Gamification when studying logical operators on the Minecraft EDU platform

Elena G. Fedorenko[1], Nataliia V. Kaidan[1], Vladyslav Ye. Velychko[1] and Vladimir N. Soloviev[2]

[1]Donbass State Pedagogical University, 19 Henerala Batiuka Str., Sloviansk, 64122, Ukraine
[2]Kryvyi Rih State Pedagogical University, 54 Gagarin Ave., Kryvyi Rih, 50086, Ukraine

Abstract

Use of visual methods plays a significant role in learning. ICT allow us to create electronic educational resources in a new format and with new opportunities. The study of their didactic possibilities, forms and methods of their application is a topical issue. Simulation, virtualization, gamification requires new knowledge about their application, and therefore, the problem of training future teachers to use them is an urgent and important part of training. In this article modern achievements in the use of serious games in education were investigated and analyzed, the possibilities of using virtual worlds in education were considered, the recommendations for the practical training of future teachers to use them were developed. In practice, the effectiveness of the use of virtual tools in education has been tested. A pedagogical experiment has been launched to identify the effectiveness of gamification in the realities of education in Ukraine.

Keywords

gamification, Minecraft EDU, professional training of pre-service teachers, logical operators

1. Introduction

On its Global Advisor platform in the fall of 2020, Ipsos conducted a survey of adults under the age of 75 from 29 countries and territories on their vision for the future of higher education, which was attended by more than 27,500 people [1]. Almost a quarter of the world's surveyed adults (23%) believe that in five years' higher education in their country will be provided entirely or mainly through Internet resources, technology, etc.; the majority of respondents (49%) believe that training will be divided in half and will take place in person and at the distance. The opinion that in the future higher education will be conducted mostly using Internet technologies is shared by 19% of respondents aged 50-74, 24% among people aged 35-49 and 25% among age groups 18-34. The introduction of e-education is impossible without the

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fedorenko.elena1209@gmail.com (E. G. Fedorenko); kaydannv@gmail.com (N. V. Kaidan); vladislav.velichko@gmail.com (V. Ye. Velychko); vnsoloviev2016@gmail.com (V. N. Soloviev)
https://scholar.google.com.ua/citations?user=9hVB6f8AAAAJ (E. G. Fedorenko); https://scholar.google.com.ua/citations?user=qFFTl0UAAAAJ (N. V. Kaidan); https://ddpu.edu.ua/cc/velychko/ (V. Ye. Velychko); https://kdpu.edu.ua/personal/vmsoloviov.html (V. N. Soloviev)
0000-0002-1897-874X (E. G. Fedorenko); 0000-0002-4184-8230 (N. V. Kaidan); 0000-0001-9752-0907 (V. Ye. Velychko); 0000-0002-4945-202X (V. N. Soloviev)

availability of special tools. The part of Internet resources such as digital electronic resources is a learning tool. The role of digital electronic resources in educational activities is constantly growing, and respectively, new types of them appear, or existing ones become popular due to the development of information and communication technologies.

For many years in a row, teachers have been using videos in the classroom to visualize the theoretical part of the new material. At the moment, the technology of the inverted ("flipped") class is becoming very popular [2]. This technology is not possible without the use of video-based learning information. However, the increasing of the level of learning with the help of electronic educational resources based on the use of videos in the genre of "Let's Plays" is almost not noticed. Note that unlike previous generations of students who interacted with websites, blogs, and social media-based learning channels, the current generation learns more through YouTube Let's Plays and Twitch-based video streams [3]. Today's younger generation makes little use of books, web pages, or any of the technologies traditionally used by adults. The formation of a new format of digital literacy is necessary for the participation of modern youth in these, mainly, special learning environments. First of all, it is the ability to record and edit video, "capture" and broadcast gameplay and other actions on the screen, a high level of technical communication and the ability to inform and teach others by performing complex tasks.

2. Research methods

In the process of research, we used search and system methods, methods of analysis, comparison, generalization, the studying of scientific approaches to selected issues. A comprehensive study of the gamification of the educational process provided a systematic method and the study of scientific approaches to selected issues. The method of analysis was used for systematization, analysis of data and information on the researched problems.

