

Possibilities of using the Game Simulator Software Inc in the Training of Future Software Engineers

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Abstract: The article presents the possibilities of use game simulator Software Inc to form a sustainable professional competence of a software engineering specialist: the ability to: apply knowledge in practical situations; communicate in a foreign language; work in a team; act based on ethical considerations; commitment to preserving the environment; evaluate and take into account economic, social, technological and environmental factors affecting the sphere of professional activity; for lifelong learning. The use game simulators, in the educational process, allows to improve the quality of educational material and to enhance the educational effects from the use of innovative pedagogical programs and methods, as it gives teachers additional opportunities for constructing individual educational trajectories of students. In the process of research, students gain knowledge, skills of the future IT specialist and competences of the legal protection of the results of intellectual activity, technological audit, marketing, product realization in the market of innovations. There are many ways in which a company can achieve a dominant position in the industry. For example, the staff of a virtual company can work on developing editorial software for designers, business tools for offices, video games for the console, and even, if time and skill level allows, they can develop their operating system. So in the game simulator Software Inc students are invited to build and design office buildings for optimal working conditions of their own software development company.


1 INTRODUCTION


More and more educational institutions are introducing new teaching methods, which result in the use of engineering students, in particular, majoring in software engineering, to deal with real professional situations in the learning process (Liu et al., 2011;


Mtsweni et al., 2016).


The use of modern ICT, including game simulators, in the educational process (Demirbilek and Koç, 2019), allows to improve the quality of educational material and to enhance the educational effects from the use of innovative pedagogical programs and methods, as it gives teachers additional opportunities for constructing individual educational trajectories of students. The use of ICT allows for a differentiated approach to students with different levels of readiness to study.


A feature of any software engineer is the need to understand the related subject area for which the software is being developed (Striuk, 2018). An important condition for the preparation of a highly qualified spe-


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cialist is the independent fulfillment by the student of scientific research, the generation, and implementation of his idea into a finished commercial product. In the process of research, students gain knowledge and skills of the future IT specialist along with the competences of the legal protection of the results of intellectual activity, technological audit, marketing, product realization in the market of innovations. Note that when the real-world practice is impossible for students, game simulators that simulate real software development processes are an alternative.

The importance and necessity of introduction of information and communication technologies (ICT), including game simulators, in training, are substantiated in (Ahmed et al., 2013; Atal and Sureka, 2015; Baker et al., 2003; Pant and Baroudi, 2008; Dantas et al., 2004; Karunasekera and Bedse, 2007; Hodges and Burchell, 2003; Calderón and Ruiz, 2014; Caulfield et al., 2011; Clarke and O'Connor, 2012; Dantas et al., 2004; Emam and Koru, 2008; Purna Sudhakar et al., 2011; Jazayeri, 2004; Noudoostbeni et al., 2009; Navarro, 2006; Sauvé et al., 2005). ICTs are part of every area of human activity and have a positive impact on education, as they open up opportunities for the introduction of completely new teaching and learning methods.

A significant contribution to the theory of educational games was made in (Elkonin, 1999; Klopfer, 2008; Michael and Chen, 2005; Vygotsky, 1962). At the same time, game technologies of teaching and use of interactive games in high school were investigated in (Alkan and Mertol, 2019; Al-Tarawneh, 2016; Buzko et al., 2018; Demirbilek and Koç, 2019; Gunter et al., 2008; Jackson and McNamara, 2017; Vieira et al., 2019; Tokarieva et al., 2019). However, the question of the use of game simulators in the training of future software engineers remains poorly understood.

2 RESULTS

Game simulators are 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.

Software Inc is a game simulator that allows students to try their hand at running a software development company.

There are many ways in which a company can achieve a dominant position in the industry. For ex-

ample, the staff of a virtual company can work on developing editorial software for designers, business tools for offices, video games for the console, and even, if time and skill level allows, they can develop their operating system.

Selling these products and complicating the tools used in the development process (for example, the transition from the command line to the graphical interface, from 2D graphics to 3D graphics) will contribute to the growth and development of the company, but to keep up with competitors, the user it is necessary to constantly update the technical support within the company.

