INNOVATIVE AND FLEXIBLE FORMS OF TEACHING AND LEARNING WITH INFORMATION AND COMMUNICATION TECHNOLOGIES

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Abstract: *This article presents a project for the modernization of study programs for teacher education by introducing innovative forms of learning using ICT, which is carried out at the University of Ljubljana. A pilot project for the implementation of the updated course for future computer science teachers, based on game-design learning and on trialogical approach to learning, is presented.*

Keywords: *innovative didactic methods, game-design learning, trialogical learning, higher education, information-communication technology*

1. Introduction

A group of experts in didactics at the University of Ljubljana was aware of the need to introduce systematic support for lecturers and professors for innovative didactic approaches to teaching and learning using information and communication technology (ICT) for a long time, but the lack of funds and insufficient support from the leadership of the University have prevented more extensive activities in this area. Last year the university finally got an opportunity to start activities in this field as it received an invitation from the ministry responsible for education to participate in a public tender for funds from the European Social Fund in the program Innovative and flexible forms of teaching and learning in the pedagogical study programs. There were finally funds available for the implementation of the project on modernisation of teaching and learning activities at faculties of the University of Ljubljana, which offer study programs for teacher education.

Lecturers and professors involved in the education of future teachers need to have priority in these activities, as they have more experiences in innovative didactic approaches and they contribute significantly to the development of skills and knowledge regarding the use of ICT in learning process that future teachers must acquire during their studies. They have also a significant indirect impact on gradual improvement of the quality of teaching and learning in Slovenian primary and secondary schools.

Preparations for the implementation of the proposed project have been under way for several years. Prior to the project application, they included the identification of active research groups and individuals in this field and joint design of project

objectives (Rugelj, 2013). An international summer school for postgraduate and doctoral students on active forms of learning with ICT, called ALICT, was organised with participation of professors and students from the South-West University "Neofit Rilski" from Blagoevgrad, Bulgaria, and from University of Agder from Kristiansand, Norway (ALICT, 2014).

Research group from the Faculty of education participated in the Erasmus+ project Creative Classroom, in the framework of which innovative forms of teaching and learning using ICT were introduced together with partners from universities from Estonia, Finland, and Croatia for teachers from Estonia. The final results of the project with examples of good practices and developed multimedia learning materials in English are available to all interested teachers around the world (Creative classroom, 2016).

2. Project on ICT in study programs for teacher education at UL

Within the framework of the project, research and development work in the field of subject didactics and the integration of new technologies into teaching and learning continues. Researchers from the University collaborate with reputable universities and international institutions in the field of research and development and in identifying good practices and achievable goals in comparable environments.

In the preliminary analysis, the faculties have proposed a number of activities for raising students' competences and the efficiency of the use of ICT. Most significant are the following:

- increased use of ICT-supported equipment for the purpose of measuring, monitoring, diagnosing, evaluating;
- improved didactic use of interactive whiteboards;
- development of interactive multimedia teaching materials suitable for modern strategies and learning methods (reverse learning, validation detection, learning by research, mobile learning, ...);
- introduction of physical computing with the emphasis on contextualisation and conceptualization of ICT use;
- employment of 3D modelling for early technological literacy already at the level of pre-primary education and the first year of primary education;
- expansion of interdisciplinary approaches to raise innovation across the entire vertical of education;
- introduction of ICT-supported experimental work in a real, virtual, and remote laboratories.

These activities will contribute to improving learning, increasing the digital literacy of students, and improving their competences needed for competitive participation in the labour market.

2.1. Analysis of the current situation

In the framework of the project, an in-depth analysis of the situation was made in eight faculties and in academy that carry out pedagogical study programs. Academy of Music, Biotechnical Faculty, Faculty of Chemistry and Chemical Technology, Faculty of Mathematics and Physics, Faculty of Computer and Information Science, Faculty of Sport, Faculty of Arts, Faculty of Education and Faculty of Theology participated actively in the preparation of the methodology and instrumentation, as well as in the empirical research and in the preparation of the report. Examples of good practices for the use of ICT were studied using the method of interviews with representatives of "advanced teachers". A group of experts developed a questionnaire on teachers' experiences of the didactic use of ICT and on the need for modernisation of study programs in order to ensure that graduates will have basic knowledge about didactic use of ICTs in individual fields of expertise and will be able to recognize the potential of ICT for achieving higher reading literacy among pupils and students. Students were also included in the survey.