3. Results of the research

Video games for education are currently a significant segment of educational content. Digital game-based learning is becoming increasingly popular. The study by Tokac et al. [4] presents the effectiveness of teaching mathematics based on video games. In their work, researchers claim that video games help to increase mathematical knowledge compared to traditional. Wouters et al. [5] examines in detail the impact of "serious games" on learning. Authors proved that those who learn serious games learned more than those who learned the usual teaching methods. Opinions of scientists on the use of games in education differ. One part argues that for digital game-based learning to succeed, you need to have the "right" learning games [6, 7, 8, 9, 10, 11, 12]. Another is convinced that teachers should take an active role in the development of educational activities through digital games [13, 14]. Teachers should adapt digital games as part of their learning toolkit.

The study of Chen et al. [15] analyzed the effect of competition in digital gaming learning. According to the data obtained during the study, competition in digital game-based learning (DGBL) was effective for mathematics, science and language. It was effective for college students.

Most of the effect was seen in solving puzzle, strategy, role-playing, and simulation games, but not for action games. As a result, it was found that competition in DGBL was equally effective for cognitive and non-cognitive outcomes.

Similar research results on the application of games in mathematical education K-12 were produced by Byun and Joung [16]. This paper, first, investigates the current trend of digital game-based learning by analyzing exploratory research on the use of DGBL to study mathematics and achievements in the study of mathematics. Secondly, the future directions of DGBL research in the context of teaching mathematics are indicated. Researchers analyzed 296 studies, of which only 33 studies were identified as empirical and systematically analyzed to study current trends. In addition, due to the lack of statistics, only 17 of the 33 selected studies were analyzed to calculate the overall effect of digital games on math education.

A similar study was conducted by Clark et al. [17]. The authors analyzed the published results of research on the overall effect of digital games on learning outcomes from 2000 to 2012. They came to the attention of 1,040 works, of which only 69 had information on unique empirical studies of the use of digital electronic games in education. 6869 respondents were involved in the selected studies. As a result, researchers have concluded that games as an environment certainly provide new and powerful opportunities, but it is active creative activity in the game environment that determines the effectiveness of the learning environment.

Gunter et al. [18] analyzed the RETAIN (Relevance, Transfer, Adaptation, Immersion, Naturalization) model, which is based on the following positions: relevance is the relevance of materials to students' needs; consistency – the need to submit academic content in accordance with the game plot; integration based on the existing experience of students in other areas, as well as the possibility of applying in real life the acquired knowledge; adaptation – change of behavior due to integration from the virtual to the real world; immersion – intellectual involvement in the game; implementation of skills acquired in the game and their application in real life.

In addition to these issues, no less important is the relationship between game, pedagogical, and realistic components in serious games. Harteveld [19] emphasizes that the attributes of a serious game are: pedagogy, low saturation of resources, step-by-step process, harmony, experience, uncertainty, research, game elements, attributes, interactivity, involvement, learning goal, target groups, organization, reality and challenge. Pedagogy proclaims the need for reflection, but the game, ideally, encourages it. Learning in action brings the highest results, which means that students should not just read the text, but live the learning process internally. The low level of information saturation of resources provides an opportunity for children to develop the ability to draw independent conclusions and make decisions.

An important issue is also the effectiveness of digital game-based learning (DGBL). There is a heterogeneity in the methods of assessing the effectiveness of DGBL, which leads to differences in determining the reliability and validity of certain methods. All et al. [20] explored a variety of methods for assessing the effectiveness of learning, identified by experts in psychology and pedagogy through semi-structured interviews to identify desirable methods for conducting research on the effectiveness of DGBL. Their proposed improvements in the methodology for determining the level of effectiveness relate to the implementation of the intervention in both the experimental and control groups. The participants themselves determine which elements are desirable to omit during the intervention (e.g., instructor guidance, additional elements consisting of essential information), and which elements will be important (e.g. procedural

assistance, training). The researchers identified the parameters by which the similarity between the experimental and control conditions should be achieved (e.g., time of intervention, instructor, day of the week). As for the measurement of methods, the proposed improvements relate to the immersion of participants in the conditions (e.g. parameters to be considered when using blocked randomized design), the general design (e.g. the need for preliminary testing and control group), test development (e.g. develop and pilot parallel tests) and testing (for example, follow-up after a minimum of 2 weeks of training).

