Achieving Teachers' Competences in the Serious Game Design Process

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Abstract: The main goal of this paper is to present ‘SADDIE’, the methodology for designing educational games that was developed at the Faculty of Education, University of Ljubljana and defines indicative phases for serious game design project that is implemented as a two-semester project in the course "Application of ICT in education". The methodology is carefully designed and its application has various positive outcomes. Serious game as a final product is just a side effect of the more important goal, i.e. achieving competences that are crucial for teachers. Such competences include the ability to determine learning objectives that are consistent with the curriculum, the selection of appropriate teaching approaches and their implementation in the learning process, preparation of feedback for students, evaluation of acquired knowledge and evaluation of the learning process.

Keywords: serious game design, teaching competences, SADDIE method

1. Introduction

At the Faculty of Education of the University of Ljubljana we always try to find new innovative approaches to efficient use of information and communication technology to support deeper learning, have better learning outcomes, and to find possibilities to facilitate knowledge transfer for topics that are complex and hard for students to understand. About six years ago, our interest was evoked by rapidly evolving research area of educational computer games. In the beginning, we were sceptical because we were not confident that games can be efficient for learning. There were a lot of research projects proving that students enjoy playing games in educational setting, but their results were not significantly better compared to the students who learned traditionally (frontal approach, using textbooks, learning from notes...). Intuitively this was hard to believe because we considered educational games as a great example of manifestation of constructivist learning theory principles. Interacting with a game environment puts student in the role of active learner and also creator of the new content and as long it takes place in enjoyable context and provides useful mastery it should yield good learning outcomes in terms of achieving higher taxonomic levels of knowledge. After carefully studying the most significant literature from the research field of learning with games we acknowledged that educational games have great learning potential but only if they are properly designed (Whitton 2009). There have been a lot of different approaches, methods and ideas developed on how to organize the process of designing and developing educational game from the initial idea into to final product. We could not agree completely with any of them so we decided to develop our own method - ‘SADDIE’. It is based on ‘ADDIE’ (Forest 2014) instructional design approach that was developed at the Florida State University in the seventies and was used for designing learning materials for American army. Our main focus while designing the method was on creating educational games with a high learning value but it turned out that the method had in fact two important outcomes. The first outcome is serious game itself. This is a side effect of the main goal, which is to motivate our students to work actively and to learn in an efficient way through carefully refined process of active engagement in the game design and production process. The second outcome is student’s improvement of the competences that are crucial for teachers. Such competences include the ability to determine learning objectives that are consistent with the curriculum, the selection of appropriate teaching approaches and their implementation in learning process, preparation of feedback, evaluation of acquired knowledge and evaluation of the learning process.

2. Serious games design project

Serious games design is implemented as a project in our two-semester course "Application of ICT in education" with a total of 8 ECTS credit points. It means that the students are supposed to spend between 220 to 240 hours in the project activities. The main idea of the course is to combine all didactic and technical knowledge that students acquired during the studies at the faculty and apply it in a relatively complex project. Students work in groups of 3 or 4 students. Students are supposed to distribute work accepting different roles and different types of organizations. In some groups there were exposed leaders and in others the responsibility
was shared among all members (Fähræus 1999). According to constructivist learning theory, the course has very limited number of traditional lectures. Students have to follow ‘SADDIE’ methodology that defines framework phases and other incidental activities. This method has been used with approximately 100 final-year students during the 6 years period. In the introductory phase, the main project requirements are presented by the lecturer and some general rules about the learning goals and about organisation of work are defined. Later, during the project, students report on the progress of work, the teacher gives feedback. If difficulties arise, the teacher explains what could be the reasons for a problem and gives some hints or suggests possible ways to solve them.

3. The SADDIE model

SADDIE (Specification, Analysis, Design, Development, Instructional and Evaluation) defines the framework phases of the model. It is based on ADDIE model but with important differences. The game design begins with the specification phase where students choose the topic from computer science curriculum for primary or secondary school. They are instructed to identify learning goals that are complex and challenging for students or the ones that are very important in general. They have to consider if the students could benefit from presenting the topic in a game format and make a didactic foundation for later stages of the project. It is highly recommended that students roughly define the game basics in this phase: time and place of the events, characters, artefacts, challenges, rules and goals. They should also ensure that game is funny, it provides some sort of competition or conflict, and it is entertaining and recreational. After this initial phase they have to submit a document in which they present: a short presentation of the selected topic with arguments for their decision, a brief description of a gameplay, a list of specific learning goals from the official curriculum, motivational elements, specific methods for achieving the learning objectives (i.e. method of: explanation, discussion, practical application, clarification...), the assessment of learning, tools for communication, collaborative work and the suggestions on how to incorporate game into learning process.

Some examples of the selected topics in the previous years are: 2D arrays in Pascal Programming language, Dijkstra algorithm, the meaning of functions and procedures in programming, comparing efficiency of different sorting algorithms, responsible behaviour when using social networks, software threats on internet, ...

We have upgraded ADDIE model with the specification phase as our students are future teachers and they need to achieve the competence for selecting challenging learning goals and integrate them with the appropriate didactical approach and gaming mechanism into an educational game format.

