.

4.2. Games on the basis of constructivist theories of learning

Nowadays, we are increasingly interested in a constructivist approach to learning, because it is based on the learner's active role and allows the achievement of higher taxonomic levels of knowledge. Learning should be to the maximum possible extent problem-based and should take place in an authentic environment. Therefore, computer games are designed as stories in a real or fairy world and represent an adapted model of reality in which the learner plays a role,

identifies with what is happening in that world, and actively solves its problems. The teacher's main task is the selection (or in certain cases production) of suitable games and provision of proper guidance and responses before or during game play. In any case, after the game play, the teacher has to lead a reflection on playing and accompanying events related to learning, and make a summary of the learning results. This helps the learner in constructing appropriate mental models.

5. Serious games in pedagogical practice

Serious games can be used almost everywhere where people learn: in all levels of education – from kindergarten to higher education, in different subject fields, in formal and informal education. Such forms of education are very popular in the army, in the field of safety, security and rescue and, more recently, in healthcare. These are the areas where it is very difficult to train people in real situations; therefore, games offer an opportunity to establish them in the desired environment, and the player can identify with it. More and more often, serious games appear in education in the field of public administration, governance and management as well as in other areas where there is a need for specific forms of communication, negotiation, and teamwork, especially in practical training.

Production of high-quality serious games is a very complex process, involving experts in selected subject areas, didactics and cognitive psychologists, graphic designers, videographers, programmers, and experts in advertising and marketing. On average, ten to fifteen people working on the project are involved in the development of good commercial games, for one to two years, and half a million euros are spent.

All these properties of serious games and the popularity of new technologies among the younger generations have been stimulus that we have started using games at the Department of Computer Science and didactics of computer science at the Faculty of Education, University of Ljubljana. Students of all teacher education study programs in which we participate as providers of courses in the field of ICT use in education, were presented the possibilities that such games offer. At the same time, we also presented ways to find suitable games according to the content of curricula and learning objectives selected for their evaluation and, of course, for the integration of games in the teaching process. For 4th year students in the Computer Science Teacher Education study program, we designed project activities for the design, development and evaluation of serious computer games in the framework of 2 one-semester courses.

This is an interdisciplinary approach in which students must acquire, and then in the context of project work apply, knowledge in the field of educational psychology, didactics and computer science. While working on the project, they also gain experience in project management, teamwork, graphic design, and adequate copyright protection and safety for the games produced. The project in its entirety

lasts two semesters and has 8 ECTS credit points, which means between 200 and 240 hours of student work. In this case we can talk about an innovative approach, as students are very active and usually invest even more work than formally required. In the polls, which are carried out after the completion of the project, actually all of them are very satisfied with the learning process itself and also with the results. The quality of work is also confirmed by the fact that students repeatedly present their activities in professional and scientific conferences, and that their results were well accepted in the scientific community. From this academic year we offer Computer Games also as a free elective course, which can be chosen by all the students of undergraduate studies at the University of Ljubljana, and students are highly interested in it.

Members of the Department exchange and enrich our knowledge and experience with participation in international projects. Thus, in 2009-2011 we participated in the project SELEAG (Serious Learning Games) in the context of the EU Comenius program and in the period 2012-2014 in the project SEGAN (Serious Games Network) under the EU Life Long Learning program. In these projects, we cooperate with colleagues from eight universities from seven European countries in the production of games, and in the preparation of guidelines for their integration into teaching and learning.

6. Games in teacher education

Project work in which students conceive, implement and evaluate the effectiveness of serious games, based on the SADDIE method, which has been developed for this purpose and is an extension of the method ADDIE [19], which was in the seventies of the last century developed in Florida State University for the preparation of educational materials in the American army. This model is the basis for most models that are used today in the development of educational content. It was named after the initials of the names of development phases: Analyse, Design, Develop, Implement and Evaluate. At the beginning, we added another phase, called Specification, in which students identify a didactic problem in the learning process which cannot be effectively solved by traditional methods, define specific learning objectives, and propose an innovative educational method or technique of the game, by means of which the problem could be effectively solved. In usual practice of development of learning materials, teachers or other experts create didactic solutions and hand them over to the game designers. Our students work in the project on the basis of the competences, acquired in the previous studies, and have to master both content and didactic aspects as well as technical solutions. So it makes sense that they themselves also carry out a specification phase.

Students document all project work phases and at the end of the project submit the project documentation together with an elaborate game for assessment. During project activities, students in groups write a log, where they report their observations about sharing and the organization of the work and about other details that provide the professor insight into the dynamics of teamwork, the perception of potential problems that are emerging, and, if necessary, appropriate immediate intervention. At the same time, such document is also an important basis for evaluating the work of individuals in the group.