Gamification is the use of individual elements of games in non-gaming practices [21, 22]. Tekinbaş and Zimmerman [23] define a game as a system in which players are involved in resolving an artificial conflict that is determined by rules and has a quantitative result. Gamification differs from other game formats in that its participants are focused on the goal of their real activity, and not on the game as such. Game elements are integrated into real situations to motivate specific forms of behavior in given conditions.

Game techniques have always been used in school education. Tests and exams, the transition from class to class, final testing – there are elements of the game, but not always effective. The problem is that classical educational methods often ignore the simple but infinitely important fact – learning should bring joy and satisfaction, should be interesting. It is known that the human brain is set on the positive, that is, when instead of fighting boredom there is a drive and positive emotions, the information is absorbed better.

The main attraction of game techniques is the attitude to mistakes. At school, teachers always focus on mistakes, but rarely praise the right answers or decisions. Fixation on mistakes leads to the fact that students focus more on grades than on knowledge. In computer games, on the other hand, mistakes are welcomed and are the main tool for success. Take the game Angry Birds, which at least once played all modern children. It clearly demonstrates how with each failure the player experiences new options for successfully achieving the goal – to defeat the pigs. When we play, we know that there is nothing wrong with failure - the sooner we do something wrong, the sooner we can find the right solution. Game is one of the ways of motivation, development of logical thinking, but not a universal undisputed means. Gamification will not work without quality educational content.

For the learning process to be called gamified, it must contain 4 characteristics that McGonigal [24] highlighted in her TED talk:

- clearly defined goals that provide motivation to participate in the game;
- logical and consistent rules that set limits and frameworks for achieving goals;
- a stable feedback system that ensures that goals are achievable and players follow the rules;
- voluntary consent to learn the game and follow the rules of achieving the goal.

Werbach and Hunter [25] note the motivational function of gamification. They believe that gamification allows to intensify human learning. In addition, gamification allows not only to create new games, but also to use their components for motivation. According to them, any component of the game can be used outside the format of the game – to form a person's involvement in a particular environment.

One of the games that has become very popular among children and teachers is Minecraft (https://www.minecraft.net/). Minecraft is a virtual community where players can roam freely and interact with the world made from blocks. Since its release in 2011, the game has become a cultural phenomenon. More than 200 million units were sold worldwide (as of May 2020) [26]. Due to this success, a special version for learning Minecraft: Education Edition (Minecraft EDU, https://education.minecraft.net/) was released.

The educational and game process with the help of Minecraft EDU is built on the following structure: the teacher controls the virtual map where his students play; the teacher can integrate the necessary lessons and tasks into this card. In order for teachers not to do unnecessary work, the game offers a rich library of previously created "worlds", as well as the development of previously created lessons. The learning worlds of Minecraft EDU provide ample opportunities. For example, find the perimeter of an area or distinguish the remains of a dinosaur from other minerals. The teacher gives each student access to buildings, areas on a virtual map, thus correcting his actions. This makes it possible to teach many individuals at the same time.

Tools such as cameras and portfolios have been added to the game for educational institutions. With their help, students take pictures, record progress. Innovations for teachers were created taking into account the real experience of teachers who used the game in their lessons. Colleagues-innovators have introduced elements such as blackboards for instructions and additional tasks. Teleport for quick movement on the map, the ability to track the location of students, settings to adjust the cycle of day and night or the complexity of the game. Blackboards are interesting elements of the game. These boards have three different sizes on which you can place tasks for students. Class mode allows the teacher to see the general picture of students' activities.

