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Educational Games in Higher Education

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Abstract

Technological innovations change the learning environments and transform the traditional methods. Educational computer game is one of the most popular emerging educational technologies. In this chapter, documentation method is used to analyze studies about educational games in higher education, in light of a deep literature review. A case study design based on the qualitative research paradigm is employed for organizing the literature review data around categories. An educational game is designed about learning computer hardware, named Computer Hardware Game (CHG). CHG is a game aiming convenience and permanence of learning with providing a close-up view of the computer hardware in three dimensions. The CHG was used in the computer hardware course of the Department of Computer Technologies at Suleyman Demirel University.

Keywords: educational computer games, higher education, digital natives, motivation, serious games

1. Introduction

Technological innovations change the learning environments and transform the traditional methods. Hence, the development of Internet Communication Technologies skills usage of technologies in teaching has become inevitable [1]. Educational computer game is one of the most popular emerging educational technologies. Important student learning principles involved by an educational simulation game [2]. Video games give problem-solving experience to students [3] and provide situated experience in which students are involved in complex problem-solving tasks. Strategic thinking is developed within games that have active, nonlinear and immersive environments because games necessitate the use of logic, memory, problem-solving, and thinking skills [4]. Moreover, educational games brought a new dimension

to education by increasing student motivation, providing students the option to learn while having fun, and supporting student-centered education [5]. In addition, educational games are suitable for digital natives.

Employing educational computer games in teaching and learning gained popularity at all educational levels, and has become the subject of scientific research. In this research, in light of literature review, educational computer games in higher education were conducted and analyzed in higher education. In addition, a tutorial was offered on the development of educational game in the field of computer engineering.

This chapter informs about educational games and its features such as game characteristics, story, and mechanics. The second section describes the methodology. In the third section, the studies about educational computer games in higher education are analyzed in light of a deep literature review. In the fourth section, a created educational game named Computer Hardware Game (CHG) is explained. The conclusion covers the consideration and suggestions for future research.

2. Educational games

Computer games are classified as educational that contain educational items that are created for educational aim. An educational game can be used as an educational material in a course. Educator can use an already available educational game or develop a new game appropriate to the course content if it has technical information such as programming. In addition to technical knowledge, developer must know game features such as game characteristic, story, and mechanics.

2.1. Game characteristics

Garris et al. [6] concluded that game characteristics can be described in six categories based on a review of the literature. Game characteristic categories are described as follows:

- fantasy: imaginary or fantasy context, themes, or characters
- rules/goals: clear rules, goals, and feedback on progress toward goals
- sensory stimuli: dramatic or novel visual and auditory stimuli
- challenge: optimal level of difficulty and uncertain goal attainment
- mystery: optimal level of informational complexity
- control: active learner control

The structural characteristics of video games include sound, graphics, background and setting, duration of game, rate of play, advancement rate, use of humor, control options, game dynamics, winning and losing features, character development, brand assurance, and multiplayer features [7]. Players' reasons to play the game when examined according to multi-motivation theory and significant effect of characteristics of the game were found [8].

2.2. Game story

Game story informs us about the game subject. There is a time difference between the narrator and the things told in book story, but game story processes interactively by player. Being interactive, game story causes the formation of concepts such as sequencing, timing, progressive stories, and repeatability [9]. According to the research [10], game interactivity is the most important feature that influences the motivation of the user against the game, and limitations in game storytelling cause restriction of player's freedom and reduce the game's satisfaction.

2.3. Game mechanics

Game mechanics include game rules that exist during a game. Also, it is a system that includes game control, interactivity between players, storytelling, player experience, game hardware, and player feelings [11]. "Game mechanics are an important type of player-game interactions" [12]. As a pedagogical approach to explain the game mechanics, it can also be named as game procedure, and defined as "events that occur within the rules, behaviours and methods." It is stated that the game mechanics guide the player's behavior [13].

