Methodology of training future computer science teachers to implement game-based learning: a case study

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Abstract

The paper is devoted to the development of a methodology for training future computer science teachers to use game technologies and organise game-based learning. The structure of the elective course "Methodology of Using Gaming Technologies" is proposed. It includes studying tools for creating quizzes (Kahoot!, Blooket), using gaming modules in the LMS Moodle and implementing Minecraft Education in the educational process. A feature of the course is the combination of gaming technologies as a means and an object of learning, which contributes to better assimilation of the material, activates students' cognitive activity and makes learning more interactive. The conducted pedagogical experiment allowed authors to assess the impact of digital gaming tools on the development of some students' skills. Analysis of the questionnaire of students revealed their high interest in implementing gaming technologies and their readiness to use them in their future professional activities. The study of game technologies in the training of future computer science teachers is recognised as an urgent task of modern education.

Keywords

digital gaming technologies, computer science, educational games, pedagogical experiment, Kahoot!, Blooket, Minecraft Education, LMS Moodle

1. Introduction

The modern educational process is undergoing significant transformations driven by the development of digital technologies [1, 2]. One of the most promising trends in education is the use of digital gaming technologies that help increase student motivation, improve their cognitive skills, and effectively learn the material [3, 4, 5, 6]. The experience of countries with developed education systems demonstrates that such technologies allow creating an interactive and personalized educational environment, increasing the level of student engagement in the learning process.

At the same time, modern education increasingly incorporates technologies such as cloud computing (CC), augmented reality (AR), virtual reality (VR), and artificial intelligence (AI). The cloud technologies serve as a foundation for deploying digital learning environments that offer scalable and flexible access to educational resources, support real-time collaboration, enable resource sharing, and integrate seamlessly with learning management systems [7, 8, 9, 10, 11, 12]. AR enriches the physical world with interactive digital elements, fostering better understanding of abstract concepts through visualization [13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24]. VR offers fully immersive environments that allow students to experience simulated real-world scenarios, thus enhancing practical skills and experiential learning [25, 26]. AI technologies support personalized learning, adapt educational content to individual students' needs, and provide intelligent tutoring systems [27, 28, 29, 30, 31, 32, 33, 34]. Although these technologies have opened new dimensions in education, digital gaming technologies offer a unique combination of accessibility, ease of integration, and strong motivational impact. Unlike AR and VR, which often require expensive equipment, or AI, which demands complex data infrastructure, educational games

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can be effectively implemented in everyday educational practice with minimal resources, making them highly suitable for wide-scale use. At the same time, numerous studies are currently being conducted on the use of AI in higher education, exploring its potential to personalize learning and optimize educational management processes. However, digital game-based learning remains a more accessible and immediately applicable solution for most educational contexts.

In particular, the use of digital gaming technologies in teaching computer science is an effective tool for developing the professional competencies of future bachelors in this specialty. Such tools as Kahoot!, Blooket, LMS Moodle, and Minecraft Education contribute to the development of subject knowledge and skills of analysis, logical thinking, and independent decision-making.

Despite its many advantages, the introduction of digital gaming technologies into the educational process in Ukraine has not yet become widespread. The main reasons for this are insufficiently developed methodological approaches, limited resources, and insufficient training of teachers in their effective use.

For the effective implementation of digital game technologies in the educational process, it is necessary to provide appropriate training for future computer science teachers. It can be carried out as part of a separate course on the use of digital game tools, integration of relevant topics into the discipline "Methods of teaching computer science" or consideration of game technologies within the framework of individual topics of other disciplines.

The purpose of such training is to develop students' ability to use digital game tools in their future teaching activities and adapt them to specific learning tasks. In addition, teachers need to understand the principles of designing digital game technologies, which will allow them to create their own educational products that are tailored to the needs of students.

One of the important aspects of training is to teach future teachers the principles of organizing game-based learning, which involves structuring tasks, gradually increasing their complexity, and providing effective feedback. In particular, tasks should contain clearly defined goals, as well as support mechanisms that will help students correct mistakes and improve their skills.

Scholars studied the methodology of using game technologies in computer science education, covering various aspects of gamification integration into the educational process, the impact of game technologies on the development of students' professional competencies, and the effectiveness of using digital game environments in pedagogical practice.

Riabko et al. [35] focused their attention on the implementation of gaming technologies in the training of future computer science teachers. In their research, they proved that the use of such digital gaming tools as Minecraft Education and Unity3D contributes to the formation of spatial thinking, algorithmic approach and problem-solving skills. For example, in the process of learning, students created interactive worlds in Minecraft Education that simulated real processes, such as the work of algorithms or the functioning of networks [35].

The experience of using quiz platforms (Kahoot!, Mentimeter, Quizizz, Socrative) in the learning process in four courses at Porto Accounting and Business School is highlighted by Silva et al. [36]. Silva et al. [36] concluded that the use of these tools significantly increased student motivation, engagement, and contributed to the creation of an interactive learning environment.

Churok and Shamonya [37] analyzes the trends in gamification of the educational process and the classification of educational computer games.

Skaskiv [38] substantiates the feasibility of using project-game technologies to activate students' educational and cognitive activities.

Karakoc et al. [39] conducted a meta-analysis of 38 experimental studies covering the period from 2000 to 2018, in order to assess the impact of game-based learning on students' academic performance. The authors concluded that the use of game technologies has a significant positive effect on academic achievement, regardless of the level of education or discipline.