In the following paragraphs we will present the individual phases of the project.

Specification
It is quite a didactic task. At this stage students on the basis of their experience identify "weak points" in the traditional teaching and learning of selected topics, where they and their pupils need help. Taking into account the curriculum, they determine learning outcomes and the didactic method or game technique, which will serve in the later stages of the project to design and develop game elements. It is very helpful if the authors formulate at least a rough idea of the story which will later be the basis for writing a scenario. The story defines time and place of the events, characters and various artefacts that appear in the story, and the links between them, along with the plot and challenges that are at the core of the story. This specification can then be transmitted to a team that will develop the game. In our project the same group of students appear in both functions.

Analysis
In the analysis phase, students collect and analyse all relevant information for game design and implementation. In addition to data from the specification phase, there is information about available resources, users and the environment where games will be used. Resources that are needed for the production of games include software tools for the preparation of the story and script. When analysing the learning objectives we are mainly interested in the expected taxonomic level of knowledge, appropriate instructional methods and appropriate game techniques. Based on the results of the analysis, students prepare work plan and timing for the remaining phases of the project.

Design
Learning objectives may be associated with different types of skills. In our work we have relied on the taxonomy developed by Kapp [20], which includes the following categories: declarative knowledge, conceptual knowledge, knowledge-based rules, procedural knowledge and so-called soft skills. For each type of knowledge, experts identified appropriate teaching approaches and game techniques.

Students acquire *declarative knowledge* mainly with memorization. Examples of such knowledge are different facts, data and terminology. It represents the basis for the acquisition of knowledge on higher taxonomic levels and students must learn it first. Learning declarative knowledge is largely based on the behavioural theory of learning.

Methods for learning the facts are the integration of new information with the existing one and showing the relationship of new facts with the existing ones in a given context. We may also use techniques of sorting and

organization with which students allocate facts or objects into logical groups, or chunking, where large amounts of data or facts is organized in smaller units. One of the known methods is linking with which students associate names with images or concepts with their definitions. A very traditional method is also repetition. These teaching methods can be more or less indirectly "mapped" in the relevant game techniques. In the case of declarative knowledge, such techniques use stories, sorting and coordination as well as repeating gameplay.

Since prehistory, stories have been used to transfer knowledge between generations, even by at that time still illiterate people. Today we can also theoretically explain why such a form was suitable. Cognitive psychologists have found that the brain has affinity for the construction of stories. We remember facts better if they are told as a story than if they are communicated in any other form, for example, in the form of a list. Thus, even legal arguments are more convincing in a story than in a formal form.

Conceptual knowledge is based on understanding concepts, which are a form of association of similar or related ideas, events, or objects that have common attributes. Examples of such concepts are free market in economics, mathematical proofs and virus, worm, and Trojan horses in computing. Traditional teaching strategies include the use of metaphors, examples and counter examples, and classification of attributes. If this strategy is transferred into a game, we get proper game techniques that enable us to achieve similar learning goals. Such techniques are sorting or organizing elements and content according to their attributes, "experiencing" the concepts about which players learn, and "experiencing" examples of these concepts. Sorting and editing in this context is not based on memorization, but on the understanding of concepts. From these facts it is evident, therefore, that the learning objectives are on higher taxonomic levels. Even when experiencing the concepts, players must understand abstract concepts and then use this understanding in a variety of concrete situations in practice.

An example of games developed by our students that help the player in the acquisition of conceptual knowledge was presented in [21]. It is called Planets of variables. Its main goal is to understand the concept of variables and assignments in computer programming. It is intended for pupils in primary school. There are many learning goals in the game. Notable among them is the aim that the pupil, after playing the game, understands the idea of variables, knows that the variable has a name, is aware of the fact that different data types are not compatible, knows that different types require different memory sizes, is familiar with assignment sentences, knows what the value of the variables is after the assignment, and can predict the values of variables after the execution of the work program with more assignments. All of these objectives are hidden in the game with more episodes. Its story takes place in a universe where mysterious space creatures are engaged in delivery of various goods to users on different planets. The player helps aliens in solving various logistical problems, and incidentally learns about the rules that are defined in the

learning objectives. The challenge of the game is to complete all planned activities for which it is necessary to understand the abovementioned concepts. To make the game more challenging, the time that players spend on problem solving is measured, which represents an additional performance measure.

