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Applying game-based learning to a primary school class in computer science terminology learning

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Introduction: Game-based learning is an innovative technique that utilizes the educational potential of videogames in general, and serious games in particular, to enhance training processes and make it simpler for users to attain motivated learning.

Methods: In this study, we propose game based learning for primary school students in computer science terminology learning. Primary school students often engage in game-based learning. Academic accomplishment motivation consequences have been researched extensively. The purpose of this research was to see how successful Game-Based Learnings are in motivating primary school kids to attain academic success. Fifty primary school students in two focus groups participated in the experiment during 10 weeks to test the involvement of game based learning to pupils.

Results: There are two kind of measurements were applied in identifying benefits of game based learning. First, one is the questionnaire that students answered to questions in three categories as Impression, Usability, and User Interface. Second part of measurement is downloading and uploading of homeworks, and their academic performance. Approximately 90% of the students found the game based learning to be beneficial in their studies and remembering computer science terminologies. The children were satisfied with its functionality and ease of use.

Discussion: The results can be useful for educators, instructional and game designers, and researchers from implementation, design and research perspectives.

KEYWORDS

Gamification, e-learning, m-learning, learning motivation, game-based learning, computer science

1. Introduction

Modern education is confronted with a slew of complicated issues relating to societal technological advancement and social changes. At least for the time being, the second generation of individuals has been recognized as digital technology carriers. These are individuals who have grown up in the digital world and see it as their preferred destination (Lindgren, 2018). Changes with in values of intellectual growth, the set of vocations, and the training rules are all determined by the technological and intellectual level of humanity. The notion of ongoing education is becoming more widely accepted, in which the process of learning information never stops and continuous

self-education and self-development become a normal professional need (Romero et al., 2017; Sousa and Rocha, 2019). As a result, the prerequisites for education system are altering as well. These are not the traditional ability to read, write, and execute basic arithmetic operations, but rather a set of particular fundamental talents that scholars refer to as “skills of the twenty-first century” (Ian and Clark, 2016). This today word does not seem to have a clear definition. Creativity, decision making abilities, joint and collaborative interaction abilities, and communication abilities are all mentioned in the majority of the publications we looked at (Chung and Chang, 2017; Brezovszky et al., 2019). Game-based learning (Hamari and Nousiainen, 2015; Sung et al., 2017) is one of the most appealing techniques of gaining such abilities.

Children and teens like games as one of their favorite pastimes (Fromme, 2003; Nippold et al., 2005). Early studies of computer games’ psychosocial consequences tended to concentrate on its negative impacts, such as addiction (Griffiths and Davies, 2002), violent conduct (Hastings et al., 2009), and poor academic performance (Gentile et al., 2004). Despite this, many games are useful for children. Serious games, educational games, augmented and mixed reality games for sports training, interactive medical games, puzzle games, coding games, memory games, and games for the development of spatial reasoning are the examples of such kind of games that useful for school children (de Freitas, 2006; van Eck, 2006; Rieber and Noah, 2008; Ting, 2010). In this study, we consider educational games for schoolchildren to learn computer science terminologies.

In educational institutions, the usage of computer games is steadily increasing. Games have revolutionized pedagogical education and learning practices as a result of their superior technology (van Eck, 2006). Games are seen to be beneficial in terms of learning certain tactics and obtaining information. Games may be utilized to investigate particular topic and have an impact on students (de Freitas, 2006; Rieber and Noah, 2008; Ting, 2010). The use of games as teaching aids has been researched at the elementary, secondary, and university levels (Gros, 2007; Annetta et al., 2009; Watson et al., 2011) and implemented in a variety of fields, including maths (Lee and Chen, 2009), biology and chemistry (Annetta et al., 2009), geography (Watson et al., 2011), and natural sciences (Cuenca and Martin, 2010), to successfully accomplish diverse educational objectives. The usage of wirelessly linked ubiquitous learning games has recently become a new learning approach in academic institutions. Children who played mobile games performed better on a knowledge exam than those who got a series of normal project-based courses, according to Huizenga et al. (2009).

If the work on extracurricular activities of students is properly organized, then in such conditions it is possible to maximize the students’ need for learning and reveal their individual capabilities. It is no secret that the upbringing of children is carried out at any time of their activity. However, the most maximum results can be obtained in a comfortable environment, i.e., in your free time from school. Coming to various additional classes, students quickly adapt to the environment of their peers, quickly establish contact, thanks to this environment, students study the material more intensively. Each extracurricular activity is aimed at involving each student in the activity, revealing their potential, and experiencing their abilities (Mishra and Kotecha, 2017).