So in the game simulator Software Inc students are invited to build and design office buildings for optimal working conditions of their own software development company. The game simulator allows you to build, provide, and maintain virtual office buildings up to ten floors high and expand workspaces in a large virtual area of the game simulator.

In the process of game simulation, future software engineers need to hire employees for their research, development, production, and maintenance of quality software, as it is necessary for the successful conduct of competitive activities of their virtual company (figure 1).

Students also face the need to manage and train their employees so that they are experienced and satisfied with their work. The attention of future software engineers to the needs, requirements, competencies, and specializations of employees, as well as their compatibility within teams is very important for the successful completion of the game simulation.

During the game simulation, students can also delegate certain important tasks (such as managing the software development process or human resource management) to team leaders within their company.

The main task of the game simulator Software Inc is to set up the process of creating their software products and franchises in a virtual company, setting up the process of selling software, concluding agreements and performing contracts, as well as obtaining patents for developed software products.

In the process of game simulation, students need to make decisions, for example, what software to develop (figure 2), how to configure their servers for software, how to manage software version control systems, and even whether to start their online store.

Players need to monitor the financial condition of the company (figure 3) because the company will be considered successful when its profits reach \$ 50,000 or double the amount from which the game simulation began.

To start the game you need to press the "New



Figure 1: Dialog for selecting employees in the game simulator Software Inc.



Figure 2: Defining software requirements in the game simulator Software Inc.

Game” button, then the corresponding screen, shown in figure 4.

In the first stages, students should use a manual to provide detailed information about the gameplay and the various individual stages of the game. Beginners are encouraged to choose Optimism and Generosity as the main features when creating a company

founder, without necessarily changing the settings of the sliders located on the left in the user interface.

In the panel on the right, you need to increase the startup capital of the company to \$ 20,000 or move the slider one mark if the game is in a different currency (the currency can be changed in the options menu). Set to default 1980 as the year the company



Figure 3: Indicators of the financial condition of the virtual company in the game simulator Software Inc.



Figure 4: Starting a game simulation in Software Inc.

was founded, there is no need to change, but at the stage of getting acquainted with the game the difficulty level must be set to “Easy”.

The Days per month parameter sets the number of days in a month. By default, it is set to 1 day, meaning one game day will count as a month. With this setting, you can change the speed of the game (most of them set 4 days, but first you need to set the value to 1 or 2

days).

After that, the student needs to change the founding person’s settings and choose a name for their company, such as “SpaceTech” or “Aperture Cake Production”, after which the students will see the next window (figure 5).

You can move the instruction box around the screen and resize it. You have to press the “Continue”

