Using Game Dev Tycoon to Develop Professional Soft Competencies for Future Engineers-Programmers

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Abstract. The article presents the possibilities of using game simulator Game Dev Tycoon to develop professional soft competencies for future engineer programmers in higher education. The choice of the term "gaming simulator" is substantiated, a generalization of this concept is given. The definition of such concepts as "game simulation" and "professional soft competencies" are given. Describes how in the process of passing game simulations students develop the professional soft competencies. Professional soft competencies include: the ability to work in a team; ability to cooperate; ability to problem-solving; ability to communicative; ability to decision-making; ability to orientation to the result; ability to support of interpersonal relations; ability to use of rules and procedures; ability to reporting; ability to attention to detail; ability to customer service; ability to sustainability; ability to the manifestation of professional honesty and ethics; ability to planning and prioritization; ability to adaptation; ability to initiative; ability to Innovation; ability to external and organizational awareness.

Keywords: simulator; game simulator; competence; professional competence; professional soft competencies; engineers-programmers.

1 Introduction

In the conditions of developing a system of pedagogical education and the introduction of innovative technologies into the process of learning [14; 28], the problem of quality and efficiency of the educational process becomes of particular importance. Over the past few years, the labor market has seen an increase in demand for highly motivated and highly skilled software engineers. One of the important directions in the development of the digitalization of education is the newest computer technologies. Availability, intensification of the learning process, feedback are significant advantages of these technologies, which determined the need for their application in various fields of human activity, especially those related to education and vocational training. At

present, the number of studies has grown significantly, the subject of which was the use of ICT in education.

Compared to other fields, such as medicine or aeronautics, future software engineers begin their professional lives with a serious lack of real practical skills. Therefore, professionals must develop their skills and experience working in real projects, where the consequences of inadequate planning or incorrect decisions can lead to the failure of the entire project or the loss of a significant part of profits [6; 30].

Typical education of software engineers lacks practical mastery of software development processes. Usually, students are presented only with relevant theories of software development processes in lectures, and opportunities to put these concepts into practice while studying the relevant disciplines are quite limited [20].

While most approaches to the training of future software engineers are aimed at adding realism to practical lessons in the classroom, some authors (Márcio de Oliveira Barros [9], Alex Baker [4], Cláudia M. L. Werner [9], Alexandre R. Dantas [9], Emily Oh Navarro [20], André van der Hoek [4]) argue that the only possible way to gain experience in real-world software development processes in academia is to use game simulators in combination with lectures and educational projects.

In addition, while the above approaches differ in terms of the processes they mimic and their specific goals, they are all designed to allow students to better practice and participate in software development processes on a larger scale and in a faster way than can be achieved based on actual projects.

That is why the question of using game simulators for the formation of professional soft competencies of future software engineers arises.

2 Literature Review

Experts and scientists justify the importance of the introduction of information and communication technologies (ICTs), in particular, game simulators, in education [9]. Alexandre Dantas, Emily Oh Navarro, André van der Hoek think, that ICT are included in all spheres of human activity, they also have a positive impact on education, as they open up opportunities for the introduction of completely new methods of teaching and learning [4].

The question of the formation of professional soft competencies for future programmers-engineers is presented in the works of Faheem Ahmed [1], Ritika Atal [3], Lisa L. Bender [5], Kunal Bedse [13], Alejandro Calderón [6], Craig Caulfield [7], Fabian Fagerholm [5], Mehdi Jazayeri [12], Shanika Karunasekera [13], Stanislaw Paul Maj [7], Jürgen Münch [5], Emily Oh Navarro [20], Kendall E. Nygard [5], Kateryna P. Osadcha [15], Max Pagels [5], Mercedes Ruiz [6], Serhiy O. Semerikov [26], Andrii M. Striuk [31], Ashish Sureka [3], David Veal [7], Gursimran S. Walia [5], Jianhong Xia [7] et al.

According to a study by Khaled El Emam [10], the biggest problem of software development projects (SDP) is a rather high percentage of unsuccessfully completed projects, that is, completed incompletely or with budget overheads, or due to lack of certain capabilities and functions.