Yao et al. [40] assess the impact of game-based learning on student academic performance. The results showed that the use of game-based technologies can positively affect academic achievement by increasing student engagement and motivation.

In general, the literature analysis shows that both Ukrainian and foreign scholars are actively researching methods of implementing game technologies in computer science education. They prove that such technologies contribute to increasing the level of motivation, developing critical thinking and forming students' professional competencies, which makes learning more effective and interactive.

Thus, the issue of preparing future computer science teachers to use digital game technologies is extremely relevant and requires further research, development of effective methodological approaches and implementation in the practice of teacher training.

To solve this problem, it is necessary to apply a comprehensive methodological approach that covers both the theoretical justification of the use of digital game technologies and practical means of their implementation in the educational process. Accordingly, our study identified the following methods that will contribute to the effective training of future computer science teachers.

To prepare future computer science teachers for the use of game technologies in their professional activities, we have provided:

1. Development of a model of their training with the integration of digital game technologies.
2. Creating a methodology for introducing such technologies into professional disciplines.
3. Formation of skills in the use of game tools in pedagogical activities.
4. Learning to design educational games.
5. Conducting a survey of 4th year students on their awareness and readiness to use digital game technologies.
6. Analysis of the results [41].

In preparing future computer science teachers to use digital game technologies, it is advisable to use various methods that contribute to the formation of the necessary competencies.

One of the key methods is the project-based method, which involves students creating their own game-based educational products. It helps students learn how to work with digital tools, adapt game technologies to learning tasks, and integrate them into teaching. They can develop educational games independently or in teams, from the initial idea to testing [42].

The case study method is effective for analyzing real-life examples of the implementation of game technologies in education. It helps students to explore problems, find solutions, and create educational scenarios, promoting critical thinking and the ability to apply knowledge in practice [43].

Gamification in software engineering education courses has mostly positive effects on student motivation, engagement, and learning outcomes, especially through the use of elements such as points, levels, badges, and competitions [44].

The simulation method [45, 46, 47, 48] is effective for designing educational processes using digital gaming technologies [49, 50]. It allows you to create learning environments with game elements, predict the results of their use, and adapt them to the audience's needs. An important role in the training is played by specially developed methods that facilitate the assimilation of material, the development of professional competencies and practical skills in working with game tools [51].

Voievoda et al. [52] was found out which digital mathematical games are the most popular in the process of teaching mathematics to students in schools in these countries, in particular, "Matific", "Kahoot", "Ten Fingers", "mathPlayground".

Tkachuk and Stetsenko [53] analyze the augmented reality technology, its definition, application features, and hardware and software tools. The authors propose a classification of existing AR technologies by type of interaction, mobility, and functional purpose. Also, Semerikov et al. [54] consider the effectiveness of combining VR/AR environments, programming tools and learning platforms, evaluate the structure and content of the course, and determine its impact on the formation of innovative competencies.

Next, students develop the concept of their own game: they define its educational purpose, game mechanics, activities, and evaluation methods. The final phase involves testing the game in an educational environment, analyzing its effectiveness, and making changes based on the results. Thanks to this methodology, future computer science teachers acquire practical skills in creating interactive learning products and adapting game technologies to the content of specific disciplines, which contributes to the formation of their professional readiness to use modern digital tools in teaching. The methodology of integrating gaming technologies into the teaching of professional disciplines in the specialty "Computer Science" is aimed at intensifying the educational process with the help of digital tools. It involves the use of gamified tasks for learning theory (e.g., Kahoot!, Quizizz), simulations and educational games in practical courses, in particular in Programming (Scratch, CodeCombat), as well as creating quests with gradually increasing complexity of tasks. This approach helps to develop cognitive interest, critical thinking and professional skills.

The methodology for preparing future teachers to implement game technologies in teaching is aimed at developing the ability to adapt these tools to educational tasks. It involves the creation of teaching materials on methodological foundations, familiarization with the principles of game-based learning (motivation, structure, feedback), analysis and discussion of pedagogical scenarios. Particular attention is paid to developing skills in evaluating the effectiveness of game technologies and correcting the learning process based on the results.

To evaluate the effectiveness of digital game technologies in the training of future computer science teachers, statistical methods are used to analyze experimental data and draw reasonable conclusions about their feasibility. The basis is made up of descriptive statistics methods: arithmetic mean (determines the overall level of achievement), median and mode (identifies typical results), standard deviation and variance (characterizes variability), and coefficient of variation (assesses the homogeneity of results). To detect statistically significant differences between the control and experimental groups, the Student's t-test (for comparing mean values), the Mann-Whitney test (for independent samples with non-normal distribution), and the Wilcoxon test (for analyzing changes within the same group before and after the experiment) are used. The relationship between the use of game technologies and student performance is assessed using Pearson's correlation coefficient.

To evaluate the effectiveness of different digital game technologies, analysis of variance was used to identify statistically significant differences between groups of students after using different tools. The final effectiveness was determined by the efficiency coefficient, which shows the proportion of students who improved their results after the introduction of game technologies.

The use of statistical methods confirmed the positive impact of digital gaming tools on students' performance, motivation, and interest. To this end, an author's course was created in the Moodle LMS with interactive tasks and game elements, and a survey was conducted among 4th year students participating in the experiment.