The analysis phase focuses on analysing the specification and preparing all the information needed for implementation phase. Students have to decide on target audience, level of difficulty, graphics, characters, interface and gameplay itself. They have to consider available resources for implementing their ideas and make compromises. SADDIE extends analysis phase from ADDIE with the crucial stage of designing educational games. The key idea is to blend learning content into the game context in such a way that no important details are lost or that translation would confuse or blur the learning content. The goals of a game should support understanding of the main concept in a different, more exciting way that is familiar to target audience and as such can ease the knowledge transfer and reduce cognitive load (Clark 2006). Progression throughout the game is possible only if player properly understands the concept, "hidden" in the game.

Otto’s index is one of the best educational games that were developed during this academic year and will serve as an example to illustrate the process. The game is about a boy who is taking care of his dog (game scenario). It is designed to teach basic concepts of one- and two-dimensional arrays in Pascal programming language (learning unit). Students cautiously combined two seemingly unrelated topics (caring for a dog and data structures) in order to present relatively complex programming concept in a new setting that is more familiar to pupils because it contains examples and activities from their real life experiences.

Learning goals with connected game goals (activities) that are covered in game are:

<table>
<thead>
<tr>
<th>Learning goal</th>
<th>Activity</th>
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<tr>
<td>Student gets familiar with one and two dimensional arrays</td>
<td>All layouts in the game (map of the village, bicycle racks, shelves in the store...) represents arrays.</td>
</tr>
<tr>
<td>Student can recognize the concept of 1D and 2D array in everyday life</td>
<td>On shelves are just products of the same type (drinks,</td>
</tr>
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</table>
Learning goal “Student knows how to search for an element by value in 1D array” is translated into activity where boy Lenart (main character) is looking for a specific drink. Drinks are stored on a shelf behind a dimmed glass so player can’t see the bottles. Player is allowed to push the glass one place to the right at a time and this allows him to observe bottles sequentially. When he finds the right bottle, there is no need to look further; so the search is over. This activity is consistent with a concept of how computer looks for a value in an array.

In the design phase, students have to follow the rules adopted from ADDIE. In addition, they have to use Kapp’s taxonomy (Kapp 2012) for classifying the game goals. Kapp’s classification defines the following categories: declarative, conceptual and procedural knowledge, knowledge based on rules and some other, so called ‘soft skills’. Each goal is classified this classification and appropriate game mecanics is selected according to Kapp’s recommendations. For development phase we decided to choose the e-Adventure game machine, which has been developed in a research project at the Universidad Complutense de Madrid. It provides efficient tools for developing complex adventure games with just basic understanding of programming.

Development is followed by implementation and evaluation phase. Each game that was developed in the framework of our course was tested in a least one of Slovenian primary schools and there were usually at least 100 pupils involved in a test. Pupils were randomly divided into two groups. Both groups have to perform a pre-test in order to detect their prior knowledge and a post-test to identify the improvement. First group learned with a game and the second one with the resources from the Internet or from textbooks. The results of evaluation are quite promising. In most cases (85%), the first group showed statistically significant better improvement in knowledge comparing to the control group; they were more motivated for learning and they often played the game in their free time or at home (data from game logs).

4. Achieving teaching competences

SADDIE method is designed to foster the process of improving teaching competences that are required for our students to be able to independently design any instructional material. Students achieve didactic and technical competences as well as skills for working in a team. Didactic competences that student are expected to achieve during the above described process are: determining learning objectives that are consistent with curriculum, reflective consideration on selection of learning goals, classification of learning goals according to taxonomic levels and type of knowledge, selecting appropriate activities that support learning on preferred taxonomic level, identifying the concept behind learning objective and ability to map the core idea into another context without losing any important information and preparation of didactically sound feedback. Students also learn how to properly evaluate their work, acquired knowledge and learning process. One of the most important considerations is about incorporating educational game into learning process. The course is not focused on technical aspects of designing a game, but students usually become so motivated during the process that they individually learn about animating, manipulating visual materials, recording and editing music and sound, drawing in perspective and learning more advanced programming techniques in order to make their projects more interesting. The ability to work in a team is a relevant competence in today’s society. It is particularly important for the teaching profession, so we paid special attention to this aspect. Groups had to report on
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different aspects of collaboration in regular weekly meetings and all important activities and reflexions are collected in the log, which is written by each group during the project.

The success with teaching with educational games that have been developed in the framework of our course implicates that students who have developed a game acquired expected competences for preparing and designing teaching materials. This is evident from the resulting reports and other documents that have been prepared and submitted by the students and from the games that have been developed. Students have also participated actively in the development of the criteria for assessment of all the results and in the peer assessment process.

5. Conclusion

The methodology for designing educational games ‘SADDIE’ that was developed at the Faculty of education to create serious games and to improve students teaching competences during the process. We have been using the serious games project approach for 6 years. Many interesting ideas have been developed in this time and our course is improving as well as students' projects and the resulting serious games. The best of them are presented in our web portal <http://hrast.pef.uni-lj.si/igre>.

References

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