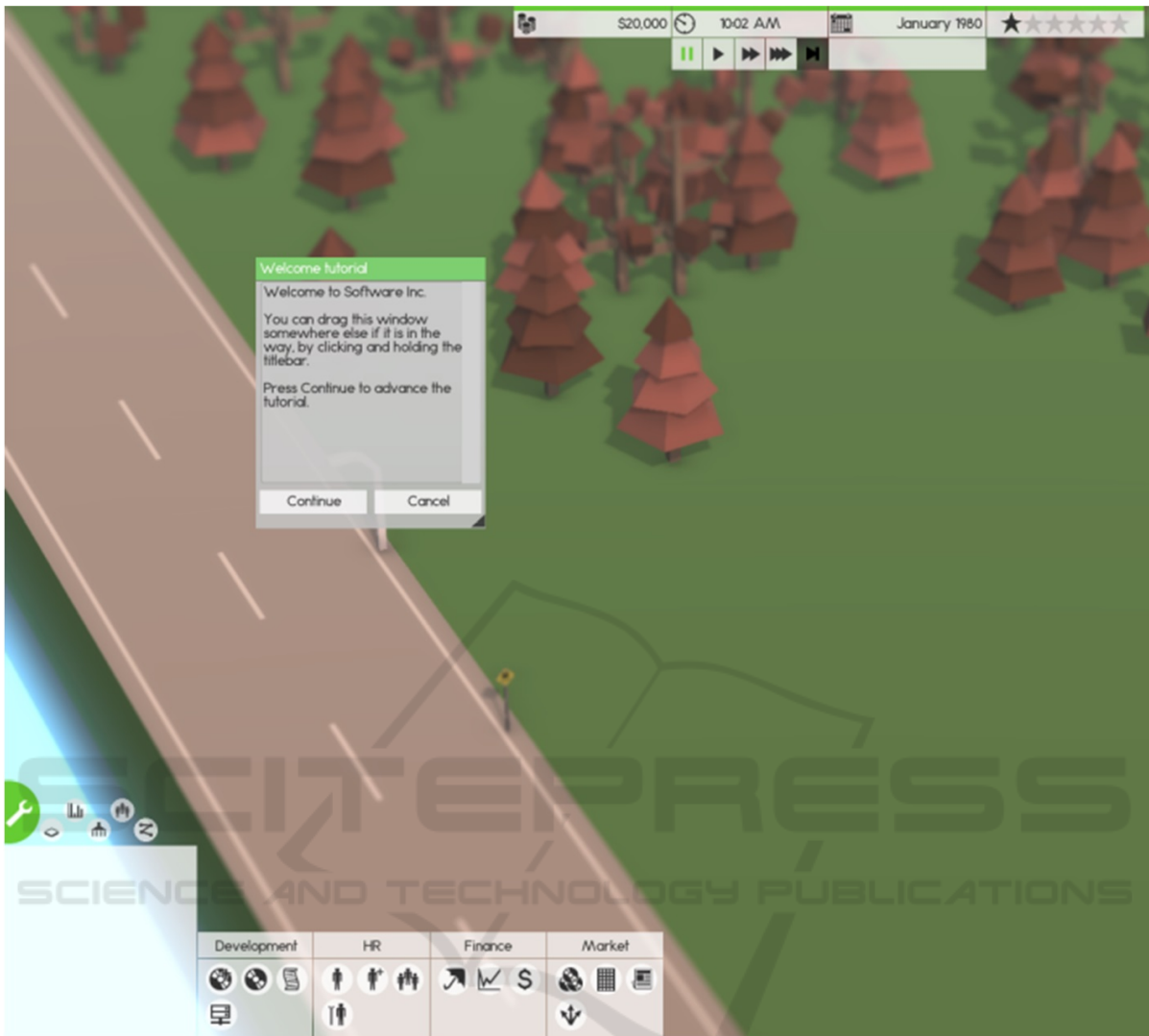


Figure 5: Welcome dialog in Software Inc.

button to flip through the manual. To start creating the premises of a future virtual company for a student, it is necessary to go into construction mode by clicking on the green button with the image of a wrench on the user interface.

Game Simulator Software Inc offers three build modes: “Construct” – construction of rooms, installation of windows and doors; “Furnish” – room furniture, choice of tables, chairs, coffee machine; “Roads” – road construction, parking, but initially this mode is not used.

Once enabled, the student must first build a small room for the virtual company. To do this, you need to use the Room Builder tool in the Construct mode menu. The initial size of the first room should be approximately 5x5 to accommodate the table and chair for the founder of the company.

To make the room light enough, you must select the windows and doors in the Construct mode menu and install them in the room.

Then students have to go into Furnish mode and have a desk, chair, and computer installed in the room. Use the Shift + left mouse button to set multiple items at once. Chairs will automatically be installed near the tables they are closest to, but you may need to turn your computer over.

Students need to click on and hold the computer, turning it in the required direction.

After that, the room will look something like this (figure 6).

Once the room has been created, the founder of the company can start working there. After reading the instructions, you must press the Tab key to exit the build mode. The process of making money and



Figure 6: A room built-in game simulator Software Inc.

working on contracts.

The first way that allows companies to make money is to work on contracts. Contracts are projects that are offered to companies for execution, and each of them has its requirements.

To find a contract, the participant must go to the “Development” menu by clicking the button with the image of a piece of paper (A). Then a pop-up window will appear on the screen (figure 7).

Players need to sort the list by “Months” (B) to ensure that contracts that require the least number of months are at the top of the list. Typically, contracts with 1 or 2 (C) contracts will have a performance period of 1 or 2 months. The company does not receive big profits for working on such contracts, but in the beginning, it is a great source of financial income.

Regarding the quality of contract work, students must set the value to “Bad” or “Horrible” (D), which allows the initial stages not to take quality but quantity.