2. Theoretical nackground

In order to substantiate the methodology for training future teachers of computer science to use digital game technologies in the learning process, a model of using game technologies in the training of future computer science teachers was developed. It involves the gradual development of professional competencies of applicants by first using digital gaming tools as learning tools, and later developing their own gaming educational resources. At the initial stage, students mastered the basic tools of digital gaming, working with The Bezier Game services to develop skills in working with Bezier curves and Codeacademy to form the basics of programming. The learning process was based on the use of a comprehensive approach that combined systemic, personally oriented, activity and competency-based approaches, as well as interactive methods, game techniques, independent work and mentoring support.

Training future computer science teachers on the implementation of game-based learning is the task of the second stage. Our own course in Moodle has been created for this purpose. It provides sample opportunities for implementing an interactive educational environment, including the introduction of game elements that activate students' cognitive activity. The model is structured around five interrelated components:

- *Target component* specifies the overarching goals, identifies the learners' needs, and outlines the pedagogical approaches to be employed.
- *Methodological component* encompasses the instructional content, teaching methods, and organizational forms that structure the educational process.

- *Technological component* defines the digital tools, platforms, and resources utilized to support and enhance educational activities.
- *Diagnostic component* includes the methods and criteria used to evaluate the development of learners' professional competencies.
- *Result component* articulates the anticipated outcomes of the educational process, particularly the professional competencies expected to be acquired by learners.

The course includes lectures, laboratory and independent work, as well as assignments using digital gaming tools. In the course of learning, students master both the basics of pedagogical design and practical skills in creating interactive content in Moodle. This organization of the course ensures mastery of the content and development of skills to apply digital game technologies in their own pedagogical activities.The course structure includes a syllabus and three thematic blocks.

The syllabus contains a description of the course, the distribution of hours, assessment criteria, a list of competencies and program learning outcomes.

The first topic is devoted to quiz creation services – Kahoot! and Blooket. Students learn the principles of their work and create their own interactive tasks. As part of the course, students developed a Kahoot! quiz for 9th-grade computer science students on the topic "Animation of Three-Dimensional Objects". The quiz included multiple-choice and true/false questions aimed at reinforcing the concepts of object rotation, scaling, and animation techniques. During the session, students participated in a live competition using the quiz, which significantly increased engagement and helped identify misconceptions promptly.

The second topic focuses on the gaming capabilities of Moodle. Students get acquainted with the modules Crossword, Anagram, Mystery Chest, etc., learn how to customize them and integrate them into the educational process.

The third topic is Minecraft Education as a tool for teaching computer science [55]. Students create game worlds, develop tasks to develop algorithmic thinking and programming skills. Within this environment, tasks were assigned to automate traffic lights using Redstone circuits and command blocks, promoting the development of algorithmic thinking and basic programming skills. The project combined creativity with the practical application of computer science concepts such as logical operations, sequences, and conditional structures.

The final control is realized through testing, which contains different types of tasks: 10 for entering the answer, 10 for establishing correspondences, and one in the format of an essay. This allows for a comprehensive assessment of learning, analytical thinking, and the ability to apply digital gaming tools in practice [56].

The course is aimed at developing the ability of future computer science teachers to create an effective educational environment using digital game technologies. Students master technical tools and pedagogical approaches to gamified learning, including: organizing feedback, motivating students, and creating adaptive game content.

As part of the first topic, students are introduced to popular digital platforms for creating quizzes, such as Kahoot! and Blooket. These tools allow you to develop interactive test tasks that motivate students to actively participate in the educational process. The classes cover the possibilities of personalizing tasks, setting up game modes, using timers and a scoring system. Students take a teacher-prepared quiz in Kahoot! to consolidate their knowledge (figure 1).

The practical part of the course involves students creating their own interactive quizzes on selected topics from the school computer science course. Special attention is paid to the analysis of how the game testing format can influence student motivation, the formation of a competitive spirit, and increasing interest in learning. Pedagogical strategies for using quizzes in the classroom are also discussed – both at the stage of mastering new material and during generalization or knowledge control.

In the second topic, students are introduced in detail to the capabilities of the LMS Moodle for creating game-based educational elements. Since Moodle is a universal system for distance learning, it is important to be able to use its functionality as a repository of materials and as an active environment for interaction and motivation. Special attention is paid to game modules, such as anagrams, crosswords,