3. Method

In this study, documentation method is used to analyze the studies about educational games in higher education, in light of a deep literature review. Google Scholar is used as an electronic database; the reviewed papers are identified through keywords; and the term game with higher education is used as a keyword employing the Boolean operator AND. The papers are considered, which have content about educational game design and implementation for teaching. Then, a case study design based on the qualitative research paradigm is employed for organizing the literature review data around categories. The papers are sorted by date and categorized as research, department, technology, developer, and year.

In this chapter, an educational game developed about computer hardware course is discussed. The game development steps are demonstrated and game characteristic, game story, and game mechanics are explained in detail. The game was used in a hardware course at the department of computer technologies, and interview results were provided.

4. Educational games in higher education

Educational games have a massive potential in science and engineering education [14]. Five reasons for its use in education are described as scale, anytime, compelling, brain chemistry, and better than a lecture to explain contribution to higher education:

- Scale: video games appeal to very large numbers of people (may be graduated people from higher-education system in science and engineering);

- Anytime: students can play game in their spare time;
- Compelling: video games are unintentionally being designed according to effective learning paradigms;
- Brain chemistry: video games stimulate chemical changes in the brain that promote learning; and
- Better than a lecture: initial studies comparing video game teaching effectiveness to the classic lecture show positive improvements, typically 30% or more.

In this section, taking into account the fact as the games' contribution to higher education, the reviewed papers that are researched are presented considering having content with respect to an educational game design and implementation for teaching.

Critical mass is a game, which is used in data structures course, and developed based on competitive programming. In a tournament environment, students can improve their codes and compete their code with other students or instructor code in the critical mass game. According to this research, student-coding performance is increased by the game, being a motivator and competition [15].

The online game Internal Force Master (IFM) was designed for civil engineering and was used during structural concrete course at masters level [16]. IFM was programmed with Macromedia Flash to assist students learning the process by using visualizations and animations. It is found that students like learning with enjoyable and incidental learning materials as educational games.

Recursive algorithm game had used Algorithms with C course in the Department of Applied Informatics, which was created based on snakes and ladders using Savie's online Educational Games Central [17]. According to the research results, the game can be used as a guide for learning algorithms, and helped them realize the misunderstandings and misconceptions on algorithm concepts.

EMERGO project contains a methodology and a toolkit to develop scenario-based serious games, even applicable for higher education. The developer can create complex scenario-based games, on the account of having essential objects and interaction modes for scenario-based game play in the project. EMERGO uses the J2EE/Java development platform. EMERGO aims to:

- study together at a distance;
- actively acquire complex skills;
- within the context of a multimedia and realistic practice;
- through gaming, simulation and pedagogical elements; and
- by using a mixture of both embedded and real-life guidance, including peer feedback.

EMERGO methodology and toolkit can be used to support serious game developers in delivering more efficient scenario-based serious games [18].

The SIMPLE game is designed for three courses (production and operation management, supply-chain management, and introduction to industrial engineering) in the Department of Industrial Engineering and Management [19]. The SIMPLE game is an effective learning environment, and can be used for peer interaction, learning motivation, and course-directed learning interest.

Cheops is a game aiming to help students understand some of the basic concepts of modern computer networks. The game is designed with Macromedia Flash program. According to researchers' perceptions, online serious games can be effective and useful elements in higher education [20].

In a general chemistry course for engineering students, an educational game about molecular geometry, polarity, and intermolecular forces was designed. The results showed that the board game is effective in reconstructing students' knowledge [21].

For programming courses in higher education, a game was designed using action script codes in flash. The game is useful for students' self-learning in introductory programming with the help of using virtual but realistic programming jobs in the game [22].

Uro-Island is created using an open source Wintermute game engine and played by medical students. According to the research results, Uro-Island has a high positive motivational impact on learning and used as an effective teaching method for self-instruction [23].

Students use programming knowledge to solve contextualized problems in Train B&P educational game. The game constitutes an effective approach to assisting novice programmers to learn computational problem-solving skills. Also, the game motivated students toward programming [24].

