Educational Games and Simulations at School: Experimental Comparison with Classic Teaching Methods and Requirements of Successful Implementation into School Environment and Curricula

Michaela Buchtová[1], Vít Šisler[1] and Cyril Brom[1,2]

[1]Faculty of Arts, Charles University in Prague
Nám. Jana Palacha 2, 116 38 Prague 1, Czech Republic
[2]Faculty of Mathematics and Physics, Charles University in Prague
Malostranské nám. 25, 118 00 Prague 1, Czech Republic

Abstract. Digital game-based learning is increasingly penetrating formal schooling system; however, it is still largely unknown which game elements (if any) have the most influential effect on learning. Based on qualitative exploratory study, we present outcomes suggesting that real-world grounding, complex systems/processes simulation and teacher's attitude, are crucial elements for increasing students' learning engagement and knowledge acquisition. The study stems from focus group discussions conducted as part of a complex experiment taking place at three high-schools in the Czech Republic in 2011 (N=64; M=32, F=32). Additional data were obtained from in-depth interviews with 8 teachers (M=5, F=3) who used at least one game within their classwork. The exploratory study utilized three educational games: Orbis Pictus Bestialis (animal training); Bird Breeder (genetics heredity); Europe 2045 (EU political, economic, and social issues). The study has been conducted within a research project focusing on developing a complex educational game Czechoslovakia 38-89 (contemporary Czech history).

1 Introduction

Today, educational simulations and digital games (including so-called serious games), are used in multiple fields such as military training, medical and public health training, rehabilitation, and foreign language practicing [1, 2]. It seems that they could also support classical curricular schooling; as argued, serious games can increase motivation of learners [3, 4] and improve knowledge acquisition or skills development [1, 5, 6, 7, 8]. However, serious games pose new challenges for the educational system [9, 10, 11, 12] and while these games gradually enter schools [13], it is far from clear how to design them to improve formal schooling environment.

Our research aim was to bring data from real school environment, which can serve as the most valuable and reliable source of understanding the process of learning with

educational game and its implementation to educational curricula. This exploratory study had qualitative design and focused on learning motivation within game-based learning and on issues that play the crucial role in successful implementation of game-based learning methods to school curricula. Through the comparative design we searched for the main differences (if some) in knowledge acquisition while comparing an educational digital game with classic schooling methods.

We developed two educational games that have been successfully integrated within formal secondary schooling system: a multi-player game for social sciences Europe 2045, a complex game featuring storytelling and role-playing aspects [12, 14], and a single player micro-game Orbis Pictus Bestialis (OPB) for biology [15]. Additionally, we used the educational mini-game Bird Breeder [16]. The second part of the article describes used educational games; in the third part we focus on research methods of our qualitative study; and the discussion of results follows.

The study has been conducted within a research project focusing on developing a complex educational game Czechoslovakia 38-89 aimed at teaching contemporary Czech history.

2 Research Instruments

Europe 2045 is an educational role-playing team-based computer game. The games' aim is to improve students' several high-level skills (most notably to increase their ability to discuss, work in teams, etc.); to teach facts about EU institutions and policies; and to help build mental models of large-scale processes and sociopolitical notions such as a model of "energy dependence" or "liberalism". The game is played in multi-user virtual environment and also in a classroom, where role-playing game activities take place. Each student assumes a role of a European state leader (defines the domestic policy as tax levels and environmental protection). In the classroom, the player has an opportunity to present drafts for policy changes to the EU. The discussions about these changes are moderated by teacher. The initial state of the game is based on real-world data [14].

Orbis Pictus Bestialis and Bird Breeder are both of similar complexity and both less complex than Europe 2045. They can be classified as single player micro-games, they both present a simulation environment and they feature only limited number of gaming elements, such as game goal and, in the case of Bird Breeder, score. The topic of Orbis Pictus Bestialis is animal training, mainly major phenomena of positive reinforcement learning and basic training techniques such as behavior capturing, shaping and chaining, and knowledge of how to use a clicker during the training. The goal of the player is to train an animal – more precisely a dog, a parrot or a lemur – to perform a task [15].

Bird Breeder [16] comes from a library of educational simulations of Netlogo toolkit [17]. The game's topic is Mendelian genetics. A student assumes the role of a bird breeder (or a dragon breeder in the second level) and his/her goal is to breed a specific line of birds or dragons. The student makes decisions according to a simple genetic representation of five traits, e.g. crest or wing color, gender, or he/she analyz-

es the underlying genotype directly from the code. The game goal can be achieved by carefully selecting animals for breeding.