2.2 Training and other support for participants in the project

The results of the analysis were the starting point for the preparation of training for the participants in the project as well as for planning the adaptation of methods for conducting lectures and seminars with the support of ICT. An analysis of the situation in comparable academic environments in other EU countries, where technology is used in an efficient and professional way, also contributed to the development of foundations for the didactic use of ICT.

Trainings in seminars, workshops and mutual hospitations were prepared for participants in the project at several levels of complexity, taking into account their previous knowledge and specific needs. Trainings have been carried out by the experts for didactical use of ICT from our university and from different institutions from abroad. We have also organized three internal conferences with the aim of presenting the project's activities, didactic use of ICT, and good practices in various fields.

After that, with the support of groups of experts, professors and lecturers have developed modifications of their teaching methods in their courses and then test implementation of a pilot course with students. Adaptations focused on the thoughtful use of ICTs in order to encourage future graduates to develop the skills and knowledge of didactic use of ICT in the learning process. In all these activities, professors and lecturers had support from the experts in didactics and in technology from our centre for innovative didactical approaches with ICT.

3. Pilot implementation of our updated course

In the following sections we will present a pilot implementation of the modified course "ICT supported learning materials". The course was renovated and

modernized with the introduction of active forms of learning, especially in the form of independent project work in small groups of 3 to 4 students.

Students designed and developed a didactic computer game, thus integrating knowledge in general and subject didactics as well as information and communication technology skills. We introduced an **active learning** approach (e.g. project work in groups) and **trialogical learning** principles. The trialogical learning plan consists of forms of learning in which students collaboratively develop, change or create common artefacts in a systematic process. It focuses on the interaction that occurs with the creation of concrete artefacts, not just between people ("dialogical approach"), or within one's mind ("monological" approach)" (Paavola & Hakkarainen, 2005).

The process of creating games is based on to the SADDIE method (Specification, Analysis, Design, Development, Instructional and Evaluation), which defines the stages of development of educational materials and we developed it at the Department of Computing and Didactics at PeF UL (Rugelj, 2015; Zapušek & Rugelj, 2014).

The educational game has, in the trialogical learning sense, the role of artefact, which students have to design and develop to the final product. During the design and development phases the entire process is described in the project documentation. Students use the online project coordination system Zoho to plan work, record results, communicate, share materials and collect project documentation.

The final game is not the most important objective of the course, since the process of creating educational games is designed in such a way that students acquire more general pedagogical competences such as abilities for project management, for computer-aided collaboration and group work on distance, for selection of appropriate didactic methods, for instructional design, and for critical analysis and evaluation.

Students prepare project documentation in all phases of the project, which shows the extent to which students have acquired competences (didactic and technical) for the independent development of learning materials. Didactic competences are assessed according to the appropriateness of chosen learning objectives for the game, the relevance of learning objectives according to the selected taxonomy, the meaningfulness of selection of activities for achieving selected learning goal, the correctness of linking learning goals with the objectives of the game, and consistency in the respect of the rules for the preparation of learning materials. We will be interested in the analysis of the final game, we will review the beta and gamma test forms and find out how they were taken into consideration. We will also evaluate technical competencies that will be gained in the course, such as the smooth gameplay without errors, the quality of graphics, animations and sound, and the intuitiveness of user interface.

In addition, students write a project log where they describe activities in the group, present organization of work in a group and describe how the communication in the

group took place, describe problems they encountered, critically evaluate each individual's contribution to the project and about other details that allow the professor to inspect the dynamics of team work, to detect problems that arise thereon, and when necessary also appropriate intervention. At the same time, such a document is also an important basis for assessing the work of individuals in the group.

3.1. Game development process in the course

Students independently formed groups and identified learning goals in computer science curricula for elementary or secondary schools that pupils find difficult to achieve according to their experience. In such cases, the use of didactic games is justified, although for their implementation we need more time than with traditional forms of teaching and learning (Whitton, 2005).

The project work is based on the SADDIE method, which we developed for this purpose, and is an extension of the ADDIE method developed in the 1970s to prepare educational material in the US Army (Forest, 2018). This model is the basis for most of the models that they use today in the development of educational content.

We added Specification phase to the above mentioned phases at the beginning of the development process, in which students identify the problem in the learning process that can not be effectively solved by traditional methods, define specific learning objectives and suggest an innovative didactic method or game technique, through which this problem can be resolved more efficiently. In the usual practice of developing teaching materials, teachers or other authors formulate didactical solutions and hand them over to the material's creators. Our students must master both the content and the didactic part as well as the technical solutions on the basis of their previously acquired competencies, therefore it makes sense to carry out this phase on their own as part of their activities in the project.