Students need to find a contract for their virtual company with a minimum work requirement for a team of 1 or 2 people for a maximum of two months and click the “Accept Work” button.

After the participants have selected a contract for their company, a project management pop-up window (A) will appear to the right in the user interface (fig-

ure 8). There are 4 stages of project implementation. The first stage is the development of the design. The product design specified in the contract is developed by the virtual company designer(s).

When pointing the mouse at the project management window, students can see the progress scale of a specific job by a company employee (B). The task is considered completed when the scale reaches its maximum value. However, students need to be careful and not delay the contracting process at the design development stage so as not to waste the time allotted for the contract.

Players must then click on the “Develop” (C) button in the project management window to proceed to the next stage – “Alpha”. At this stage, the software engineers create the product according to the design developed by the designer in the first stage. Students can monitor the completion of the assignment using the progress bar. When the task is completed, you must click on the “Promote” button to proceed to the next step.

The next stage is called “Delay” and is only an intermediate stage, which lasts a certain amount of time depending on the skill level of the company’s employees. The higher the skill level of the employees, the less time the Delay stage takes.

The project then proceeds to the “Beta” stage,

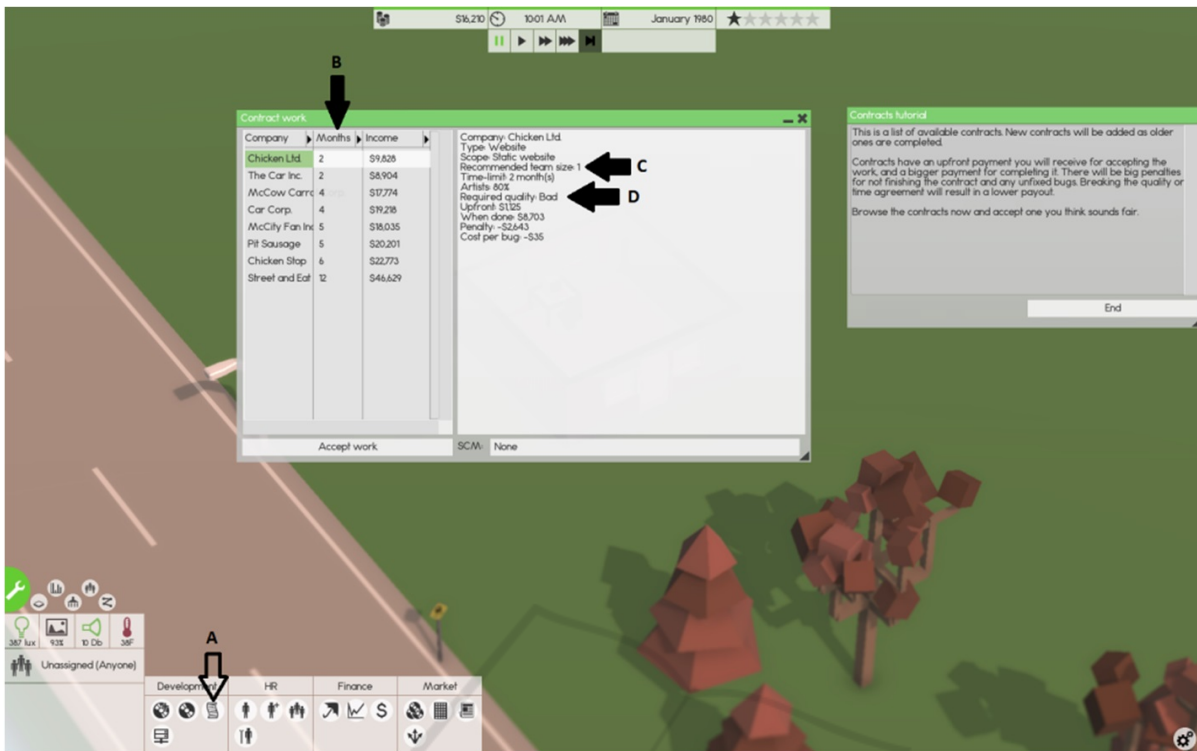


Figure 7: Software search contract simulator popup window.



Figure 8: The project management popup in the game simulator Software Inc.

which is to test and prepare for the product release. The company may release a product that is not ready for completion, but it is important to remember that the presence of errors and defects in the product will adversely affect its sales and contract payments.