Since we live in the age of information technology, the involvement of a child in educational activities based on the use of computer technology, mobile communications, digital devices for recording observations of electronic educational resources in an educational institution has a number of positive aspects, both in terms of the development of his personality, as well as for continuing the computer

science course at school. The knowledge obtained as a result of studying computer science at school determines the further information position of children not only in educational activities, but also in the child’s society (Alhammad and Moreno, 2018).

Currently, conducting lessons based on game techniques in teaching computer science in junior classes comes to the fore. This is due to the fact that these methods, including almost all forms of work, provide ample opportunities for creative activity and intellectual development of the child. As you know, the game gives a break in everyday life with its utilitarianism, monotony, with its rigid determination of the way of life.

In this article, we offer a mobile game for learning computer terms for elementary school students. Testing of experimental and control groups shows that the mobile game helps to quickly memorize computer science terms, opens up an overview of the use of computer spare parts and helps in practical work.

2. Literature review

The concept of “gamification,” derived from the word “game,” originally meant the process and result of using game approaches, mechanics in non-game space, which meant the transfer of computer game elements to various spheres of social life (Behl et al., 2022). Gamification, representing the process of irradiation of game elements into new types of activities for which it was previously not characteristic, quickly penetrated into the field of education, where it turned out to be improperly mixed with other means and technologies used by teachers to enhance the involvement of students in the pedagogical process, in particular, with didactic-oriented computer games (Hayes et al., 2022).

Currently, there are specialized online platforms (for example, services LearningApps.org, Kahoot.com), providing technical opportunities for teachers to independently create games of various subjects attractive to students of different ages, providing operational feedback (Kohnke and Moorhouse, 2021; Susanti et al., 2021). In most of them, the essential characteristics of the didactic game are preserved, namely: the merging of game and didactic tasks, the solution of which occurs simultaneously, in the process of performing certain game actions (tasks) regulated by game rules, which ensures the achievement of a game result (winning). Interest in the activity is supported by a variety of multimedia effects (sounds, color changes, the appearance, disappearance or movement of objects on the screen, etc.; Nigmatova, 2022). At the same time, the games created by teachers (without the participation of IT specialists) are characterized by a simple structure (the presence of only one task), the absence of a storyline, game levels and a number of other gameplay elements (and gameplay). The latter is an ordered set of certain methods of interactive interaction between a computer program and a player, a system of game mechanics and game rules that ensure its implementation. For example, in the game “School Adventures. Space Games of Literates” (2007) elementary school students are invited to take part in virtual space battles, while performing a series of educational tasks in mathematics and linguistics for a limited period of time (Nash and Brady, 2022). The success of their implementation is not only promptly evaluated and rewarded, but also determines the achievement of the final result – the receipt of a new spaceship (in the presence of a large number of errors, the player eventually sees an old destroyed spaceship). In the future, with the proper cooperation of teachers and programmers, the content of such games could fully meet the requirements of the educational program

being implemented, covering specific sections, which would increase their relevance in practice (Patel et al., 2022).

For many practical teachers who have a need to introduce innovative teaching methods into the educational process, a computer game seems to be an effective way to improve the quality and productivity of learning (Liberona et al., 2021). At the same time, the game is defined as the sphere of self-expression of students, their self-realization, self-identification and self-examination. In addition, many teachers note the increased interest of students in mastering educational material during the game. It is a well-known fact that in the process of learning, game activity performs educational, developmental, educational, communicative, psychological, entertaining and relaxation functions (Ohanyan and Barexamyanyan, 2021). Meta-analysis of qualitative indicators of the effectiveness of digital games as a learning tool revealed that the most effective models for the development and use of educational games can be obtained by integrating key variables such as learning, learner and the design of a learning digital game (Fadda et al., 2022).

In the field of information technology education, games are regarded as conceptual models operating in formal and informal learning contexts. In an informal context, games often reflect the content of students' leisure time, as they are a key activity outside of educational institutions (Sadovets et al., 2022). Information technology training is a long and time-consuming process for both the student and the teacher. If educational computer games are fun, relaxing, motivating and strengthening the student's self-confidence, students' interest in this tool for learning foreign languages should increase (Abdelhamid, 2020).

Contextual learning based on digital games is also of considerable interest (Zou et al., 2021). This is an approach to building an educational process in which students immerse themselves in a gaming context to gain a learning experience, as well as a gaming experience. Starting from the theory of situational learning, which involves involving students in a real life context, this method is based on social interaction embedded in the life context of the participants in the process. From the point of view of contextual learning, knowledge is born in the course of interaction between participants, contexts and communities. Therefore, contextual game learning is considered a promising method of providing students with prerequisites for acquiring and applying constructive knowledge in their familiar environment (Behl et al., 2022).