Goparaju Purna Sudhakar, Ayesha Farooq and Sanghamitra Patnaik found that 70% of SDP failed [23, p. 187]. The high percentage of failed SDP results in the fact that organizations and companies that are customers of SDP do not receive the full benefit of projects.

According to research by Paul Clarke and Rory V. O'Connor, another disadvantage for such companies and organizations is that they do not receive the appropriate return on investment (ROI). Scientists point out that several factors lead to the failure of the SDP: insufficient user participation, as well as senior management in project development; unsuccessful project management; low leadership qualification and low level of understanding of available technologies [8, p. 433]. In particular, the researchers note that the main factor in the failure of the completion of the SDP is the lack of professional competencies in project participants, in particular, in program engineers, or their low level of ownership [22; 29].

According to Ali Noudoostbeni, 67% of SDP failed due to an insufficient level of professional soft competencies of project participants [21].

Emmanuel S. Mtsweni, Tertia Hörne and John Andrew van der Poll have been established that professional competencies are important for the successful completion of the SDP, completion of projects on time, within the budget and with all the necessary capabilities and functions. Researchers distinguish three main professional soft competencies for software developers: teamwork, professional integrity, and ethics, as well as collaboration [19, p. 150].

In turn, teachers are also faced with similar, and possibly even more complex, problems: how to prepare highly skilled programmers-engineers. The challenge is related to the problem of how to train programmers-engineers, which changes over time, as learning technologies, educational programs, and requirements for the learning process are constantly changing [16; 17; 32].

Soft and hard ("solid") competencies are needed for effective professional work. Dave Hodges, Noel Burchell, Elizabeth Rainsbury and Mark Lay believe that professional soft competencies control and determine the behavior and performance of professionals. Authors identify the terms of soft competencies and soft skills [11; 24].

The purpose of this article is to show the possibilities of using the gaming simulator Game Dev Tycoon to form the professional soft competencies of future engineers-programmers.

3 Results

According to a study by Louise Sauvé, the game, in its formal definition, is purposeful competing activity that includes one or another form of conflict (the conflict is represented in the form of an obstacle that does not allow the player to easily achieve the goals of the game) and is conducted within certain agreed rules [25]. The game is attended by at least one person (player) or a group of people (players) who in the context of this game need to make certain decisions to achieve the goal.

Mariya P. Shyshkina in her classification of learning tools allocates a microcosm, in which "the modeling and representation of objects in the subject field, their properties

and relations, object manipulation, changes in their properties, etc., the study of the interconnections between properties" [27].

According to Maryna V. Artiushyna, for didactic purposes, games are divided into "those used to study the new material, the activation of cognitive activity, the consolidation of assimilation of information, verification of assimilation" [2].

Iryna M. Melnychuk offers her classification of interactive gaming technologies for higher education. According to this classification, didactic games are divided into the simulation and role-play [18]. Among the role-playing games, the author highlights simulative-role situations in which students can associate themselves with a certain person whose role they perform, put themselves in the position of this person in certain circumstances, enriching their life experience, will help to acquire practical skills in the specialty, which would stimulate students to consciously master the knowledge and creative use of acquired skills and abilities. At the same time, as the scientist emphasizes, the process of fulfilling a certain role in simulative virtual-professional interactive games involves gaining a sense of self-confidence, verification-belief in the results of his professional training, and hence the readiness to perform professional functions [18].

In this study, under game simulators, we will mean interactive programs that fully or partially simulate certain real processes or systems that capture and motivate students through fun and interesting game experiences, where students can perform different roles in a variety of realistic circumstances and are used in the educational process. when the real practice is impossible or inaccessible.

As a consequence, in this study, the term "game simulation" determines the work of the corresponding game simulator, complete or partial simulation of the corresponding real processes or systems.