Due to its flexibility, the game easily adapts to different subjects. Those who decided to try Minecraft EDU in their classes could be advised:

1. Before the game, discuss with students the rules of behavior in the virtual world. No one will like it if a classmate destroys a copy of the Arc de Triomphe, which you worked on for several lessons.
2. Make sure that your world is set up for the task of the lesson, before running students in it. For very busy teachers, Minecraft EDU offers ready-made starter kits for basic school subjects (https://education.minecraft.net/class-resources/lessons/).
3. Make a paper copy of the instructions, tasks, questions, or tips for students. This will help them focus on the task at hand.
4. Take time for the introductory lesson to show children the basics of the game process: click the menu, perform the basic actions. It is best to combine novice players with experienced ones to facilitate learning. It is important to remember that this is just a game that helps us perform certain tasks. Combine the usual educational environment - books, textbooks with the Minecraft environment.
5. Take a break every half hour. At this time, invite students to share with the class their achievements or difficulties, as well as their impressions.

Consider some of the existing worlds of Minecraft EDU that can be used by teachers of various school subjects. The first world is called Tutorial-world and is a guide to the world of

Minecraft. The world of Fantastic-mr-fox is the fairy-tale world of Mr. Fox, who gave us the idea of creating his own fairy-tale world. A geography teacher will like worlds with biomes such as savannah, mountains, taiga and ocean, such as the world of secret-reef. The world of project-storytelling offers its own version of training that will be useful for teachers of literature and Ukrainian language. For biology teachers, there is a lesson on studying the life of elephants and their protection, which is called watr-humans-and-elephants. An interesting lesson lesson-hub-volume-i, the author of which wrote that in this world there is a collection of educational activities where you can study fractions or study the history of the United States in the middle of the 20th century. Physics teachers will be interested to learn about the properties of Redstone in the worlds of redstone-breakout and redstone-lodge. In this learning and virtual world, you can create traps, automated farms for growing and harvesting and much more. The world of chemistry and chemistry lessons will be useful for chemistry teachers. In these worlds there is a large table of chemical elements of Mendeleev. Children are happy to learn the process of creating balloons. Computer science teachers will be interested in programming lessons trainings/code-builder-for-minecraft-education-edition. In this game you need to use Code connection and be able to work with Scratch, CodeMake, Tynker, which is still engaged in 3D modeling and allows you to move the created objects into the world of Minecraft.

The interesting thing in Minecraft is a resource called Redstone, which you can use to create logic circuits. In this way, the player can make their buildings interactive. Circuits created from Redstone transfer energy from one Unit to another like electrical circuits, and a torch is needed to supply energy to the circuit. If you install levers, buttons and other controls and use them, the player will be able to switch the chain from one position to another.

Minecraft allows players to create logic gates that perform simple logic operations. For example, with the help of two levers, you can create a valve “AND”, which passes “energy” through the chain only when both levers are activated, or a valve “OR”, which passes “energy”, if either of the two was activated levers. This system simulates the device of real electronics and Boolean logic, which allows you to create complex mechanisms. Thanks to this feature, the game can serve as a virtual constructor for programmers and engineers.

The teacher can use not only ready-made lessons, but also create their own. We explored a virtual learning environment created by Minecraft EDU and its practical application on the example of the topic “Logical Operators”. This topic is considered during the study of the subject “Computer Science” (Grade 8) and is related to such issues as the basics of algorithmization and programming, processing and storage of information. Not only paper sources of information, but also working digital models are necessary for the better understanding of a training material. Implementing such models on the basis of real mechanisms or electromagnetic devices is quite difficult and inefficient, because students, for the most part, will not be able to understand the existing analogies. In this case, it is best to use a virtual learning environment, which is in fact a virtual world where most modern children feel “at home”.

Despite the large number of studies on gamification, this educational trend has not chosen its primacy in the education system of Ukraine, as evidenced by a study conducted under the MoPED project [27]. Only 7.5% of lecturers, 18.6% of students and 15% of teachers attributed gamification to the selected three important educational trends. The reasons for this result are the weak technical base of universities, partial awareness of the teaching staff in the field of information and communication, English language used by most of Internet platforms, lack of

methodological developments in the use of gamification, lack of financial resources for paid subscriptions.