Educational online games are used to increase motivation to participate in the learning process, as well as to improve communication skills due to the fact that they contribute to the favorable development of foreign languages, as they create a relaxed emotional background in which students, and, importantly, teachers can fully integrate into the learning process, in connection with this, this auxiliary teaching tool has been widely recognized among teachers (Anak Yunus and Hua, 2021). Due to the almost ubiquitous Internet connection in the modern world and the widespread use of personal computers at home, educational games are increasingly being developed to take advantage of network interactivity. Most of the newly developed online learning games involve the user's connection with other users either in the form of a competitive plan activity or in the form of collaboration to achieve joint educational goals. Despite the growing popularity of educational online games and the theoretical arguments existing in the modern scientific literature in favor of the possible advantages of such games, empirical studies devoted to the study of the effectiveness of online games of an educational nature are not so numerous.

3. Problem statement

Modern general education schools are qualitatively updated, using the interrelationships of traditional and innovative approaches to the organization of a holistic educational process as a joint creative activity of a teacher and a student (Zou et al., 2021). Among the technical innovations that came to the school, interactive whiteboards took an important place. They are more often used in the classroom, although they have a high potential for extracurricular activities (All et al., 2021). Therefore, it is necessary to consider possible methods of teaching computer science in the context of organizing extracurricular activities on the subject. One of the leading factors in improving the effectiveness of computer science education is the use of games and game forms of organizing extra-curricular activities. Computer game programs have an advantage over other forms of games (Wang and Zheng, 2021).

The problem of the research is the need to justify the methodological foundations, design, development of interactive computer games that provide effective teaching of computer science in extracurricular activities of students.

Research hypothesis: if interactive games are used in the process of teaching computer science in extracurricular activities, which are specially designed and include appropriate content, this will increase the effectiveness of teaching, consolidate students' knowledge and increase interest in the subject "Computer Science."

4. Materials and methods

In this study, we proposed a game based learning for computer science terms learning. Before we start creating a game application, we need to collect data and decide on a list of words that will be taught by the game. The following list of the most used words and phrases from the terminology of information technology was proposed. Table 1 contains the most used words in the field of IT. The words were written in three languages: English, Russian, and Kazakh.

After determining the words that the game will teach, it is time to decide on what the game will be written on and on which engine it will be developed. Before doing this, we need to explore the products offered on the market and choose the most suitable one. The Unity game engine is used to develop the game. It is a cross-platform environment for computer game development proposed by Unity Technologies (Zi Xuan et al., 2020). Unity allows to create applications running under more than 20 different operating systems, including personal computers, game consoles, mobile devices, Internet applications, and others (Bama and Fodor, 2017; Iskandar et al., 2020). It allows creating games running on personal computers and mobile devices with different operating systems. Unity Editor has a simple drag-and-drop interface that is easy to configure. The engine supports two scripting languages: C# and JavaScript. Physical calculations are made by the PhysX physical engine from NVIDIA.

It is not possible to write in many languages on the Unity engine. It is necessary need to rely on the capabilities and flexibility of the language to create a platformer in two-dimensional graphics mode. Unity natively supports three programming languages like C#, UnityScript is a language designed specifically for use in Unity modeled after JavaScript. UnityScript has been around since the very first version of Unity 1.0, but its lifetime is nearing its end. Developers are slowly discontinuing support for UnityScript. Recall that this is a JavaScript-like programming language offered as an alternative to the C# language. UnityScript and C# are roughly comparable in terms of functionality and performance:

TABLE 1 Sample of terminologies.

English	Русский	Qazaq
Computer Science	Информатика	Informatika
Information	Информация	Aqparat
Calculating Machine	Вычислительная Машина	Esepteý mashinasy
System Unit	Системный блок	Júelik qorap
Screen	Экран	Ekran
Keyboard	Клавиатура	Pernetaqta
Personal Computer	Персональный Компьютер	Derbes kompyúter
Hardware	Аппаратное Обеспечение	Apparattyq qurylym
Software	Программное Обеспечение	Programmalyq Qurylym
Operating System	Операционная система	Operatsionalyq júie
Memory	Память	Jad
Random Access Memory	Оперативная память	Jedel jad
Hard Disk	Жесткий диск	Qatty disk
Desktop	Рабочий стол	Jumys ústeli
Variable	Переменная	Aynymaly
Value	Значение	Mán
Font	Шрифт	Qarip
Bold	Жирный	Qoıy
Italic	Курсив	Qisaitylǵan
Underlined	Подчеркнутый	Asty syzylǵan
Array	Массив	Jıym
Store	Хранить	Saqtay
Assign	Присвоить	Menshiktey
Folder	Папка	Qapshyq
Spread Sheet	Электронная таблица	Elektrondyq keste
Cell	Ячейка	Uıashyq
Column	Столбец	Baǵan
Row	Строка	Jol
Insert	Вставка	Kiristiry
Edit	Редактировать	Túzety
Encoding	Кодирование	Kodtay

But C# takes the lead when it comes to creating a development ecosystem – it's not just millions of different documentations and lessons, but also sets of supported tools like refactoring or IntelliSense in Visual Studio. Based on the above, the choice of programming language fell on C#. Most of the styles are intuitive. However, we invite you to read carefully the brief description below.