Pharmacy Challenge is a multiplayer game, designed for pharmacy students and used by Kingston University. According to students' perceptions, the game is interesting, stimulating, and helpful. The game can be added to pharmacy curriculum, as being a motivator [25].

Skills-O-Mat is a game designed for training rhythmic and period motor skills in dental education. The game requires only a training video and motion data as input, and is designed as a reusable component. The game is a valuable instrument for teaching and developing practical skills [26].

Digital games in 3D simulations are used to develop self-management and teamwork. OpenSim multiuser virtual environment is used to develop the game and training activity. Students had a positive perception to use the simulation environment for the development of transferable skills [27].

Ztech de Object-Oriented is a game that aims to learn Object-Oriented programming in an easy and relaxing environment. Most of the computer science and software engineering students enjoyed playing the game. Students can concentrate on the learning topic with the game [28].

DesigMPS is a game which is designed in java platform for software engineering. A software process can be modeled with this serious game by students. Playing the DesigMPS can have a positive learning effect [29].

To train emergency care skills, an educational game named abcdeSIM is designed. Medical students play the game and it has a positive effect on development of students' cognitive skills and motivation [30].

According to literature review of this research, there are examples of the serious games designed for higher education that are used in different departments. Brief information about these researches is given in this section. In **Table 1**, these papers are categorized as research, department, technology, developer, and year.

Research	Department	Technology	Developers	Year
Teaching data structures using competitive games	Computer Science	MySQL, PHP, Java, HTML	Lawrence R	2004
Successful implementation of user-centered game-based learning in higher education: an example from civil engineering	Civil engineering	Macromedia Flash	Ebner M, Holzinger A	2005
Educational games in higher education: a case study in teaching recursive algorithms	Applied Informatics	Savie's online Educational Games Central	Rossiou E, Papadakis S	2007
EMERGO:a methodology and toolkit for developing serious games in higher education	All departments	J2EE/Java development platform	Nadolski RJ, Hummel HG, Van Den Brink HJ, Hoefakker RE, Slootmaker A, Kurvers HJ, Storm J	2008
Serious games for use in a higher education environment.	Computer Science	Macromedia Flash	Liarokapis F, Anderson EF, Oikonomou A	2010
Examining the effects of learning motivation and of course design in an instructional simulation game	Industrial Engineering and Management	Web based	Chang YC, Peng HY, Chao HC	2010
Educational games for self-learning in introductory programming courses-a straightforward design approach with progression mechanisms	Computer and System Sciences	Flash	Ljungkvist P, Mozelius P	2012
Design and implementation of an educational game for teaching chemistry in higher education	Engineering students in a general chemistry course	Game board	Antunes M, Pacheco MAR, Giovanela M	2012
A constructionism framework for designing game-like learning systems: Its effect on different learners	Computer Science	Physics engine	Li ZZ, Cheng YB, Liu CC	2013
Game-based E-learning is more effective than a conventional instructional method: a randomized controlled trial with third-year medical students.	Medical	Wintermute game engine	Boeker M, Andel P, Vach W, Frankenschmidt A	2013

Research	Department	Technology	Developers	Year
Skills-O-Mat: computer supported interactive motion-and game-based training in mixing alginate in dental education	Dental	Flash	Hannig A, Lemos M, Spreckelsen C, Ohnesorge-Radtke U, Rafai N	2013
The design and evaluation of a multiplayer serious game for pharmacy students	Pharmacy	Web application	Dudzinski M, Greenhill D, Kayyali R, Nabhani S, Philip N, Caton H, Ishtiaq S, Gatsinzi F	2013
Developing self-management and teamwork using digital games in 3D simulations	Marketing	OpenSim	Cela-Ranilla JM, Esteve-Mon FM, Esteve-González V, Gisbert-Cervera M	2014.
Computer game as learning and teaching tool for object oriented programming in higher education institution	Computer Science and Software Engineering	2D tile based design game engine	Seng WY, Yatim MHM	2014
Experimental evaluation of a serious game for teaching software process modeling	Information system and Computer Science	Java	Chaves RO, von Wangenheim CG, Furtado JCC, Oliveira SRB, Santos A, Favero EL	2015
An experimental study on the effects of a simulation game on students' clinical cognitive skills and motivation	Medical	Web site	Dankbaar MEW, Alsma J, Jansen EEH, van Merrienboer JJG, van Saase JLCM, Schuit SCE	2016

Table 1. Serious games designed for higher education.