We also note that in this study, under professional soft competencies, we will understand a complex of non-specialized competencies that in one way or another relate to problem solving, interaction between people and responsible for successful participation in the work process, high productivity and, unlike specialized competencies, not related to a specific area, control of equipment and technical skills. They cover such aspects of behavior: cognitive competence (situational awareness, decision-making, error management, etc.) and the competence of interpersonal communication.

Game Dev Tycoon is a gaming business simulator that simulates the activity and process of managing a game development company. This game simulator offers an attractive user interface as well as interactive and appealing game play. In Game Dev Tycoon (Fig. 1), students take on the role of owner and manager of their own software development company. At the beginning of the game simulation, students are independent software developers working on their own. As their software development studio becomes more successful, more and more opportunities are available to expand business with several employees and on a larger workspace.

In Game Dev Tycoon, at the beginning of the game simulation, students are independent developers of games that work on their own. They start with the process of developing simple games for different platforms in the virtual garage, as shown in

Fig. 2. As games become profitable, players move into a new office and can hire and train their employees, as well as focus on research, project selection, and contracting.

Fig. 1. The graphics interface of the game simulator Game Dev Tycoon

Fig. 2. The virtual garage in game simulator Game Dev Tycoon

The use of the game simulator Game Dev Tycoon is worth the teacher to include in the curriculum in the amount of 10% of the total score for the subject. The purpose of this game simulator is to supplement the experience of group work that students have learned in the process of learning and developing their group project and thus allow each programmer to lead the development team and manage the SDP. Students should go through the game simulation in Game Dev Tycoon for four weeks and weekly to reflect on the lessons learned and discuss it with the teacher and other students.

Gaming simulator Game Dev Tycoon offers many basic project management elements. During the game simulation, students can go through three main stages of the company's development, namely:

1. Stage of the garage.
2. Stage management team.
3. Stage of world domination.

In these three phases, students have to deal with three relevant project and team management areas, namely:

a. the process of developing high-quality innovative game applications;
b. the growing process of hiring, training and managing within a development team;
c. establishing and maintaining appropriate marketing, sales, and innovation research processes.

Game Dev Tycoon has many details and variations that make it attractive, realistic and interesting for students.

For example, the stage in the garage requires students to focus on creating high-quality games for popular gaming platforms. At this stage, the emphasis is on the continuous production of high-quality innovative games, which requires students to constantly address the design and testing issues of gaming projects, as well as focusing on the latest industry news to identify the industry and market trends.

At the stage of managing a team of growing projects, students will have to go through recruitment/dismissal, training and management teams of software development. A high level of awareness of the competencies of hired employees will be required for students to optimize the time to develop gaming projects of due quality.

Finally, the stage of world domination requires timely and thoughtful management of all aspects of the project, such as developing, debugging, testing software, hiring employees, attending industry conferences, dealing with users and fans, and marketing. The main tasks of students at this stage range from managing a large team of software development to optimizing its cost and choosing the right direction for advancing created game projects, as shown in Fig. 3.

It is also important to have an ethical component of the business process: the players can be questioned by the subjects who offer their services to incite sabotage in the competing companies or offers industrial espionage for additional benefits. So, students are specifically offered to think about aspects of ethical choices and to practically consider the ethics of utilitarianism, the ethics of Immanuel Kant and the prospects of choice. For example, in Fig. 4 shows the suggestion of sabotage.

Another interesting feature of Game Dev Tycoon game simulation is that the company can get loans from banks if the developed game projects were not successful. If the company can not return the amount received within a certain period, then it is declared bankrupt and the game simulation ends. Game Dev Tycoon covers a large number of aspects of PRP management and leadership. At the same time, the intuitive realistic user interface of this game simulator makes it attractive and interesting for students.

Fig. 3. Evolution workspace in the game simulator Game Dev Tycoon

Fig. 4. Proposition of sabotage in the game simulator Game Dev Tycoon

Let's describe some features of this game simulator.

Each project in this game simulator begins with the fact that students are planning to develop a new game. They set the theme, genre, and platform of the game, and then add several technologies that will be used when developing the game (for example, "2D-interface" and "mouse support").