3 Methods

The study involved eight high-school classes in the Czech Republic. Students were involved in learning sessions with educational game/simulation. The serious game Europe 2045 was employed in three social science classes during one month of regular education. Students were engaged in the role-playing activities of Europe 2045 twice a week in a normal class (45 minutes; no computers were present) and they interacted with the game environment via computers at homes.

As opposed to Europe 2045, going through the whole scenario of Orbis Pictus Bestialis or Bird Breeder does not take longer than 20 minutes. Therefore both games were investigated as part of a half-day biological workshop, supplemented by appropriate theoretical lectures and a debriefing. Five classes from two different schools were involved: three for OPB and two for Bird Breeder.

Focus group discussions were used as the main research method for the qualitative data collection. The focus groups lasted approximately 45 minutes and took place in a separate classroom. Based on the class observation, we chose focus group participators (in each group three most active, three least active and two average active students, gender balanced), final sample comprised 64 students (F=32, M=32) in eight separate focus groups.

During the group discussions, students were also given a questionnaire to compare classic lecture and educational game on 10-points Likert-scale in the characteristics of (1) subjective evaluation of learning benefit, (2) entertaining value and (3) learning difficulty.

Data were supported by semi-structured in-depth interviews collected with eight high-school teachers (M=5, F=3) using one of three above mentioned educational games in their school curricula.

4 Results

Within the analysis of focus group discussions with students and depth interviews with teachers, several themes emerged repeatedly and indicated importance of several features which might be crucial for efficient learning and implementation of educational games into school curricula. The main thematic categories that emerged are the following: (1) Classic lecture for learning facts vs. game for building mental models; (2) Real data: enhancing learning and learning motivation; (3) Crucial role of a teacher.

4.1 Classic Lecture for Learning Facts Vs. Game for Building Mental Models

Students commented on the knowledge differences gained through an educational game in comparison with a classic lecture. Approximately one third of the students (19 in total) spontaneously declared this fact. They expressed the difference by words as "*understanding*", "*better representation*", "*view from inside*" while commenting an educational game learning experience. The classic elements of games and simulations, such as clear representation of complex processes, direct feedback on causalities of the player's behavior, and visualizing or modeling inner relations of system and/or processes – subjectively help in the developing representative mental models.

Quotations:

"Maybe I more understand the connections. If I do something in the country, what could be the consequences." (Europe 2045)

"If we only sit in the classroom and listen, we would not imagine it so well." (Orbis Pictus Bestialis)

"It gave me an opportunity to understand [genetics] *deeper. Always when somebody explains me something – even two times or three times - it's not that clear. Maybe I don't listen all the time. It's much better if I try it alone."* (Bird Breeder)

"The simulation taught me to think politically, economically. In the lesson you learn definitions, that's the difference. In the simulation you wonder how it works in reality." (Europe 2045)

In contrast to previous students quotes, in questionnaires comparing the subjectively evaluated knowledge acquisition within classic lecture and educational game on the scale from 1 = the least, 10 = the most knowledge, the average value for game was 5.8 (SD = 1.9) and classic lecture 7.3 (SD = 1.5). From the following discussion it emerged that approximately four fifth of the students perceived games and simulations mainly as a tool for practicing and strengthening the knowledge gained by classic lecture or studying text or on-line sources. This outcome can be influenced by the strong schooling tradition in the Czech Republic where the curriculum mainly focused on factual knowledge and "drill and practice" methods (there has been an ongoing school reform in the Czech Republic for the last about 10 years).

Quotations:

"The classic lecture is good to learn facts, in the simulation, we can practice it." (Bird Breeder)

"The lecture gives you more information." (Orbis Pictus Bestialis)

"The game was good because it brought us to situation which we cannot experience in real life. It is more about the feeling to try it and also to enjoy. When you try it you can remember it." (Europe 2045)

The students (31 in total) proposed a combination of classic lecture and educational game as the best learning method. Quotations:

"The game is good for practicing. To verify if you understand well." (Orbis Pictus Bestialis)

"Before, the image was hazy, the game has cleared it." (Europe 2045)

"The lecture with a game has a better effect on remembering." (Bird Breeder)

Teachers were generally more optimistic about educational value of games/simulations however there were quite large differences between each game. In the case of Europe 2045 teachers generally accepted it as an independent learning

tool, while Orbis Pictus Bestialis was in their opinion comparable to classic lecture and Bird Breeder required additional teacher's intervention.