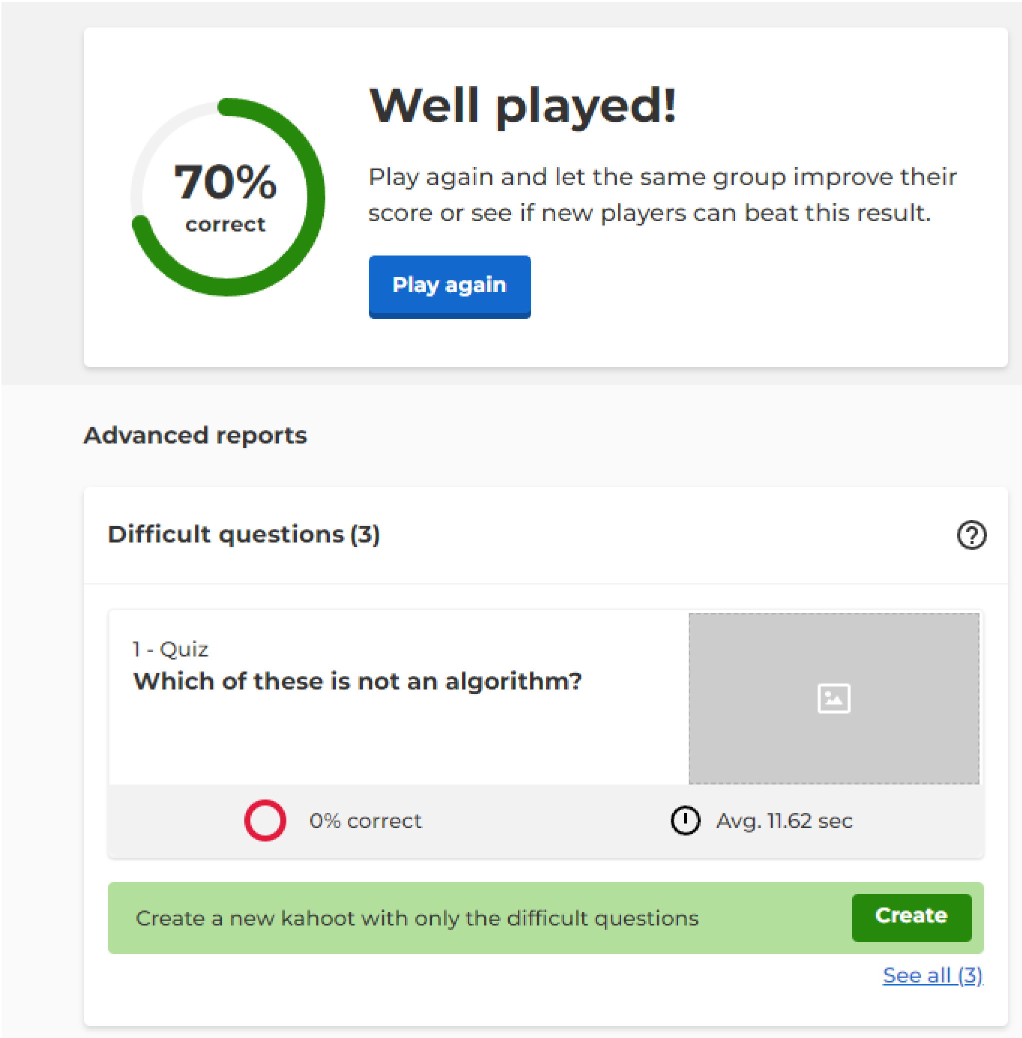

Figure 1: Report on passing the quiz to master the capabilities of Kahoot!

quizzes and other tools that can be added by installing additional plugins. Students learn to integrate these elements into the course, configure difficulty levels, define a scoring system and feedback. Students created an educational quest for the topic “Computer Networks and Internet Protocols” in the Moodle LMS. Using the “Anagram” and “Hidden picture” modules, students designed a quest where participants had to solve riddles and assemble key terms related to networking concepts. The quest structure encouraged exploration, critical thinking, and collaboration among learners.

During practical work, participants develop their own game tasks for specific computer science topics, taking into account the age characteristics and level of training of students. Examples of creative use of Moodle for organizing educational quests and missions are also considered. As part of laboratory work, applicants create their own interactive tasks. In particular, they add a resource of the “Anagram” type (figure 2), in which they form a set of terms for the game. The point is to make the correct word or phrase from the jumbled letters.

Thus, future teachers gain technical skills in working with Moodle and an understanding of how to generate interest in educational material through game interaction. Within the third theme, students work with Minecraft Education, a tool that allows them to implement educational tasks in a gamified format. The platform allows them to create virtual worlds in which students perform programming tasks, solve algorithmic puzzles, and develop logical thinking. Minecraft Education’s creative mode is the most convenient for educational purposes in the course “Methodology of Using Game Technologies”, as it allows students to focus on creativity without resource limitations. One of the main tasks is to