4.1. Creating the game concept

Since the game is to complete as many levels as possible and learn as many words as possible, it was decided to create a platformer game. What is a platformer? Plat-former (English platformer, platform game) – a genre of computer games in which the main

feature of the gameplay is jumping on platforms, climbing stairs, collecting items that are usually necessary to complete a level (All et al., 2021).

The next stage is the selection of the player for whom the user will play. Using an open library of assets (English Assets) and because of the training in terminology related to information technology, the choice fell on a small robot. Figure 1 demonstrates prototype of the robot that used in the proposed game.

After selecting the main character, work began on the implementation of the terminology training functionality. A system was created to collect oil drops (bonuses, stars), without which he would not have been able to complete the level. The goal of the game was to keep the little robot from rusting and try to collect all the oil drops so that he could lubricate all his mechanisms. At each level, three drops of oil were created, which the robot had to collect.

The name of the game was based on the main character of the game and its goal, collecting oil. The game was called “Rusty Rusty,” which implies a little wordplay. The first word, translated from English, means “rusty,” and the second already means the name of this small robot. That is, the game is called “Rusty Rusty.” And then you can immediately see the goal of the game-not to let Rusty rust, collecting oil droplets.

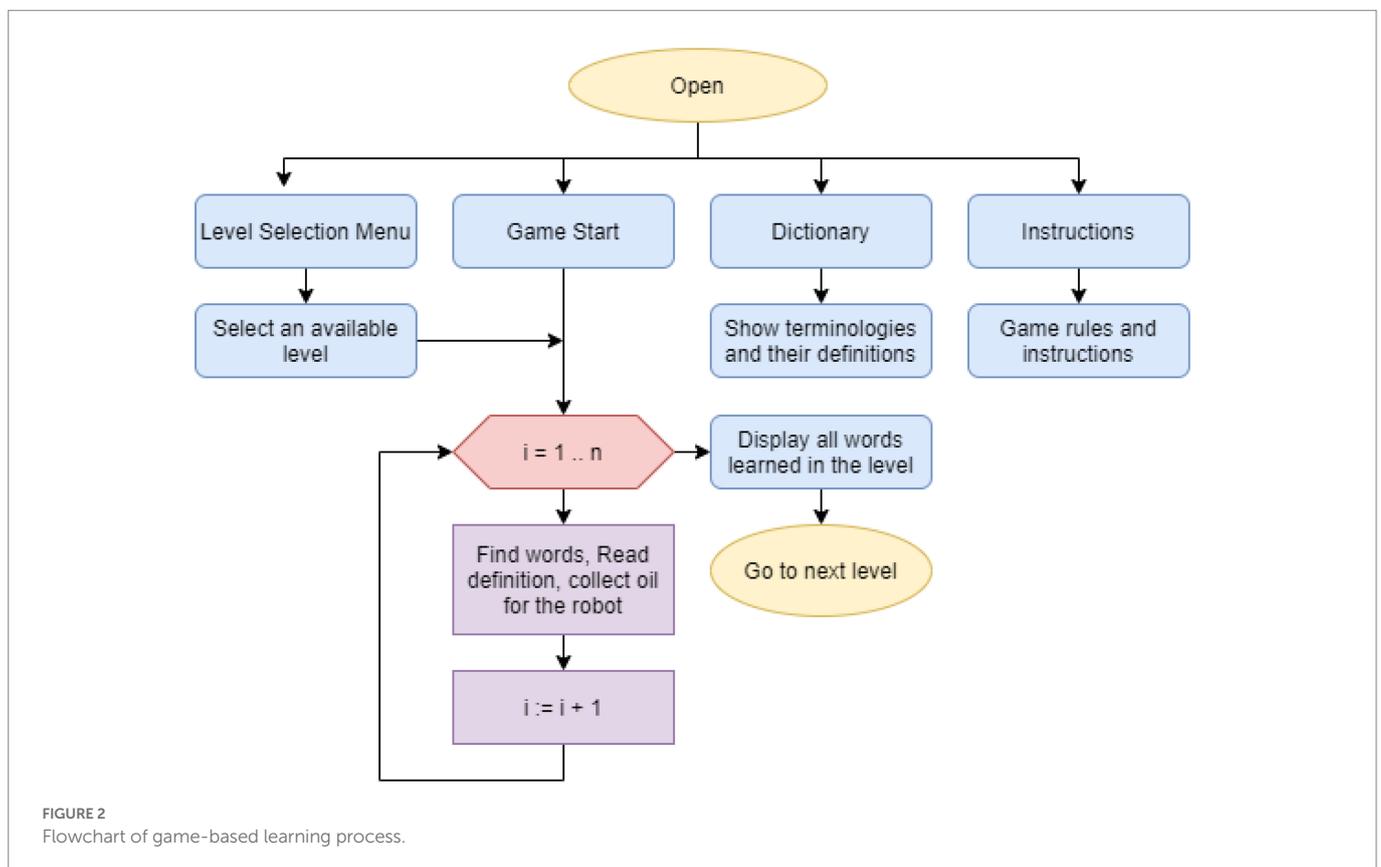
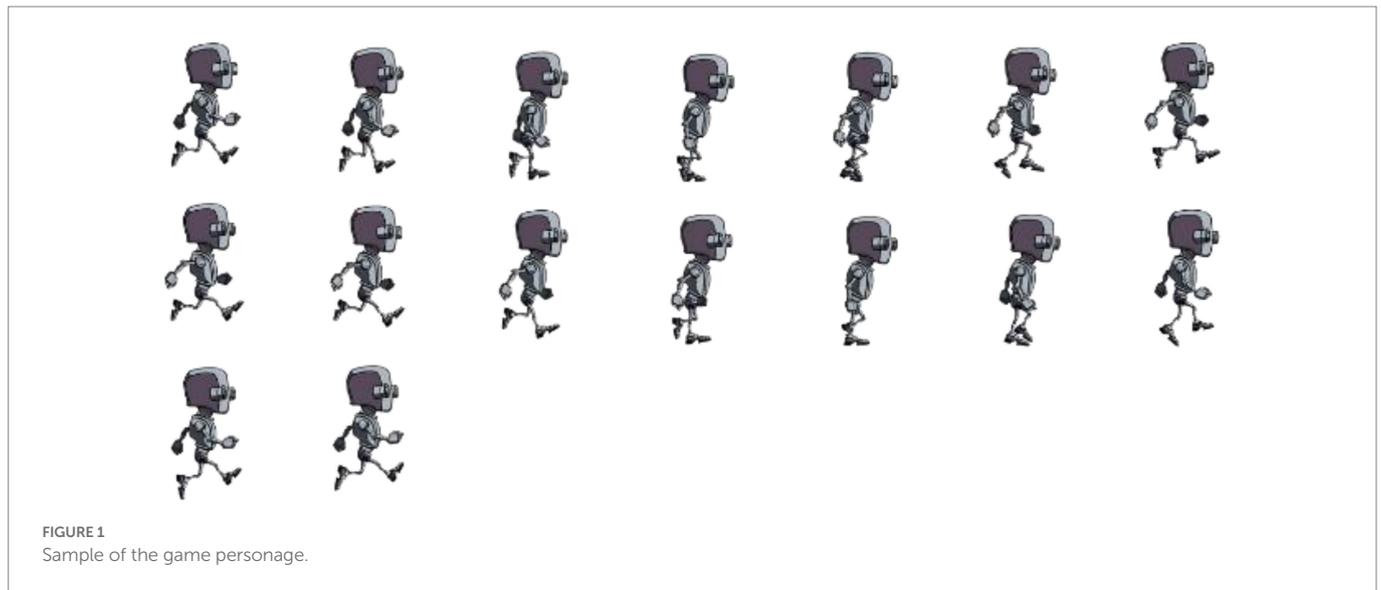
4.2. Learning information technology terms while playing