When building premises, students need to remember that employees are first and foremost people who have basic needs (want to eat, go to the restroom, drink coffee, prefer quiet, comfortable rooms with sufficient lighting, comfortable air temperature, and a comfortable environment). Therefore, you should build a facility that addresses all these needs, and do not forget to build small facilities for restrooms and rest areas.

Make sure you also have a fridge and coffee table in the lounge. Windows, lighting, and doors between rooms are required. It is important to keep in mind that indoor plants will have a positive effect on employee productivity and mood. Elements such as heat radiators and ventilation in the main room are also very important as they provide comfortable air temperatures.

After the company has reached a certain level of development, students need to hire new employees in the team. When looking for a new employee, you first need to answer two questions:

1. In what position to open a vacancy?

- team lead;
- designer;
- creative manager;
- marketer.

2. How much time and resources can be spent on finding a new employee?

Then more time is spent on searching, then more applications from candidates will be considered. At the same time, it is necessary to consider the insurance policy of the company. Having a solid insurance fund will be an attractive factor for skilled workers. Therefore, every time after the completion of contract work and products, students need to invest in improving the insurance fund to attract highly qualified employees to the company (Vakaliuk et al., 2020).

After the list of candidates is created, you can go to the interviewing stage, during which you need to determine who should be hired and who should be better off. Keep in mind that you need to hire those who can be part of the team, as this will have a positive effect on the performance of the company and help you get things done faster.

The following is an example of a candidate whose compatibility with an existing team is low (figure 9).

At the same time, there is a candidate whose compatibility with the team is sufficient (figure 10).

By finding a candidate with sufficient compatibility with the development team, as well as sufficient professional performance, players can hire a suitable candidate for their development team. They can then focus on managing software development or, if they see fit, continue to hire employees.

In the process of using game simulators in the educational process, the following methods are used:

1. *Project method.* This game simulator is based on simulation of software development projects, where future software engineers can directly feel like a participant in a realistic software development project and directly influence its progress, as well as the success of its implementation and completion.

As the player manages the process of completing the software development project, he can also hire and fire employees, give them tasks, monitor their progress, and buy tools, and more.

A great advantage of project activities is the skills that students acquire, namely:

- plan their work, pre-calculating the possible results;
- use many sources of knowledge and data;
- independently collect and accumulate material;
- analyze, compare facts, argue their point of view;
- make a decision;
- establish social contacts (distribute responsibilities, interact with each other);
- to create a “final product” – a material carrier of project activities (report, abstract, film, calendar, magazine, prospectus, script).

2. *Adaptive learning.* With the help of a game simulator, a so-called “examination cycle” is created, ie game simulations will present students with similar types of problems until the necessary professional soft competencies are formed. Then game simulations create new problems for students, which can no longer be solved only with the help of previously formed competence. This forces students to rethink the existing professional soft competencies and acquired experience, knowledge, skills, and abilities and to form new competencies and integrate them with the previously formed ones.

3. *Modeling situations.* The game simulator simulates a variety of professional situations: project development with restrictions on time, budget, and quality of the final product; the need to hire, train and manage a software development team; situations where timely communication with other

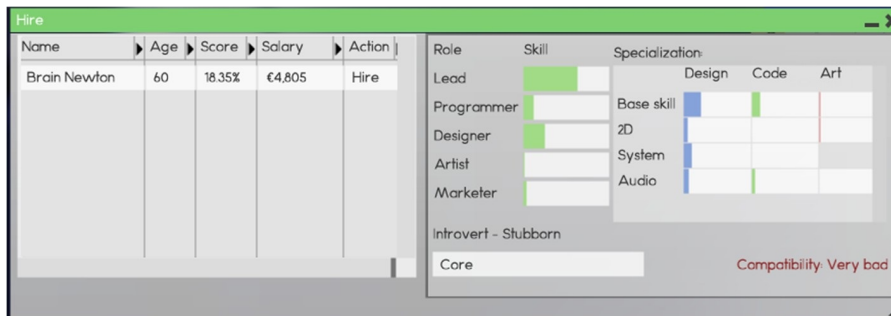


Figure 9: Example of showing poor candidate compatibility with an existing team in a game simulator Software Inc.