Quotations:

"In my opinion, a classic lecture would not offer more. And if yes, only for a short term, it means that students would use the knowledge only in test and then they would forget it." (Europe 2045)

"A classic lecture and the simulation were in this case comparable. Thanks to the simulation, they could understand well and we did not need any supportive theoretical lecture. On the other hand a classic lecture is basically more time effective." (Orbis Picture Bestialis)

"I think the simulation is wonderful, it is attractive, it offers a clear image and explanation of the processes. But I still insist on the importance of theoretical explanation, because it helps me to assure that students did not miss any crucial information." (Bird Breeder).

4.2   Real Data: Enhancing Learning and Learning Motivation

Students and teachers similarly appreciated the benefits of real data incorporated in game or simulation. Approximately one fifth (12 in total) of students spontaneously commented on importance of real data, which gave opportunity to transfer the knowledge from game to their appreciation of reality. In the case of Europe 2045, not only did they appreciate real economic data but also vividness of in-game events and game feedback. In the case of Orbis Pictus Bestialis, approximately one third of students claimed they accepted the virtual dog as a real animal. Five students also complained when an aspect of a game was not as real as they would prefer.

Quotations:

"The game gave me an opportunity to explore the existing ideologies from inside, now I will be able to see the ideological and political problems from more points of view." (Europe 2045)

"I contrasted the game with my own world." (Europe 2045)

"I learned how to train a real dog." (Orbis Pictus Bestialis)

"I would appreciate a dog behaves more realistic. He might get fat while eating so much. He didn't even sleep." (Orbis Pictus Bestialis)

Teachers shared students' opinion. In addition, in Europe 2045 they appreciated the connection with current socio-political events which can possibly help to deeper knowledge transfer.

Quotations:

"Students could finally try the functions of decision-making processes and for the first time they realized what European politicians do. They know that they exist but it is hard to realize their real purpose. Also they saw the large extent and complexity of European agenda." (Europe 2045)

"All my students also read articles from real newspapers about their countries." (Europe 2045).

4.3   Crucial Role of Teacher

Teachers pointed out the importance of teacher's good preparation, instant control of learning process and last but not least a positive attitude towards the game-based learning process. To incorporate the gaming experience, teachers spent in average one hour of preparation before each gaming session. To strengthen students' knowledge, throughout lessons following the game-playing they constantly referred to game experience. Furthermore they verified a level of students' understanding of the given topic by repeated questioning. Also not every games/simulations are stand-alone educational tools, not all of them are built on a mechanism forcing students to think about the crucial processes. Some of them can be solved or even won by simple trying. This was Bird Breeder's problem in our case. Teachers need to be prepared for these situations and to be able to provide students with additional reflection to make a coherent mental model.

Quotations:

"Generally all the learning process can fail with a teacher who does not understand EU and computers." (Europe 2045)

"When I played the simulation, I did it through my knowledge of genotypes. The students were only pairing letters [genotype mark], I think they could not understand it deeply." (Bird Breeder)

5   Conclusions

The qualitative study collected data from students and teachers using educational games in their classwork. From our analysis it emerged that majority of students perceive educational games mainly as a tool for practicing and strengthening the knowledge gained by classic learning and teaching techniques. Generally they appreciate a classic lecture as one the most efficient method for learning facts, while games and simulations can in their opinion offer a deeper understanding of inner connections and factors within presented systems and processes. Teachers supported educational games as full-fledged learning tool but emphasized a strong need of constant monitoring of learning process because students can miss some important connections.

Both teachers and students agreed on positive value of real-data grounding, which can enhance learning motivation and possibly also efficient mental model acquisition. Teachers additionally commented on importance of teachers' positive attitude towards game-based learning and intense preparation for the classwork.

Our results nowadays serve as a springboard to a consecutive study running at Charles University: a complex longitudinal comparative study that should help us to pinpoint features of games that are most promising regarding mental models acquisition. The results of this study are also directly incorporated into the development process of the educational game Czechoslovakia 38-89.

Acknowledgements

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