Regarding the study of terms, three terms in English were hidden at each level. They were located directly under the bonuses (oil drops) and the catch of each level was based on collecting at least one bonus, which means that the user will not be able to go to the next level without collecting at least one bonus (oil drops, words). After the user collects all three bonuses, a window opens for a few seconds, which contains the translation of all the words that he collected into Russian and Kazakh. Only after collecting these words, an additional item opens in the menu, where the user can find out the translations of all the collected words and their brief description. Figure 2 illustrates flowchart of game-based learning process of the proposed game.

As can be seen in the figures, in order for people to understand how they look when collecting terms, photos were added next to the names. Figure 3 demonstrates an example of appearance of terminology during the game. The proposed educational game was developed using the Unity platform, which is a multifunctional platform with full functionality for working with two-dimensional graphics and creating games for any device, including mobile phones.

4.3. Testing and releasing the game for general use

After developing the game, it was fully tested for bugs and improved every time. After all the requirements of the testers were taken into account, a beta test was launched, a test of the game by a small group of real users. Minor design flaws were identified, and soon everything was taken into account and corrected. Thus, we received the necessary data from the first users of the game. After a week of using the game, we received positive feedback about the system of learning terms through unobtrusive study during the game. As soon as the game was



ready to launch, we sent it to the Android games and applications platform – Play Market (Wang and Zheng, 2021).