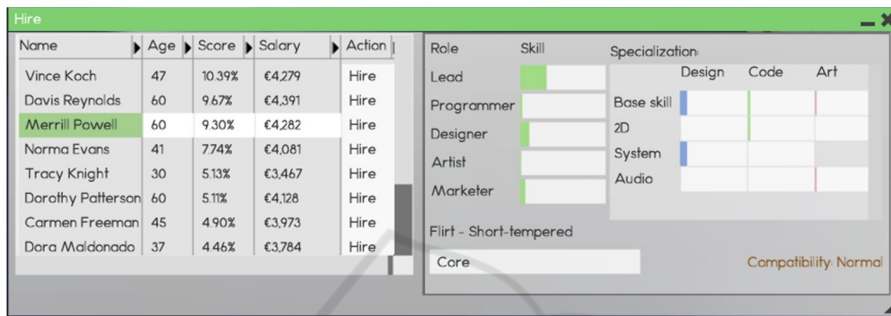


Figure 10: An example of showing good candidate compatibility with an existing team in a simulator Software Inc.

team members or clients is required; professional and ethical dilemmas; situations of the need to establish and maintain appropriate processes of marketing, sales and innovation research. Also important is the exciting gameplay provided by the game techniques and the dynamics of game simulations. This captures and sharpens students' interest, making the learning process more memorable and therefore more efficient.

During the game simulation in the game simulator Software Inc are formed as follows competencies aimed at forming a stable professional competence of a specialist in software engineering (as defined in (Semerikov et al., 2020)):

- ability to apply knowledge in practical situations;
- ability to communicate in a foreign language;
- ability to work in a team;
- ability to act based on ethical considerations;
- commitment to preserving the environment;
- ability to evaluate and take into account economic, social, technological, and environmental factors affecting the sphere of professional activity;
- the ability for lifelong learning.

After all, in the process of passing the simulation, students need to work with their staff to achieve common goals. To complete game simulations, students

need to identify, organize, and maintain mutually beneficial relationships not only within the team but also outside it. Another important factor is the fact that this simulator is in English, and therefore students develop foreign language communication skills.

The comparative research method allowed to trace the positive dynamics of the levels of formation of professional competencies during the application of this game simulator in the educational process (figure 11). Statistical analysis was performed using the Pearson test, in which students were divided into two groups, and accordingly established the approximate equality of the level of formed competencies of students in both groups at the initial stage and the difference at the final. As a result, the results show the positive dynamics and, accordingly, the effectiveness of the proposed game simulator in the learning process.

3 CONCLUSIONS

During the game simulator Software Inc are formed as follows competencies aimed at forming a stable professional competence of a specialist in software engineering: the ability to: apply knowledge in practical situations; communicate in a foreign language; work in a team; act based on ethical considerations; commitment to preserving the environment; evaluate and