During the game simulation, players can manage the levels of the three main game qualities in each of their projects, namely: the quality of the game process, the quality of the game core and the quality of the game plot being developed.

When project development begins, participants need to set certain priorities for developing the game, allocating the appropriate percentage of working time and distributing the available resources between the development of the game process, the game core, as well as the game plot (Fig. 5). At this stage, the choices made by students and their success depend on the combination of the genre and the themes of the game already selected. For example, the focus on the kernel is considered to be more effective for games such as Sim City, while gameplay and script are more important for role-playing games. Players need to experiment, to learn and understand which combinations are more beneficial and will lead to the success of the project.

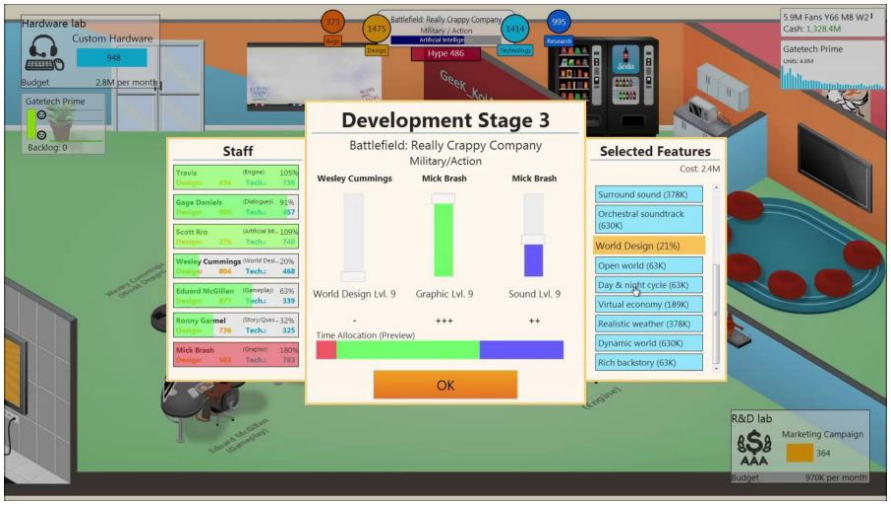

Fig. 5. The Priority Dialog for Game Dev Tycoon

If a company already has several employees, then in the process of developing the game, they can be secured by creating different parts of it, and, importantly, their features and competencies will determine how effectively they perform the tasks.

The project development process is illustrated in graphically small areas that appear alongside the staff and indicate the levels of the two main components of the game: its design and technology. As the project progresses, these two indicators indicate to students how well the process of developing the game is. These indicators do not have a clearly defined scale, but one should understand that the larger the number is better for the project. Using these indicators, players know how well they are playing the game simulation, and as a result, they can challenge themselves to work even better and make more effective decisions when designing the following projects.

Students can choose, game projects that will be released with errors or it's time to postpone the release date and invest more time in fixing them. The three main game qualities above, as well as the platform for which the game is being developed, affects

game rankings and how well it is sold. Throughout the entire gaming simulation, news updates appear on new gaming platforms, as well as reports of major industry events that may affect the gaming simulation, for example, the release of the new Ninvento gaming platform, as shown in Fig. 6.

Fig. 6. Exit Ninvento new gaming platform in the game simulator Game Dev Tycoon

When the project is ready for release, it generates a series of reviews, as well as general remarks about the game, such as "This game is fun" or "Needs improvements". Previous player experiments around the genre and themes of the game can be noted with such comments or reviews as, for example: "This combination of genre and theme works very well," and students may also be given feedback if the selected priorities were correct (or vice versa – unsuccessful) with the following comments: "The orientation of the game on the design of the world was not quite successful". This feedback, as well as a counter indicating how the game is sold over time, allows the player to analyze their achievements and helps to quantify the effectiveness of decisions made by students in the process of developing this project. This encourages students to try again if the selected combinations and decisions are not optimal, or to achieve even better results if the project was still successful.

During the game simulation, students can create and maintain an active base of fans, as well as solve piracy issues. With experience and a good team, they can produce larger and more sophisticated gaming projects. It is worth noting that big projects also bring new challenges, that is, players need to manage a larger team and solve new more complex problems for the release of game hits.