Educational games increase motivation to do the course, and can be an effective way to enhance learning. Considering these contributions of the serious computer games to education, new educational games must be designed and implemented in education with recent technological advances.

5. Educational games in higher education

In this section, an educational game, designed for learning computer hardware, named Computer Hardware Game (CHG) is discussed. CHG is a game aiming convenience and permanence of learning with providing a close-up view of the computer hardware in three dimensions (**Figure 1**). The CHG was used in computer hardware course in the Department of Computer Technologies at Suleyman Demirel University.



Figure 1. Computer hardware game view.

In CHG, a teen room was designed considering digital natives preferences (**Figure 2**). A worktable and course books were added in the CHG room. In the computer hardware book, computer technical parts such as mainboard, processor, hard disk, RAM, video card, DVD-ROM, and



Figure 2. Teen room view.

Ethernet card were modeled in three dimension. The CHG was designed with 3D Studio Max, animations were programmed to the objects by adding anchor link and using touch and sensor.

In the introduction part of the CHG, “Welcome to your virtual room, you can go around and find the special file in your bookcase, have a good time!” was written to attract student’s attention to the game. With the opening of the bookcase door, a link is activated (**Figure 3**). Then students could open the special file that contained 3D computer hardware parts. In **Figure 4**, 3D view of mainboard from CHG is shown. Students can study with the 3D mainboard view as it is in the computer hardware laboratory. Also, technical information about mainboard is given to users. After getting information, questions about mainboard are asked to users such as “how many ports are there on the main board?” and user must answer the question in a limited time. User score could be higher, and getting a high score depends on how fast they answer questions. If correct answers are given to the questions and users have enough points, users were able to see another part of computer hardware in 3D as the next level of the game. Also, user must solve puzzles about course content to win the game with the highest score.

The students’ perceptions about CHG is analyzed with semistructured interview method. According to the interview data, playing game is funny even if it is being about course content according to students, and students also mentioned that they liked 3D content and the game. According to instructors’ perceptions, the game increased students’ motivation as being the students are in the race with the game to gain the highest score. As a proposal for a new version of CHG given from students is multi-player version of the game can be developed.



Figure 3. Opened bookcase door view for getting special file view.