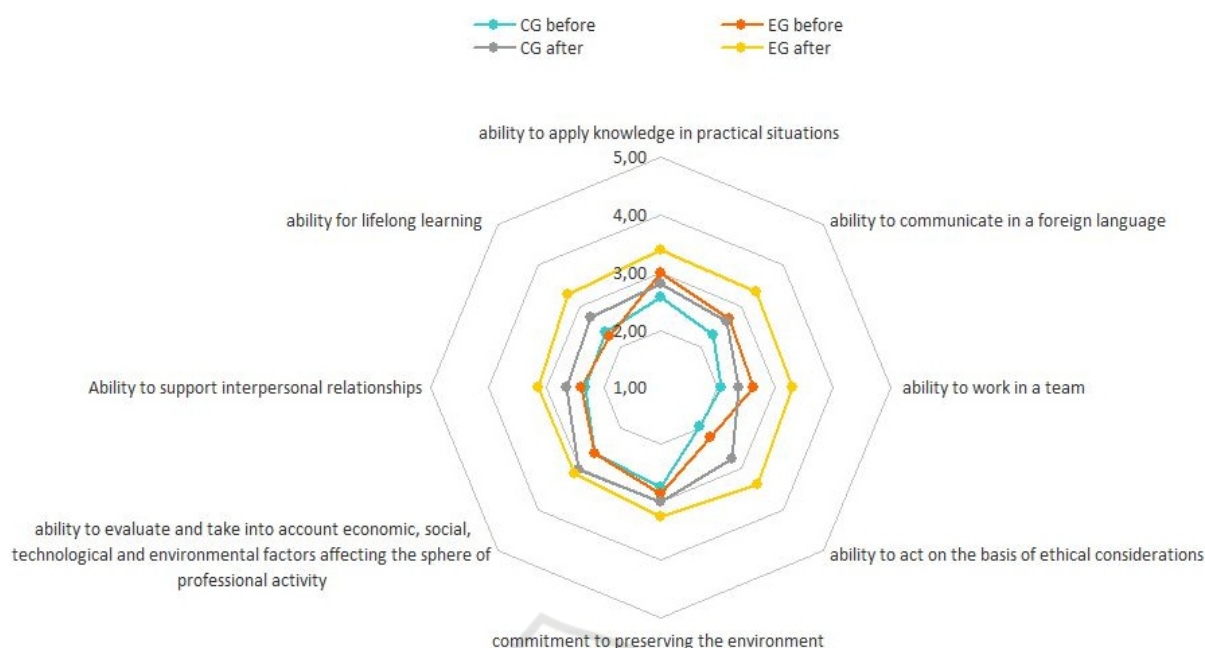


Figure 11: The average assessment of the levels of professional competencies of students in CG and EG at the beginning and end of the experiment.

take into account economic, social, technological and environmental factors affecting the sphere of professional activity; for lifelong learning. This has been confirmed experimentally. Prospects for further research may be a set of non-use of several simulators and their impact on the development of professional competencies of future software engineers.

REFERENCES

Ahmed, F., Capretz, L. F., Bouktif, S., and Campbell, P. (2013). Soft skills and software development: A reflection from the software industry. *International Journal of Information Processing and Management*, 4(3):171–191.

Al-Tarawneh, M. H. (2016). The effectiveness of educational games on scientific concepts acquisition in first grade students in science. *Journal of Education and Practice*, 7(3):31–37.

Alkan, A. and Mertol, H. (2019). Teacher candidates' state of using digital educational games. *International Journal of Evaluation and Research in Education*, 8(2):344–350.

Atal, R. and Sureka, A. (2015). Anukarna: A software engineering simulation game for teaching practical decision making in peer code review. *CEUR Workshop Proceedings*, 1519:63–70.

Baker, A., Navarro, E. O., and van der Hoek, A. (2003). Problems and programmers: an educational software engineering card game. *CEUR Workshop Proceedings*, pages 614–619.

Buzko, V. L., Bonk, A. V., and Tron, V. V. (2018). Implementation of gamification and elements of augmented reality during the binary lessons in a secondary school. *CEUR Workshop Proceedings*, 2257:53–60.

Calderón, A. and Ruiz, M. (2014). Bringing real-life practice in software project management training through a simulation-based serious game. In *Proceedings of the 6th International Conference on Computer Supported Education*, volume 2, pages 117–124.

Caulfield, C., Xia, J., Veal, D., and Maj, S. P. (2011). A systematic survey of games used for software engineering education. *Modern Applied Science*, 5(6):28–43.

Clarke, P. and O'Connor, R. V. (2012). The situational factors that affect the software development process: Towards a comprehensive reference framework. *Information and Software Technology*, 54(5):433–447.

Dantas, A. R., de Oliveira Barros, M., and Werner, C. M. L. (2004). A simulation-based game for project management experiential learning. In Maurer, F. and Ruhe, G., editors, *Proceedings of the Sixteenth International Conference on Software Engineering & Knowledge Engineering (SEKE'2004), Banff, Alberta, Canada, June 20-24, 2004*, pages 19–24.

Demirbilek, M. and Koç, D. (2019). Using computer simulations and games in engineering education: Views from the field. *CEUR Workshop Proceedings*, 2393:944–951.

Elkonin, D. B. (1999). *Psikhologiya igry (Game psychology)*. Vlados, Moscow.

Emam, K. E. and Koru, A. G. (2008). A replicated survey of IT software project failures. *IEEE Software*, 25(4):84–90.