5. Results

Qualitative and quantitative evaluations of academic performance were conducted using the following methodologies (Zi Xuan et al., 2020) to guarantee that the game-based approach promoted students' active involvement in the learning process.

- Student behavior observation;
- Online survey investigation;
- Students' self-report of activity;
- Administrative data collection including attendance, late arrivals, number of material downloads, lab exercise results, and academic performance;
- Collection of administrative data such as student attendance, late arrivals to class, number of reference material downloads, completion rate of lab exercises, and academic performance;
- Usability Testing.



FIGURE 3
An example of the appearance of terminology during the game.

- Observation of student behavior

In this study, we divided the students into two groups: control and experimental. There are 50 elementary school sophomores in each group. Throughout all classes, the majority of experimental group students displayed the following traits, which are regarded instant indications of involvement (Franklin, 2005; Robinson, 2019):

- Actively listened, focused attention, and made eye contact;
- Responded to the teachers' suggestions;
- Actively engaged in the courses;
- Used decision-making or problem-solving abilities in questioning and replying;

5.1. Online survey exploring the effects of gamification in the classroom

To get quantifiable feedback on the gamified experience's efficacy, usability of the game, and user satisfaction of the game, we created a questionnaire based on three different surveys (Lewis, 1995; Lin et al., 1997; Murugesan et al., 2022). The questions divided into three groups as Impression that indicates overall reaction of a user (12 questions), Screen that refers to representation on the screen (three questions), UI group that refers to Usability and User Interface questions (three questions). All experimental group students (Nexp = 50) completed an 18-question online survey at the end of the course. The questions Every question had five possible answers measured on a Likert scale of 1 (Strongly Disagree) to 5 (Strongly Agree).

According to the weighted Likert scale average presented in Figure 4, students overwhelmingly acknowledged that class games made learning more enjoyable and that they would want to see them used in future courses as well. Students were also typically motivated to show up for class and come on time, as shown by administrative data obtained at the conclusion of the course. While playing, the majority of students interacted with their classmates and claimed that doing well in the games boosted their self-confidence. Surprisingly, there were conflicting feelings regarding receiving concrete benefits, such as the conversion of gaming points into genuine module grades. Finally, most students said gaming was a good use of class time since it helped them enhance their analytical and problem-solving abilities, as well as their ability to memorize computer science words quickly. In addition, students began to realize what each part of the computer is used for.

5.2. Semi-structured interviews for in-depth student feedback

Qualitative research was undertaken in the form of focus groups and semi-structured interviews to get further insight into the survey findings, including questions on collaborative learning, cognitive growth, and personal skill development. The general reaction of respondents was quite favorable, as seen by the following selection of responses:

- "I know I've learnt from both watching other people play the game and playing it myself."
- "I love it when I have all the answers." It's also nice to have bragging rights."
- "Completing a course by playing a game makes you feel like you have learned something."
- "Fast memorizing complex computer terminologies made me proud and clever."
- "Playing Rusty Rusty strengthened my confidence and made it simpler for me to remember computer terms"
- "At long last, even if it was just for educational reasons, I was permitted to use my iPhone in class."
- "I like Rusty Rusty! because it is always fun."
- "Lessons are no longer boring."

In the survey's last portion, there are three questions with blank areas to fill in. The students were questioned about the game's three most good and negative aspects, as well as their overall assessment of the laboratory. As a result, the following was the most common unfavorable aspect: Due to tiny delay in loading of the game, and loading of the next tours, the youngsters would want to have the program function quicker. The ability to view and memorize the definitions of each computer science terminology without interfering with gaming process, are the most frequent responses among favorable components of the program. All of the students' suggestions and criticisms was useful and taken into account while developing the next edition of the game.

As a result of the performed surveys, the children are happy with the game's functioning and user interface as a supplement to their study. Furthermore, they submit-ted not only recommendations for improving the game, but also the beneficial influence of the game on their studies in the comments. Some of them, for example, re-marked that the textbooks they use in class lack color images, making it difficult to comprehend the computer peripheries and imagine them, just from written explanations. In this situation, colorful images in the game are really helpful. They also expressed an interest in applying such applications to other courses, such as physics, geography, or biology.

5.3. Survey results and analysis

A comparative analysis of students' participation and late arrivals (pupils coming to class with at least a 15-min delay) between the control and experimental groups was used to gauge student perseverance, interest, and effort in the gamified sessions (Figure 5).