Knowledge based on rules is the next taxonomic level that is known in Kapp's categorization. By definition, the rule is a statement that expresses the relationship between the concepts. The rules define the parameters that dictate the desired behaviour with predictable results. An example of such rules is etiquette. Learning strategies that are most commonly used in this type of knowledge is illustration with examples and role-playing. If we use games, the most appropriate techniques for such knowledge type are simulation of tasks, experiencing consequences of non-compliance with the rules, and sorting and classification according to certain rules.

Simulation of tasks is a very common form of serious games. There are no strict boundaries between conventional simulations and games based on simulations. Typically, the latter contains an additional motivation in the form of a story added to it, which can further increase the interest and challenges. Simulation allows the player to encounter a customized virtual reality, which allows adjustment of the complexity of the situation and control, while allowing the implementation of activities that would be is too dangerous (or too expensive) in the a world. Otherwise, the various forms of simulations of driving, shipping or flying are known for a long time in the education of drivers, sailors and pilots. Even the operation of nuclear power plants or dangerous chemical process in practice cannot be done just for practice. Today's performance of multimedia technology increases the realism of the action and lowers the price and availability of such systems. Therefore, they are often also used in the activities in the field of protection and rescue, in the health sector, in public administration and even in business studies. Experiencing the consequences of compliance with the rules is just an extension of these simulation processes. Sorting and organizing, which we already encountered in both types of skills previously discussed, are here associated with the application of the rules.

Procedural knowledge is the sequence of steps that need to be done in the right order to reach a selected goal. Learning strategies for acquiring such knowledge is beginning with "big picture" and learning "how" and "why". In serious games, these strategies are translated into techniques such as carrying out exercises by following the procedure in difficult conditions, presentation of the challenge, which is achieved through instructions, and experience with the procedure in various forms of performance, which includes playing the demo, training, and various game modes (e.g. test mode, free mode).

Based on the results of specification and analysis phase, and taking into account the recommendations about the selection of game techniques, students can enter into writing stories that will allow the inclusion of specified learning objectives and will represent the basis for a game

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Sersious Games
10 -11 2015 | Volume 2 | Issue 6 | e6

scenario. This is certainly one of the most creative phases of the project. In a scenario, all the details of the game have to be described, from the scenography through a description of all characters who appear in the game, to dialogues and, if necessary, any other individual details of the story. Typically, the script also includes drawings of all key elements of the game, which need to be developed in the next phase.

Development

In this phase, students develop the game. It means that they have to create scene artefacts and all occurring characters with the use of various graphical tools. Students tackle these time consuming tasks in different ways. Some of them create all of these graphic elements using the selected software tools. It requires a lot of skills and knowledge of the technology of work, but then further processing of graphical elements is much easier. Others draw key elements on paper and then digitize images. Especially for characters that are animated in a game, this work is time-consuming because it is necessary to draw each character in different positions and from different angles. Designed graphic elements must then be uploaded into a game machine. This is a program that supports animation, dialogues, and player's interaction with the game environment. The technology is progressing rapidly and we try to follow it and select the solutions which enable students to give the maximal attention to the didactic aspects, while the computer takes care of the technical aspects of the realization of games. Recently, students have used the e-Adventure environment, which was developed at the Universidad Compultense de Madrid. We cooperate with the authors of this tool in different European projects and, therefore, we have access to the latest versions of the software and the opportunity to influence the development of new capabilities of the tool.

Implementation

Implementation in the context of our project is the application of serious games in a learning process. Students take their games, which have been designed and developed in the framework of the project, when they go to practical education in schools. During their teaching practice they integrate them into the learning process. In spite of some difficulties, it is a very rewarding experience for teacher students as pupils are usually extremely motivated to learn with games. How to integrate games into their teaching depends on many factors and is specific for each game. The general problem is the limited time that can be devoted to the game, so it is usually played in the classroom only as an introductory motivation or for illustration of selected phenomena. In general, it makes sense to use games especially in the cases where it is difficult to achieve learning goals with the traditional methods. Students then often play serious games at home. It is very important that after such home activities the teacher plans relevant reflective activities at school as this is the only way to achieve the expected learning goals.

Evaluation

We evaluate the whole process of game development together with students, as it is one of the most important learning activities in two of the key courses of our study programme and it includes a large set of learning goals. We explain students that the game they have developed in the course is actually just a side effect of their learning process.