The whole game design and development process that was used in our course is presented in the chapter entitled *Serious computer games design for active learning in teacher education* in a monograph *Serious games, interaction, and simulation,* published by Springer verlag (Rugelj, 2015).

This technology is rapidly progressing and we are trying to follow and select such solutions that enable students to dedicate themselves to the most important didactic aspects, and the technology provides most technical solutions in game realization.

Implementation is in the context of our project the use of educational games in the learning process. Students prepare their games that they have designed and produced in the framework of the project. The "pedagogical package" contains all the necessary instructions for including the game in the classroom. These are all activities that need to be done with pupils before using the game, while playing the game and after playing and can be designed and stored in the LePlanner environment. In the

next semester, our students will, during their teaching practice activities, take their games to schools and test and evaluate them in classrooms.

The method for integration of serious game into a classroom is specific for each game. This topic is discussed in more detail in (Rugelj, 2015).

3.2. Technology used in the project

In the pilot project we used two different development environments that are designed for the development of games. They differ in the ease of use, the number of functionalities they offer, and complexity of the games that can be made with them.

The first tool we offered was **e-Adventure**. e-Adventure is an open source development environment and game machine for Windows and Mac operating systems, developed by the e-UCM research group at the University of Madrid. This group deals with the development of serious games for education and medicine. The program is designed to create adventure 'show and click' games, based on an interesting story, on collecting and using items, solving puzzles and on rich dialogs. The e-Adventure program is very easy to use, it does not require programmatic knowledge and greatly simplifies the making of the game. Its biggest drawback is a limited set of functionalities.

Another development environment that we have proposed to students is **Unity**, which is a game development environment for Windows and Mac operating system, designed to produce complex games. It requires from users fluency in C# or Java programming language. With this tool it is possible to produce 2D or 3D games of any genre and complexity. It is possible to implement practically any functionality with it. Fortunately, it offers a library of already written scripts that can save developer's time. Unity can be used free of charge by students.

We found that the specific digital competences, important for our students, are: 1) the ability to communicate and collaborate with digital technologies; 2) the ability to create and modify digital content; 3) knowledge about intellectual property and its application in practice; 4) the ability to solve conceptual problems and problem situations in digital environments.

3.3. Student projects

During the semester students developed four educational games that covered various computer science topics. We want to expose a project that exceeded pilot requirements and demonstrated excellence in pedagogical and game design. History Journey is an educational game intended for learning how to program in a block structured programming languages (e.g. Scratch, Blockly, Snap!). It was developed with Unity and uses stylish 3D graphics that resembles popular block toys. Story, graphics, learning goals and difficulty were selected in a way they are suitable for 9 to 12 years old pupils. It covers the following learning goals: 1) Students are able to

express the solution for the problem in a sequence of predefined commands; 2) Students are able to represent a simple task with an algorithm; 3) Students can design an algorithm based on instructions written in simple text; 4) Students are able to evaluate the efficiency of different algorithms for the same problem.

The story begins with a scene where main character, *Vinko Historian,* is taking a history test at school. Something extraordinary happens and Vinko and his friends are teleported back in time to the old Egypt era. His main objective is to figure out what happened and to return everyone safely back to the present time. Player is confronted with serious of quests that are designed in a way that the knowledge of corresponding learning goal is needed in order to formulate the correct solution. For example, player has to make an artificial leg for *Onelegged Gogi*, who lost his leg in a vicious dinosaur fight. In order to complete this game goal he has to write an algorithm using blocks that represent Vinko's actions (e.g. "turn left", "go 10 steps", "pick up an item", …) using knowledge defined in learning goals. If the player is successful at completing the game goals he implicitly proves he achieved the corresponding learning goals.

3.4. Student evaluation of the upgraded course

11 out of 12 students who attended the course ICT supported learning materials during winter semester of the academic year 2017/18, participated in the evaluation. The number of students involved in the survey is small, but this is our reality for years. We received valuable information from open questions where students described their opinions descriptively.