Gunter, G. A., Kenny, R. F., and Vick, E. H. (2008). Taking

- educational games seriously: using the retain model to design endogenous fantasy into standalone educational games. *Educational Technology Research and Development*, 56(5-6):511–537.
- Hodges, D. and Burchell, N. (2003). Business graduate competencies: Employers' views on importance and performance. *Asia-Pacific Journal of Cooperative Education*, 4(2):16–22.
- Jackson, G. T. and McNamara, D. S. (2017). The motivation and mastery cycle framework: Predicting long-term benefits of educational games. In Baek, Y., editor, *Game-Based Learning: Theory, Strategies and Performance Outcomes*, pages 97–121. Nova Science Publishers.
- Jazayeri, M. (2004). The education of a software engineer. In *Proceedings of the 19th IEEE International Conference on Automated Software Engineering, ASE '04*, page .18–xxvii, USA. IEEE Computer Society.
- Karunasekera, S. and Bedse, K. (2007). Preparing software engineering graduates for an industry career. In *20th Conference on Software Engineering Education & Training (CSEET'07)*, pages 97–106.
- Klopfer, E. (2008). *Augmented Learning: Research and Design of Mobile Educational Games*. MIT Press, Cambridge.
- Liu, J. Y.-C., Chen, H.-G., Chen, C. C., and Sheu, T. S. (2011). Relationships among interpersonal conflict, requirements uncertainty and software project performance. *International Journal of Project Management*, 29(5):547–556.
- Michael, D. R. and Chen, S. L. (2005). *Serious Games: Games That Educate, Train, and Inform*. Muska & Lipman/Premier-Trade, Cincinnati.
- Mtsweni, E. S., Hörne, T., and van der Poll, J. A. (2016). Soft skills for software project team members. *International Journal of Computer Theory and Engineering*, 8(2):150–155.
- Navarro, E. (2006). *SimSE: A Software Engineering Simulation Environment for Software Process Education*. PhD thesis, University of California, Irvine. <https://www.ics.uci.edu/~emilyo/papers/Dissertation.pdf>.
- Noudoostbeni, A., Yasin, N. M., and Jenatabadi, H. S. (2009). To investigate the success and failure factors of erp implementation within malaysian small and medium enterprises. In *International Conference on Information Management and Engineering, ICIME'09*, pages 157–160. IEEE.
- Pant, I. and Baroudi, B. (2008). Project management education: The human skills imperative. *International Journal of Project Management*, 26(2):124–128.
- Purna Sudhakar, G., Farooq, A., and Patnaik, S. (2011). Soft factors affecting the performance of software development teams. *Team Performance Management*, 17(3/4):187–205.
- Sauvé, L., Renaud, L., and Kaufman, D. (2005). Games and simulations: theoretical underpinnings. In *Changing Views: Worlds in Play. Digital Games Research Association's 2nd International Conference*. http://www.savie.ca/SAVIE/Publications/Jeux/083_Sauveetal_DiGRA_Games_EN.pdf.
- Semerikov, S., Striuk, A., Striuk, L., Striuk, M., and Shalatska, H. (2020). Sustainability in Software Engineering Education: a case of general professional competencies. *E3S Web of Conferences*, 166:10036.
- Striuk, A. M. (2018). Software engineering: first 50 years of formation and development. *CEUR Workshop Proceedings*, 2292:11–36.
- Tokarieva, A. V., Volkova, N. P., Harkusha, I. V., and Soloviev, V. N. (2019). Educational digital games: models and implementation. *CEUR Workshop Proceedings*, 2433:74–89.
- Vakaliuk, T. A., Kontsedailo, V. V., Antoniuk, D. S., Korotun, O. V., Mintii, I. S., and Pikilnyak, A. V. (2020). Using game simulator Software Inc in the Software Engineering education. *CEUR Workshop Proceedings*, 2547:66–80.
- Vieira, E. A. O., da Silveira, A. C., and Martins, R. X. (2019). Heuristic evaluation on usability of educational games: A systematic review. *Informatics Educ.*, 18(2):427–442.
- Vygotsky, L. S. (1962). *Thinking and speech*. The M.I.T. Press. <https://www.marxists.org/archive/vygotsky/works/words/Thinking-and-Speech.pdf>.