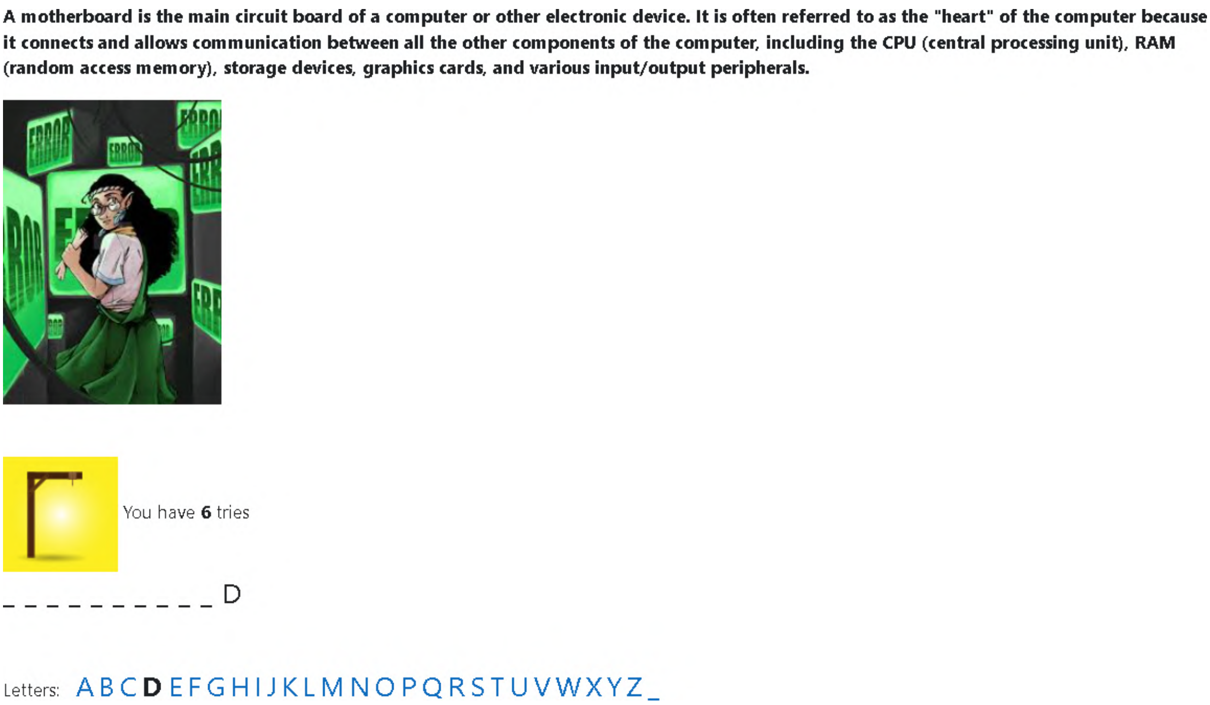

Figure 2: The process of completing the game "Anagram" in the LMS Moodle.

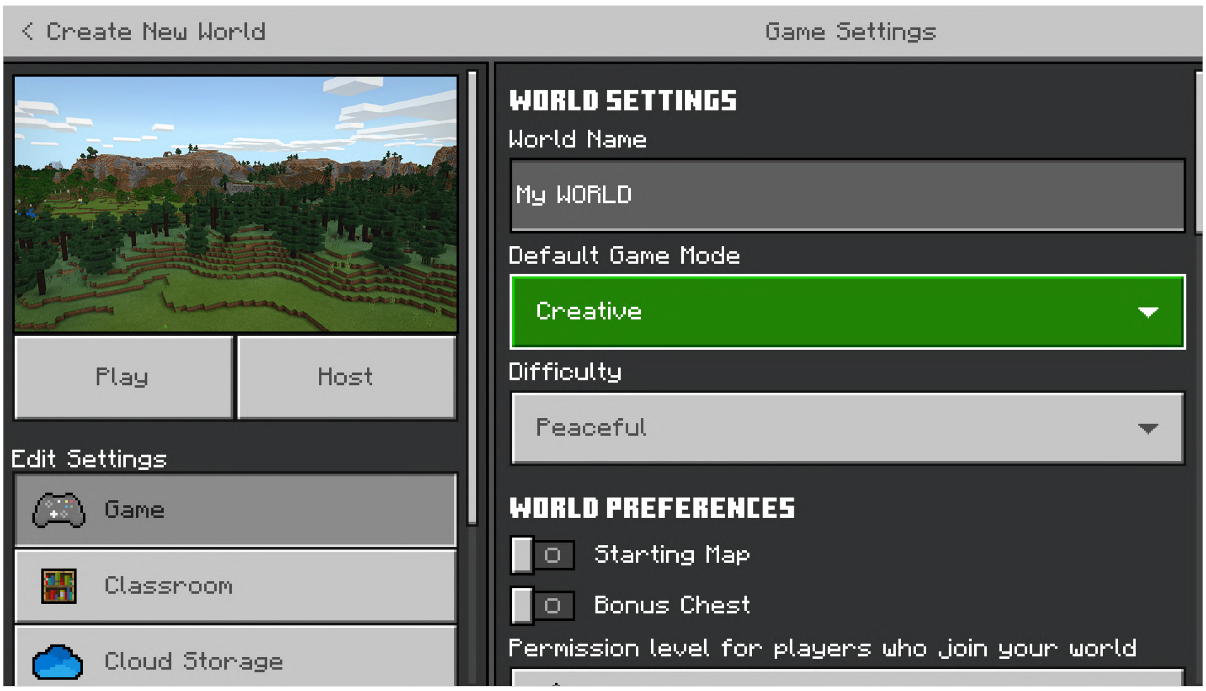

Figure 3: The process of creating a new world in Minecraft Education.

create their own game worlds (figure 3), which contributes to the mastery of algorithmization and programming topics.

Thanks to the "creative" mode, participants can focus on the content of the task without being distracted by side game elements. Students develop educational game projects that involve completing a series of programming tasks. For example, a quest for automated resource collection or creating an algorithm for moving a character. Command blocks, variables, and loops are used to implement mechanics, which allows integrating computer science knowledge into practical activities [57].

Group work is an important element: students distribute roles (design, programming, task development), which contributes to the development of team interaction skills, planning, and responsibility for a common result. Such projects can cover both individual school topics and interdisciplinary connections [58].

The teacher guides the work, helping with technical aspects, provides advice on the pedagogical feasibility of game mechanics and conducts discussions after the projects are completed. Reflection is an important component: students analyze difficulties, discuss experiences, receive feedback and formulate ideas for improvement. The final assessment involves checking the technical correctness of the tasks and analyzing creativity, pedagogical feasibility of using the game, and the level of interaction in the team. Thus, students learn modern digital tools and master the principles of effective instructional design.