Successful progression in gaming simulation will allow students to choose not only typical projects but also unlock new objects in a game simulator, such as a marketing department, open up innovative research labs, and choose projects that change the

industry. This gives the participants a sense of satisfaction, a certain achievement, and also allows you to gradually unlock new tactical approaches that allow you to experiment with new tools and features. All this makes the process of game simulation not monotonous, but on the contrary – more exciting. Also, players can be presented with several secret projects that can be selected in certain circumstances.

When opening a marketing department, students should understand that in Game Dev Tycoon, marketing is understood to mean any activity that aims at or advancement of a developed gaming project, or market analysis before the development of the project.

When passing gaming simulations in the Game Dev Tycoon game simulator, students develop the following professional soft competencies:

- *Ability to work in a team* – in the process of game simulation, students must work together with their employees to achieve common goals. Students need to be actively involved in team tasks and involve other team members in the work. During the game simulation, students should take into account the feedback from colleagues appearing in replica bubbles and take into account their proposals to achieve common goals.
- *Ability to cooperate* – students need to identify, organize and maintain mutually beneficial relationships not only within the team but also beyond their borders, for example, with virtual clients when discussing software requirements for the successful game Dev Tycoon game simulations.
- *Ability to solve problems* – in the process of game simulations students often have to deal with problems that arise during the development of software, identify options for their solution, assess the strengths and weaknesses of each of the options and make decisions based on their knowledge, abilities, skills, and experience. Students also need to analyze and take into account the various factors and information received from employees, customers and other sources.
- *Ability to communicate* – in the course of game simulations, students are responsible for clear and effective communication, and also take responsibility for the understanding of others.
- *Ability to make decisions* – students must take into account costs, benefits, risks, and chances of success in the decision making process, make logical conclusions based on facts in complex and ambiguous situations, and also make informed, timely, and timely decisions to complete the tasks in the game simulator, effective solutions, taking into account only the necessary data.
- *Ability to focus on the result* – Game Dev Tycoon game simulations are constructed so that students need to use metrics and indicators to achieve their goals and outcomes, make decisions and effectively involve employees in the process of achieving goals (by identifying their strengths and distributing tasks between them) so that the projects remain within the set goals and the budget.
- *Ability to support interpersonal relationships* – in the process of passing game simulations students are constantly faced with the need to maintain positive relationships with other people. Another important aspect is that students are constantly demonstrating examples of constructive discussion of problems, options

for professional responses to certain situations, examples of professional communication with employees and customers based on understanding, courtesy, tact, empathy, care, and courtesy.

- *Accountability* – is the process of passing gaming simulations in Game Dev Tycoon, students must take responsibility for the positive and negative results of the virtual team's work and report their achievements and failures to the teachers during the learning process.
- *Sustainability* – in gaming simulations, students need to maintain high productivity and self-control under pressure and in times of trouble for successful completion of tasks.
- *Ability to demonstrate professional integrity and ethics* – in the process of game simulation students can ask questionable industry subjects, so students are specifically invited to think about aspects of ethical choices. Students also need to deal with piracy issues during game simulation. To complete the game simulation, students need to be educated and contribute to maintaining the desired behavior by the existing standards of organization and society.
- *Ability to plan and prioritize* – students need to set certain priorities for the development of the game, allocating an appropriate percentage of working time and distributing available resources between the development of the game process, the game core, as well as the game plot.
- *Adaptation ability* – students must constantly pay attention to the latest industry news, identify trends in the industry and the market, adapt quickly to change, and easily consider new approaches to software development and business conduct, to complete the game simulation.
- *Ability to take the initiative* – the Game Dev Tycoon game simulator requires students to actively identify existing opportunities and challenges, search for maximum benefits, and solving the problems. To complete the simulation, students need not lose their opportunities to achieve their goals.
- *Ability to innovate* – the successful passing of the simulation requires students to experiment a lot to learn and understand which combinations are more beneficial and will lead to the maximum success of the project. Students also need to open up innovative research laboratories and select projects that change the industry for the successful passing of game simulation.