Control group students had a 65 percent (35 students) average class attendance, whereas experimental group had a 78 percent (42 students) average class attendance. Furthermore, an average of 4–5 control group students and 1–2 experimental group students came late to class each week.

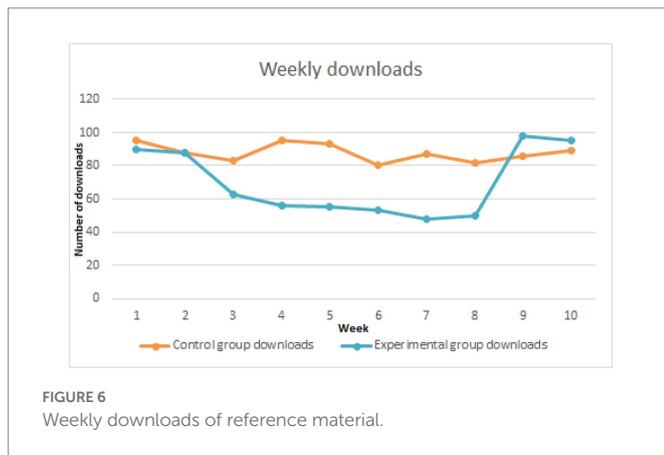
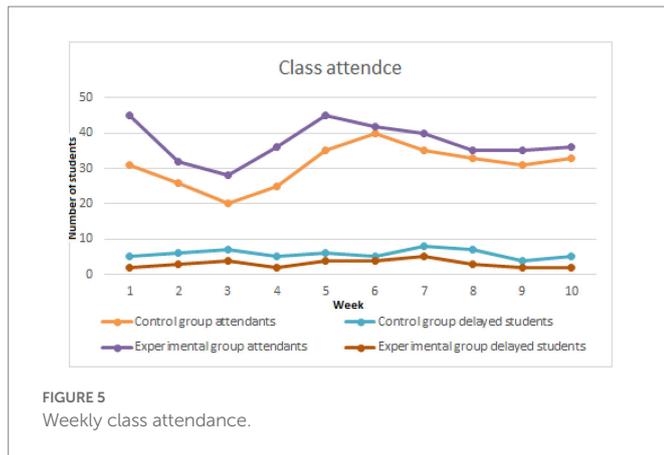
#		Question	Disagree ... Agree	Aver.	Var.	Dev.	Med.
1	Impr1	The games made the learning environment a fun and engaging one		4.7	0.79	0.79	5
2	Impr2	The games motivated me to attend classes		4.78	0.47	0.46	5
3	Impr3	The games motivated me to arrive to class on time		3.96	1.00	0.99	4
4	Impr4	I was more motivated to study the course material every week in order to do well in the leaderboard for the games		3.74	1.05	1.05	3
5	Impr5	I would recommend the application to a friend		4.78	0.41	0.42	5
6	Impr6	Learning computer science terms using the game is a pleasure		4.72	0.50	0.50	5
7	Impr7	I communicated with other players while playing		4.42	0.61	0.61	4
8	Impr8	The total duration of the game was satisfactory		3.78	0.98	0.97	3
9	Impr9	I believe that the games have improved my understanding of the covered topics		4.98	0.14	0.14	5
10	Impr10	Performing well in the games increased my self-confidence in computer science learning		4.9	0.20	0.46	5
11	Impr11	I believe that the games have improved my skills in remembering computer science terms		4.9	0.24	0.36	5
12	Impr12	I believe that gaming is a valuable use of instructional time		4.88	0.31	0.33	5
13	Sc1	The game has a friendly user interface		4.66	0.56	0.56	5
14	Sc2	The interface elements are clearly distinguishable and understandable		4.8	0.46	0.45	5
15	Sc2	Buttons and other elements of the game is understandable		4.72	0.50	0.50	5
16	U1	The game is flexible		4.84	0.47	0.47	5
17	U2	I can play the game anywhere and any time		4.78	0.54	0.55	5
18	U3	Game instructions are always available		4.82	0.49	0.48	5

FIGURE 4 Online survey results.

Both data indicate that gamification encouraged experimental group students to be more timely and attend class more often than their control group counterparts.

In terms of reference materials, each week the instructors submitted two zipped files: one including lecture notes and handouts, and the other including additional reading material. According to the number of weekly file downloads for reference material, control group students showed a relative lack of interest, with an average of

1.2 weekly file downloads per student (an average of 65 total downloads per week), which peaked only during the 2 weeks leading up to final exams; in comparison, every experiment student downloaded 1.7 files every week (an average of 89 total downloads per week); (Figure 6). When paired with the survey data, this might indicate that experimental group students were driven to download and study the course and additional reading material on a weekly basis in order to do well in the classroom games.