We used 5-point Lickert scale in our survey. In the first question we asked students whether they understood the content in the course better because of the use of ICT. 70% of students answered that they agree or completely agree. The average score was 3.8, with standard deviation 1,1, which we consider to be a good result. When they were asked about the quality and efficiency of implementation of learning activities, the resulting average score was 4.0. The result shows that students evaluate the performance of the activities as very well and no one was unsatisfied with the performance. Very similar results we got for a question that examines the attitude of students to the use of ICT in the course, where average score was 3,9 with standard deviation 0,9. In the fourth question, students express their opinion on how successfully professor integrated ICT in the implementation of the course. The average score was 4,3 with standard deviation 0,7.

The rest of questions in the survey were open ended. They give us more qualitative data, with respondents' opinions and experiences.

Among the key advantages of using ICT in the implementation of the course, students emphasized the possibility of active communication among the members of the group online, without the need to meet physically. They liked the practical use of tools for creating different materials for educational game (e.g. characters, artefacts,

scenes), as well as the game itself. They estimate that in this way they learned more than learning only the functionality of the tool without its meaningful application to a real problem. In the use of ICT, they see the enrichment of teaching and learning activities because they have a positive effect on their motivation for learning. They repeatedly pointed out in their answers that they liked the fact that in the learning process they themselves developed an educational game that they published on the web and thus offered it to others for use. They liked the use of cloud services because they made it easier to share files and record versions.

Among the suggestions for future updates of the course, they told us that they liked it because they learned a lot about the latest technologies in the course and that the course should be updated regularly when the new ones appear. Students want more activities in the course that deals with video recording and processing, and more options to choose from game development environments. They suggested more collaboration with students from other study programs to increase interdisciplinarity in game development, which we consider to be a very positive result.

The students gave the most answers to the question about the use of the acquired knowledge in their future work in the classroom. They pointed out that the learned knowledge is not useful only in the teaching context, but that they have acquired knowledge that makes them more competitive in the labour market. They emphasised the acquired knowledge in the field of computer graphics, which they believe will be useful for teaching. Students also noted that in addition to professional knowledge, they also developed competences for cooperation with members of the group, as they had to communicate in the course of their work, exchange information, divide the work, and take into account deadlines. The activities connected to games motivated them to use games in their teaching, because they realised it is an innovative way of teaching, which can help in more effective teaching in many different courses. They like the fact that they can actively engage pupils in the learning process through the game play.

The last question in the survey was about the student proposals where they would use ICT to achieve objectives from primary or secondary school curriculum. The answers are very interesting. Many of them believe that ICT could be applied to any topic, while it is evident from the answers that they are aware that the activities should be carefully planned. They emphasize that ICT should only be used when it supports learning and contributes to achieving learning outcomes. Among the concrete suggestions they pointed out the possibility of using ICT in astronomy, as they could illustrate movement of objects with animations, and using objects for observing stars to search for objects in the night sky. Many see the advantage of using educational games for illustrating complex models or processes, modelling, manipulating and observing the behaviour of the system. They are aware that, through educational games, we can design scenarios that facilitate the understanding of complex, heavier learning contents.

4. Conclusions

We discussed with our students about their impressions and experiences at the end of the course. From their responses we can summarize, that they were highly motivated to produce a very good game, and that they therefore studied additional learning materials and other sources. They were delighted to experience the whole process of creating a complex project and thus learned how to work in the group, as they had to plan, participate and help.

We believe that using the trialogical method of teaching we have met the challenging learning objectives of the course and have even exceeded them. Students were highly motivated to work, since they for the first time designed and created the game by themselves. Thus they achieved all the foreseen learning goals of the course. The advantages of this approach were that students have been actively involved in the learning process, and most of the time they were in various interactions with each other, with lecturer, and with the game they produced. It would be difficult to achieve the same level of attainment of the envisaged learning objectives equally with any other method. All the games created in the course can be found on dedicated web portals http://hrast.pef.uni-lj.si/zipug and http://hrast.pef.uni-lj.si/games

One of the problems we observed during the implementation of the project was a great complexity of the Unity program, which required excessive efforts from students and prevent them to dedicate more time to didactical aspects of game design. In the future implementations of the course, we will use another game development tool, that is less complex than Unity, but offers more functionality than e-Adventure. We decided for the Visionaire Studio environment after a careful review of the available tools. It is designed to create adventurous, "show and click" games, it does not require advanced programming skills for use, it provides a wide range of embedded functionality and offers a way to write the code.

In the future, we are going to link activities in the course with other courses, where students could participate anyhow in the development of educational computer games to share their ideas, skills and knowledge. We believe that the use of the trialogical learning concept is a good option for many other courses, since it comprises most of the important elements of the up-to-date learning process.

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