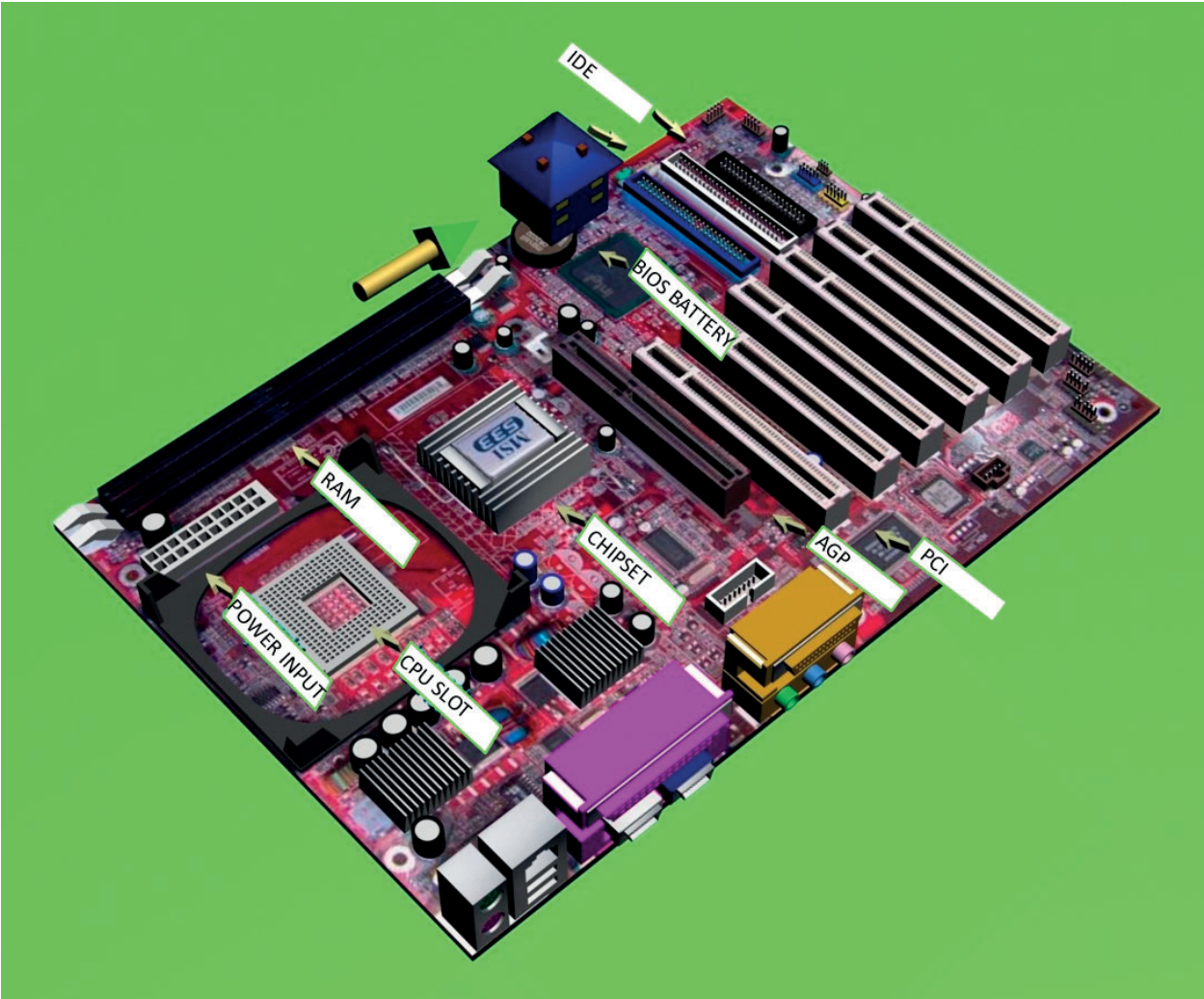


Figure 4. Mainboard view.

6. Conclusion

So many developed educational games are aiming to motivate the students to the course. According to the research [31], if a game is designed for learning, it should support the learning context perceived by the students as the best way to learn that game being the right type of game. The right games provide active and experiential learning, and are highly engaging. For this reason, new educational games must be developed as a training material. In this chapter, a new game is designed.

In this research, a well-done categorized educational game studies literature review is exhibited. This literature review helps to see all instances about educational game for digital natives in higher education. The studies were categorized as research, department, technology, developer, year, and titles. Research titles are presented to have information about educational games. Departments are provided to determine the usage of educational games. Technology

is used for programs or coding languages to help researchers who want to develop a new educational game. In addition, developer and year of publication of the paper information is also given. According to the brief information of the paper, in conclusion, educational games increase motivation to do the course and can be an effective way to enhance learning.

In addition, an educational game development, that acts as an example of educational games in higher education, is demonstrated. Game characteristic, story, and mechanic themes are explained to help people who have developed a great interest in developing educational games. The CHG game is developed for the hardware course, aiming to teach computer hardware to students. The game has 3D views of the computer hardware part, so students can practice and learn about the course subject. The CHG provides information about computer hardware and then asks questions to students about the subject. As being a game, a limited time and score cause challenge when answering questions and solving puzzles in the game. According to instructors' perceptions, the game increased students' motivation. Students found the game funny, and they liked the game.

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