3. An experimental study

The objective of the experimental study was to assess students' self-assessment of their abilities to work with educational game tools and students' readiness to use these tools in their future professional activities. For this purpose, a questionnaire was developed and filled out by 4th year students majoring in 014.09 Secondary Education (Computer Science). The choice of self-assessment through a questionnaire was made because we consider it inappropriate to compare a group of students who completed the elective course with those who did not. Therefore, a self-assessment method was chosen to objectively capture the students' subjective perceptions of their readiness and skills. Most of the questions in the questionnaire were constructed in accordance with the Likert scale. Its use is justified by the need to measure the level of agreement with the statements related to the readiness of students to use digital game technologies for educational purposes. With the help of this scale, we were able to collect data on students' attitudes towards digital games and assess how open they are to learning to create such tools. 53 respondents filled out the questionnaire, and the results were analyzed using descriptive statistics (median, mode, interquartile range) and methods of comparing data between groups. The sample size of 53 respondents is sufficient to fulfill the objectives of the study, as the main focus is on studying trends and conducting descriptive statistics, which allows for reliable results even with a relatively small sample. The sample also allows for comparisons between groups within the study, as its size meets the minimum requirements for applying non-parametric statistical analysis methods. The questionnaire consisted of 9 questions the respondents answered after studying the elective course, which was developed according to the author's methodology. These are the questions.

1. Assess your own ability to configure the Blooket environment so that participants can play in real time
2. Assess your own ability to create your own world in Minecraft Education, where players have unlimited access to all. resources, cannot be harmed by the environment and can build any structures.
3. Assess your own ability to create a lesson plan using the Kahoot! environment for 9th grade computer science students on the topic 'Animation of three-dimensional objects'..
4. Evaluate your own ability to change the types of questions in Kahoot! (test, true/false).
5. Assess your own ability to create and customize the "Anagram" game in the Moodle LMS using the "Glossary" question bank.
6. Assess your own ability to create a lesson plan with a quest in the Minecraft Education game for 9th grade computer science students on the topic 'Arrays' in programming.
7. Assess your own ability to set up a multiplayer mode in the Minecraft Education game and invite others to your world.
8. Assess your own ability to use command blocks to automate processes in Minecraft Education.
9. Assess your ability to set a timer for each question in Kahoot!

The Likert scale was transformed into a numerical scale by assigning a numerical value to each level of response. In this case, the Likert scale looks like this:

- ‘Strongly disagree’ – 1.
- “Disagree” – 2.
- ‘Neutral’ – 3.
- ‘Agree’ – 4.
- ‘Strongly agree’ – 5.

To choose a statistical method for processing the data, we checked whether the distribution of answers to each question in the questionnaire was normal. Therefore, we applied the Shapiro-Wilk test, which showed that none of the questions in the questionnaire demonstrated a normal distribution, as all p-values were less than 0.05.

Cronbach’s alpha was calculated to check the internal consistency of the questionnaire. Its value of $\alpha_{cr} = 0.780$ indicates a moderate level of consistency between the questions, which suggests that they are partially related to each other, but the scale could be improved to increase reliability.

Descriptive statistics of the questionnaire data involve the calculation of such values:

- The median value is located in the middle of the ranked series of the sample. It shows the central tendency in the students’ choice of.
- Mode as the most frequent option.
- Interquartile range (IQR), which reflects the distribution of answers between the 25th and 75th percentiles. It is used to assess the variability of the selected answers.

The calculation of these statistics is presented in the table 1.

Table 1
Descriptive statistics of students‘ survey.

Question number	Median	Mode	Description
1	4.0	5	Most students perform this task, but a certain part of the respondents have difficulties observed.
2	4.0	4	The vast majority of applicants have the appropriate skill, but there is a group that needs additional training to master it.
3	5.0	5	There is considerable confidence among all respondents in their ability to complete this task.
4	4.0	5	Most applicants are able to complete this task, although some respondents note the presence of certain difficulties.
5	4.0	4	Students are fully proficient in these tools.
6	4.0	4	Confident performance of this task by the majority of applicants, although some respondents have difficulties.
7	4.0	4	A significant part of respondents have basic skills in setting up this mode, but more complex functions cause them difficulties.
8	4.0	5	High level of development of automation skills in applicants.
9	5.0	4	Students confidently apply this function in the educational process.

The next step in analyzing the survey data was to determine the distribution of responses by Likert scale options. The frequency of choosing each answer option (“Strongly agree”, “Agree”, “Neutral”, “Disagree”, “Strongly disagree”) for each question was calculated (table 2).

The distribution of answers to the questionnaire is shown in figure 4.

The table 2 and figure 4 show that most respondents chose high ratings (“4” and “5”) for many questions, which indicates their confidence in their skills. For example, in the question “Can you create a lesson plan with Kahoot!” (question 3), no rating “1” and “2”, which indicates their complete confidence in their competence to perform these tasks. A similar situation is observed in question 5, which concerns the use of the Moodle LMS. Although the majority of respondents answered “Agree” or “Strongly Agree”, there are also “Neutral” and “Disagree” responses, indicating varying levels of confidence in creating games in the Moodle LMS. The greatest discrepancy in responses is seen in

Table 2
Frequency table of responses.