Students who design and develop a game must also evaluate the game itself as well as a learning process, in which the game is integrated during practical training at school. Students first use peer evaluation in the so-called beta testing. The next step is gamma testing in a school. Students interview pupils about their opinions regarding the comprehensibility of the game, and evaluate the effectiveness of learning by means of selected experimental methods. Students monitor and observe all the activities in the classroom and discuss them with teachers. All collected data are then used for revisions and improvements, if needed. Summarized results are also used to evaluate to what extent the goals, set in the specification at the beginning of the project, were achieved.

7. Conclusion

The results of the project work with students of the Faculty of Education, University of Ljubljana, in the last five years have shown that serious games are a very effective learning technology. For students, serious computer games are particularly challenging as they produce serious games as part of their study activities and they have to demonstrate a large set of competences to be successful. They must use and integrate their knowledge of general didactics subjects and knowledge in the field of computer science. In addition, they have to learn about planning and carrying out project work, practice team work, prepare relevant project documentation and user instructions, and test and evaluate learning materials and learning processes.

The use of games can be justified by all relevant theories of learning. They can be used for all age levels and in all forms of education. However, this applies only to properly designed and constructed games and to appropriate teaching approaches in the classroom, which together can ensure effective learning.

References

[1] Clark, R. C., & Mayer, R. E. (2011). *E-Learning and the Science of Instruction*. San Francisco: J. Wiley & Sons (Pfeiffer).

[2] Ainslie, E., Carswell, L., Bernat, A., Deveaux, D., Frison, P., Meisalo, V., Meyer, J., Nulden, U., Rugelj, J., & Tarhio, J. (1998). Development and use of multimedia and Internet resources for a problem based learning environment. *ACM SIGCSE bulletin*, *30*, 45–60.

[3] Lapuh Bele, J., & Rugelj, J. (2009). Comparing efficiency of web based learning contents on different media. *International journal on emerging technologies in learning (IJET)*, *4*(3), 31–35.

[4] Fåhræus, E. R., Chamberlain, B., Bridgeman, N., Fuller, U., & Rugelj, J. (1999). Teaching with electronic collaborative learning groups. *ACM SIGCSE bulletin*, *31*, 121–128.

[5] Hansen, T., Dirckinck Holmfeld, L., Lewis, R., & Rugelj, J. (1999). Using Telematics to Support Collaborative Knowledge Construction. In P. Dillenbourg (ed.), *Collaborative learning: cognitive and computational approaches* (Advances in learning and instruction series). Amsterdam [etc.]: Pergamon.

[6] Rugelj, J. (2000), Collaborative Virtual Environmental For Problem Based Learning. In G. Orange & D. Hobbs (ed.), *International perspectives on tele-education and virtual learning environments,* 140–155. Aldershot [etc.]: Ashgate.

[7] Clark, R. C., Nguyen, F., & Sweller, J. (2006). *Efficiency in Learning: Evidence-Based Guidelines to Manage Cognitive Load*. San Francisco: J. Wiley & Sons (Pfeiffer).

[8] Mayer, R. E. (2009). *Multimedia Learning*, 2nd ed. Cambridge [etc.]: Cambridge University Press.

[9] Whitton, N., & Moseley, A. (2012) *Using Games to Enhance Learning and Teaching: A Beginner's Guide.* New York: Routledge.

[10] Whitton, N. (2009) *Learning with Digital Games: A Practical Guide to Engaging Students in Higher Education.* New York: Routledge.

[11] Barab, S., & Squire, K. (2004). Design-Based Research: Putting a Stake in the Ground. *Journal of the Learning Sciences*, *13*(1), 1–14.

[12] Van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N. (2006). Introducing educational design research. *Educational design research, 1*, 3–7. New York: Taylor & Francis e-Library.

[13] Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development*, *53*(4), 5–23.

[14] Mor, Y. (2010). *A design approach to research in technology enhanced mathematics education*. *I Can*. London: Institute of Education, University of London.

[15] Walker, D. (2006). Toward productive design studies. In V J. Van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (eds.), *Educational Design Research*. Abingdon, Oxon: Routledge.

[16] Prensky, M. (2001). *Digital Game-based Learning*. New York: McGraw-Hill.

[17] Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience.* New York: Harper & Row.

[18] Malone, T.W. (1981). What makes computer games fun? *Byte, 6(12)*, 258-277.

[19] Forest, E. (2014). The ADDIE Model: Instructional Design. Frameworks and Theorie. <http://educationaltechnology.net/the-addie-model-instructional-design>.

[20] Kapp, K.M. (2012). *The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education.* San Francisco: Pfeiffer.

[21] Zapušek, M., & Rugelj, J. (2013). Learning programming with serious games. *Game-Based Learning*, *1*(13).