To test the efficiency of this game simulator for the formation of professional soft competence software engineers were involved in 95 and 88 students (control group (CG) and experimental group (EG)).

In the experimental group, students were trained using this simulator, and in the control group, the training was conducted by typical traditional learning conditions.

Formation of control and experimental groups was carried out based on the results of preliminary testing in such a way as to ensure statistical correspondence of the level of knowledge of students of control and experimental groups.

During the period of implementation of this simulator in the educational process, the observation method was applied, the essence of which is that during practical classes the teacher observes the activities of students in a specific model of a game simulator

and discusses the result with the student on the results of the generated report. The final grade for the practical work was presented taking into account the personal point of view of the teacher, which he formed during his observation of the student.

The levels of professional soft competency formation were determined based on final testing within the discipline “Professional Practice of Software Engineering”.

Let us present a statistical analysis of the results, which was carried out taking into account the comparative study strategy. The comparative method was implemented by comparing the results of the experimental and control groups in the study process. The comparative distribution of students according to the assessment of professional soft competency formation in the control and experimental groups at the beginning and the end of the experiment for each competency is shown in Fig. 7.

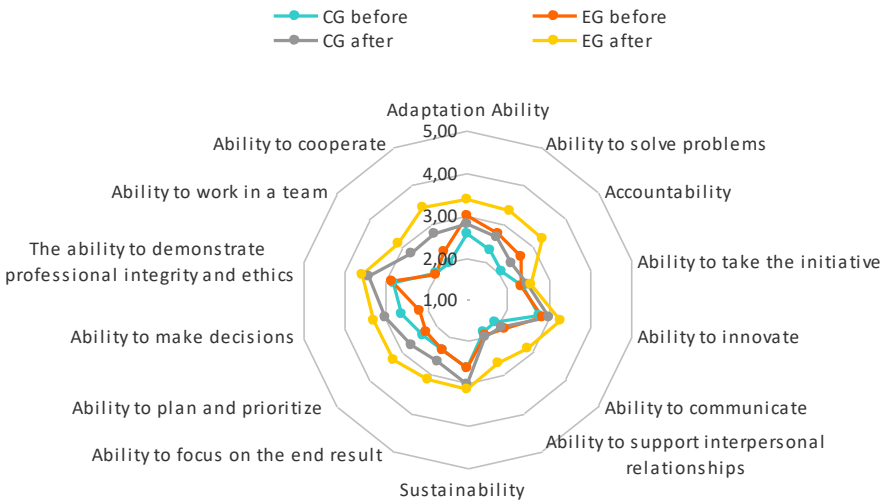

Fig. 7. Average assessment of the level of professional soft competencies of students in CG and EG at the beginning and end of the experiment

The comparative research method allowed us to trace the positive dynamics of the formation of professional soft skills in the application of the game simulator Game Dev Tycoon.

All competencies were divided into three criteria, for each of which were calculated Pearson χ^2 criterion. Since $\chi^2_{exp} > \chi^2_{critical}$ for each of the criteria, the results suggest that the higher level of professional soft competencies of students is the result of the introduction of the game simulator Game Dev Tycoon in the training of future software engineers.

That’s why efficiency of the formation of professional competence soft software engineers increase significantly when used game simulator Game Dev Tycoon in training future engineers-programmers.

4 Conclusions

In the process of using this game simulator in the learning process, future professional engineers develop the following professional soft competencies that they need in their further professional competencies: ability to work in a team; cooperate; problem solving; communicative; decision-making; orientation to the result; support of interpersonal relations; use of rules and procedures; reporting; attention to detail; customer service; sustainability; the manifestation of professional honesty and ethics; planning and prioritization; adaptation; initiative; Innovation; external and organizational awareness.

It is statistically confirmed that the efficiency of the formation of professional competence soft software engineers increase significantly when used game simulator Game Dev Tycoon in training future engineers-programmers.

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