Options(Grade)/Question	1	2	3	4	5	6	7	8	9
Strongly disagree (1)	2	3	0	2	0	5	10	10	0
Disagree (2)	4	7	0	4	3	8	7	7	2
Neutral (3)	8	8	4	5	12	9	9	7	4
Agree (4)	16	18	14	20	21	17	14	14	20
Strongly agree (5)	23	17	35	22	17	14	13	15	27

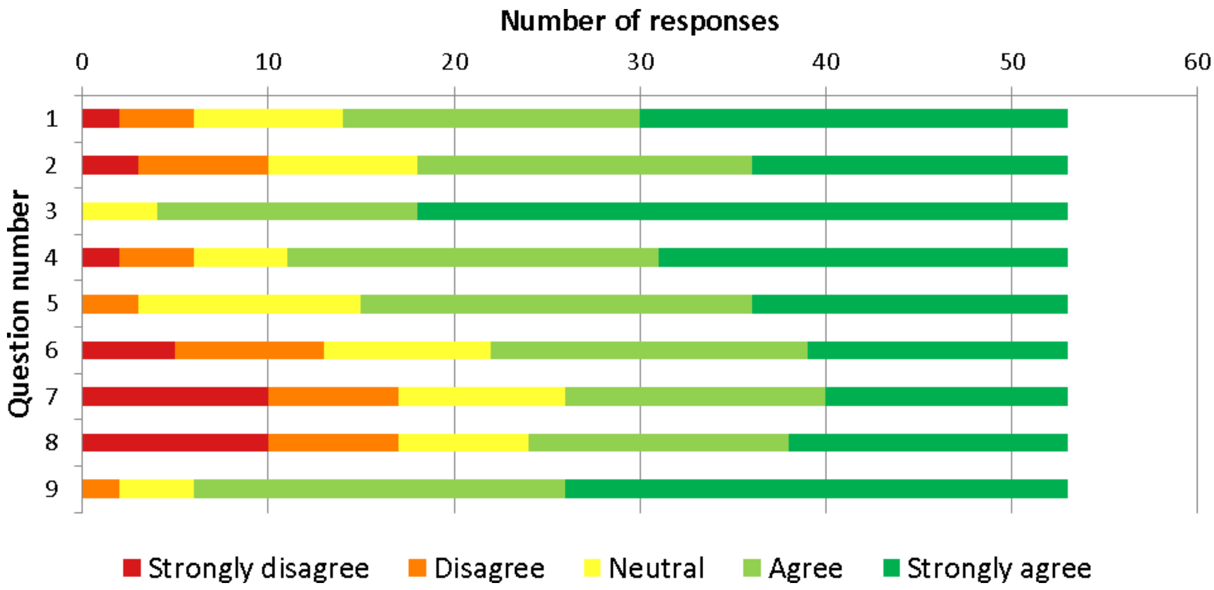

Figure 4: Distribution of students' answers.

questions 6, 7 and 8, where a significant number of respondents chose the options "Strongly Disagree" and "Disagree". In particular, questions 7 and 8 have the highest number of negative ratings. We believe this indicates that students have technical and pedagogical problems in using Minecraft Education platforms. Therefore, it is appropriate to provide additional training or practice cases on the relevant topics. The results indicate a fairly high level of confidence among respondents in using digital tools such as Kahoot! and Blooket (questions 1 and 2), as evidenced by the prevalence of "Agree" and "Strongly Agree" responses. In contrast, responses to questions 7 and 8, which relate to Minecraft Education, show significant variability, ranging from "Strongly Disagree" to "Strongly Agree". This may indicate a heterogeneous level of student preparation and some difficulties in mastering this platform.

Another step in analyzing the results of the survey is to assess the dispersion of data using the interquartile range (IQR). The table 3 shows the values of the first quartile (Q1), third quartile (Q3) and interquartile range (IQR) for each question of the questionnaire, which allows us to determine how the central 50% of answers are grouped and whether there is a variation in respondents' confidence.

As you can see from the table 3, the IQR for question 9 is 0. This means that there is complete homogeneity of respondents' answers (a large number of students chose the same answer options). This indicates that students generally agree on the time settings of the Kahoot! service. In questions 3 and 4 (also related to the service), the IQR is 1, indicating a high consistency of answers, with minor deviations. This means that most respondents chose the options 'Agree' or 'Strongly agree'. This IQR value indicates a positive but somewhat variable attitude towards task creation and the use of Kahoot! in the classroom in general. An IQR of 2 (questions 1, 2, 5, 6) indicates moderate variability in responses. In these cases, the answers of the central 50% of respondents are in a broader range (e.g. from "Neutral" to "Strongly agree"), indicating different levels of confidence or experience. This situation may be a result of the heterogeneity of previous experience with the relevant digital tools (Blooket

Table 3
Interquartile analysis of respondents' responses.

Question number	Q1	Q3	IQR
1	3	5	2
2	3	5	2
3	4	5	1
4	4	5	1
5	3	5	2
6	3	5	2
7	2	4	2
8	2	5	3
9	4	4	0

service, MOODLE LMS and Minecraft platform). Question 7 (setting up multiplayer mode in Minecraft Education) has an IQR value of 2 but with a lower value of the first quartile (2.00), which may indicate the presence of a part of respondents with a low level of training in particular, the complexity of the topic for some participants. Question 8 has the highest IQR value of 3, which demonstrates a high variability of answers. This heterogeneity indicates that respondents have radically different levels of knowledge and skills in automating game processes in Minecraft Education. Some respondents showed high confidence in this question, while others chose the lowest scores.