Experimental group students exhibited a tiny but continuous weekly rise in their completion rate of the practical exercises, which may also imply that the weekly difficulties inspired them to work harder to finish their exercises and improve their programming abilities. Finally, experimental group had the strongest overall academic achievement, with a 61 percent average final grade vs. 53 percent for control group students. However, because of the small number of participants, further research is required to find any links between gamification and academic success.

6. Discussion

The results show, that the proposed game is useful in computer science terminology learning for schoolchildren. Moreover, weekly downloads during the semester demonstrate that applying game based learning increases motivation of schoolchildren. According to a number of scientists and experts, the positive aspects of the use of gaming practices and, in particular, video games in education are as follows:

- in order to succeed, a computer game encourages a human player to work on errors. The faster the student learns the rules of the game, the faster he will feel the joy of “victory”;
- games are useful in the format of learning in a team. Often, the student is bored to perform any tasks alone at home or at the university, and through games, team interaction and spirit develop, greater involvement in the study of the material;

- play as a special activity can bring satisfaction and joy, capturing the attention of the student both on the process and on the results of the game;
- game strategies allow each person to determine their own goals, time and spatial conditions for achieving them in the mode of an individual educational trajectory (Brezovszky et al., 2019).

It is also important to note that from a pedagogical point of view, educational games should not exhaust the entire educational process, complementing and compensating for the lack of interaction of students with real objects of study, but not replacing interaction with the teacher and classmates and not cancelling other pedagogical technologies. Any extracurricular activity is an integral part of the educational process (Sousa and Rocha, 2019). The implementation of extracurricular activities will contribute to the further formation of students’ interests and views on the surrounding space, the disclosure of the role of computer science in the formation of a natural science picture of the world, the development of thinking, including the formation of an algorithmic style of thinking, and the preparation of students for life in the information society.

In this research, the technology and stages of developing an interactive computer game in computer science are considered, the system of tasks for this game is selected, possible forms, methods and means of using an interactive game are considered, and the effectiveness of its use is analysed. The use of interactive computer games allows you to form the motivation of learning, stimulate initiative and creative thinking, develop spatial thinking, develop the ability to act together, and subordinate their interests to common goals.

In our world, it is extremely important to gain knowledge, regardless of the place and time. Unfortunately, not everyone has access to all the latest technologies that appear almost daily. Children in remote parts of the country do not even know about such a science as “Computer Science.” To raise children’s awareness and engage the younger generation in the science of information technology, it was necessary to create something incredible. During the project, the game “Rusty Rusty” was developed, which allows children and adults to get the necessary knowledge from the field of information technology through the game. The words that the game taught were taken from the most commonly used terms in this section of Computer Science.

According to the study, the most popular games in the Play Market are games that do not require any special skills from the user, and are often used only to have a good time. For this reason, the platformer genre for mobile devices was chosen, for the introduction of learning new sciences effortlessly. The dominance of the Unity game engine as an engine for developing 2D platformers for mobile devices was revealed. In the future, we are going to develop versions of the proposed game for the iOS operating system. In addition, we are developing a proposed game for personal computers and want to check how much a computer game can be useful when studying the terminology of computer science by schoolchildren.

The effectiveness of using game applications as training in any sciences, in particular, computer science, has been proven. As the study showed, it is easier for children to perceive and remember all the information through entertainment applications. In further, we are going to use different technologies in educational game

development. We consider augmented reality, virtual reality and mixed reality tools as a technology to improve students' motivation and spatial reasoning ability. Based on the results of the project, we want to study in depth and offer a completely new and very effective method of teaching young children through the introduction of game applications, which will serve to improve the quality of education in the country.

7. Conclusion

The goal of this study was to evaluate how game-based learning in a computer science course influenced students' motivation, memory capacity, and performance. Using a multi-dimensional game-based learning technique to satisfy the pedagogical goals stated in the introduction was a success, according to the statistics. It enables teachers and students to witness firsthand how gaming aspects may be used to make learning more enjoyable and addictive. The proposed game is built on the concepts of the gamification, game-oriented learning, and gaming movements, which are gaining popularity. When games are used in combination with good learning, they can be a more effective and less intrusive way of evaluating learning than traditional assessments.

Working on this problem, we came to the conclusion that game methods of teaching younger students are most acceptable when studying computer science, since the use of these methods develops students' interest in studying computer science as a science. In addition, weekly downloads emphasize that the proposed computer game and game-based learning increase students' desire to learn throughout the academic semester and support their motivation. In the future, the proposed game can be modified to apply to other subjects other than computer science.

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Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

BO developed the research idea and contributed to all parts of the manuscript development and finalization. BKa, BO, LZ, AT, GB, BKu, and AA involved in game development, pedagogic experiments, data gathering, analysis, literature review, and manuscript development from the initial phases to the finalization of the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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