For a deeper analysis of the scale structure, it is advisable to examine the relationship between the responses to individual items and the overall score. Items that demonstrate a high correlation with the summary score can be considered as those that better represent the essence of the scale. In our study, a correlation analysis was conducted to assess the relationship between individual questions. Since the data do not fall under the normal distribution according to the Shapiro–Wilk criterion, we used the nonparametric Spearman rank correlation coefficient (r). This allows us to assess the strength and direction of the relationship between ranked variables.

A correlation is a statistical relationship between two variables. It shows how much one variable changes when the other changes. Correlation is measured using a coefficient that takes values from -1 to 1. Where 1 is a perfect positive correlation (both variables change in the same direction), 0 means no correlation (the variables are not related), and -1 is a perfect negative correlation (the variables change in opposite directions). This makes it possible to investigate how individual student ratings of their ability to use game tools are related. Therefore, we calculated correlation coefficients between all 9 questions of the questionnaire (table 4). For this purpose, we used the previously transformed nominal scale from 1 to 5.

Table 4
Correlation matrix for the questionnaire.

Question number	1	2	3	4	5	6	7	8	9
1	1.000	0.409	~~0.015~~	~~0.166~~	~~0.108~~	~~0.083~~	~~0.171~~	0.251	~~0.206~~
2	0.409	1.000	0.349	~~0.226~~	0.365	0.509	0.496	0.434	~~0.254~~
3	~~0.015~~	0.349	1.000	0.060	~~0.016~~	0.215	0.563	0.420	0.296
4	~~0.166~~	0.226	~~0.060~~	1.000	0.473	0.280	~~-0.077~~	~~0.009~~	~~-0.055~~
5	~~0.108~~	0.365	~~0.016~~	0.473	1.000	0.475	~~0.064~~	~~0.180~~	~~-0.065~~
6	0.083	0.509	0.215	0.280	0.475	1.000	0.565	0.526	0.318
7	0.171	0.496	0.563	-0.077	~~0.064~~	0.565	1.000	0.714	0.386
8	0.251	0.434	0.420	~~0.009~~	~~0.180~~	0.526	0.714	1.000	0.314
9	~~0.206~~	0.254	0.296	~~-0.055~~	~~-0.065~~	0.318	0.386	0.314	1.000

In the table 4, statistically insignificant correlation coefficient values with a $p > 0.05$ are crossed out. The values on the table's diagonal are always 1 because each question correlates with itself. The table 4 shows a high positive correlation between questions 7 and 8 ($r = 0.714$). This indicates that respondents who are confident in setting up command blocks in Minecraft Education are usually equally confident in setting up multiplayer in this environment. Given the relatively large number of disagreement responses, we note that the coefficient also reflects the corresponding uncertainties of students. The moderate correlation coefficient for questions 6 and 8 ($r = 0.526$) indicates that the same students are equally confident and uncertain about their skills in Minecraft Education. We also found a moderate correlation coefficient value for questions 3 and 7 ($r = 0.563$). Instead, a similar relationship should exist between similar questions about students' pedagogical skills (3 and 6). Here, we can assume that the 4th year students were not frank in answering one of these questions. Other r coefficients reveal a weak relationship between the questions. All negative values of the correlation coefficient were statistically insignificant. Therefore, there are no means whose confidence in use has an inverse effect on the level of self-assessment of others.

4. Conclusions

The study describes some aspects of designing an elective course "Methodology of using game technologies" for students of the specialty 014.09 Secondary Education (Computer Science). The course is focused on familiarizing students with modern digital game technologies. It includes a detailed study of platforms for creating interactive quizzes (Kahoot!, Blooket), game modules in the LMS Moodle, and the features of implementing Minecraft Education in the educational process of secondary education institutions.

Based on the conducted research, it is possible to conclude about the effectiveness of using digital game technologies in training future computer science teachers. The developed elective course contributes to the assimilation of theoretical knowledge about game technologies and the formation of practical skills for their application in the educational process. Analysis of the experimental results confirmed the positive impact of interactive educational tools on the level of development of students' professional competencies, which indicates the feasibility of their implementation in the educational process.

The results obtained confirm the need for further research in the direction of expanding the use of digital gaming technologies in the training of future computer science teachers. Promising directions are the integration of gaming elements into the process of studying artificial intelligence, cybersecurity, and robotics, as well as the development of methodological recommendations for the effective use of gaming technologies in various educational contexts.

Author contributions

Conceptualization, Vasyl P. Oleksiuk; methodology, Vasyl P. Oleksiuk; software, Vasyl P. Oleksiuk and Dmytro V. Verbovetskyi; writing – original draft, Dmytro V. Verbovetskyi; writing—review and editing, Vasyl P. Oleksiuk. All authors have read and agreed to the published version of the manuscript.

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Data availability statement

No new data were created or analysed during this study. Data sharing is not applicable.

Conflicts of interest

The authors declare no conflict of interest.

Declaration on Generative AI

While preparing this work, the authors used ChatGPT by OpenAI to rephrase and improve their own text. Scopus AI was also used to search for relevant literature. Microsoft Copilot was used to generate table code in TeX. All content generated with the assistance of AI tools was reviewed and edited by the authors, who take full responsibility for the article's final version.

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