This problem can be partially solved by preparing future teachers for the use of gamification technology in the educational process of the school within the university educational programs. Preparing future teachers for the use of serious games should be a process that has a purposeful, planned, multilevel, multi-stage nature with organized interaction of all participants in the educational process and aimed at mastering the knowledge and skills of serious games in educational activities with constant monitoring of results. This makes it possible to argue about the need to include in the professional training of future teacher's disciplines aimed at acquiring knowledge and skills in the field of application of gamification in the educational activities of students.

Educational training programs for future teachers of mathematics, physics and computer science do not contain educational components that form competencies in the use of serious games in professional activities. However, elements of such training should be included in the educational components, taking into account the sectoral focus of training. Our research topic "Logical Operators" is related to such educational components as mathematical logic, algorithm theory, discrete mathematics, programming, teaching methods, etc. The inclusion of elements of gamification in the above educational components will lay the foundation for further application of gamification in professional activities. To do this, you must use any opportunity. In our opinion, such opportunities include:

- visual materials for lectures (screenshots made in the game environment or on its background, product placement);
- practical tasks with elements of gamification (involve full or partial involvement of serious games);
- independent work performed in game environments (additional points for use in the process of playing games);
- laboratory work on teaching methods (results are aimed at creating educational content and take into account the desire of students to use games).

Particular attention should be paid to the training of future teachers regarding the knowledge and skills of using serious digital games in education in the discipline of Methodology of teaching in the fields of knowledge. It is necessary not only in theory but also in practice to study the stages of organization of educational activities on the basis of serious games, namely:

- determine the target audience of educational content;
- set a learning goal;
- create a structure of educational content;
- determine which elements can be gamified;
- implement the selected elements through a digital game;
- apply the developed educational content;
- perform current and final control over the educational process;
- perform an analysis of the results.

When studying in a higher education institution, future teachers need to be prepared for the use of serious games based on the advantages and disadvantages of gamification. The advantages include: the ability to use distance learning (individually and collectively); the ability to use a variety of multimedia tools and modern technologies; strengthening the creative abilities of the individual, the development of creative thinking, self-organization, self-control and self-discipline; less study load, increased independence in learning and self-development; increasing interest in learning through interesting presentation of the material, which increases the degree of assimilation of the material. The disadvantages of gamification are: the lack of communication during training; the probability of incorrect conclusions; increase the amount of time a person will spend on the screen; possible technical failures in work; the need for special training of teachers and some time to master new technologies; spending a significant amount of time on the development and implementation of game technologies; high financial and time costs.

At the beginning of our study, a survey was developed and conducted among 4th year students of the State Higher Educational Institution "Donbass State Pedagogical University" who study in the educational programs of secondary education (mathematics), secondary education (physics), secondary education (computer science) or their combination with other educational programs. Respondents were asked the following questions:

1. Do you know the concept of gamification? (Yes/No)
2. What do you feel about learning through play? (Positive/Negative)
3. What do you feel about restricting the use of mobile devices in schools? (Support/Disapprove)
4. Have you had any experience learning through a computer game? (Yes/No)
5. Are you ready to learn to use games in educational activities? (Yes/No)

67 students took part in the survey. The results of their answers are presented in table 1.

Table 1
The results of answers during the survey

Question	Yes/Positive/Support	No/Negative/Disapprove
Q1	25	42
Q2	58	9
Q3	12	55
Q4	26	41
Q5	64	3

The results show that most students are not familiar with the concept of "gamification", although they are ready to learn by playing. Most respondents are willing to learn and support new forms and means of learning and do not understand the restrictions on the use of mobile devices that can be useful in educational activities.

As noted in the theoretical part of our study, we introduced elements of gamification in the disciplines of teaching methods. Laboratory tasks on development of educational scenarios of studying of a theme "Logical operators" in the Minecraft EDU environment were offered. As a

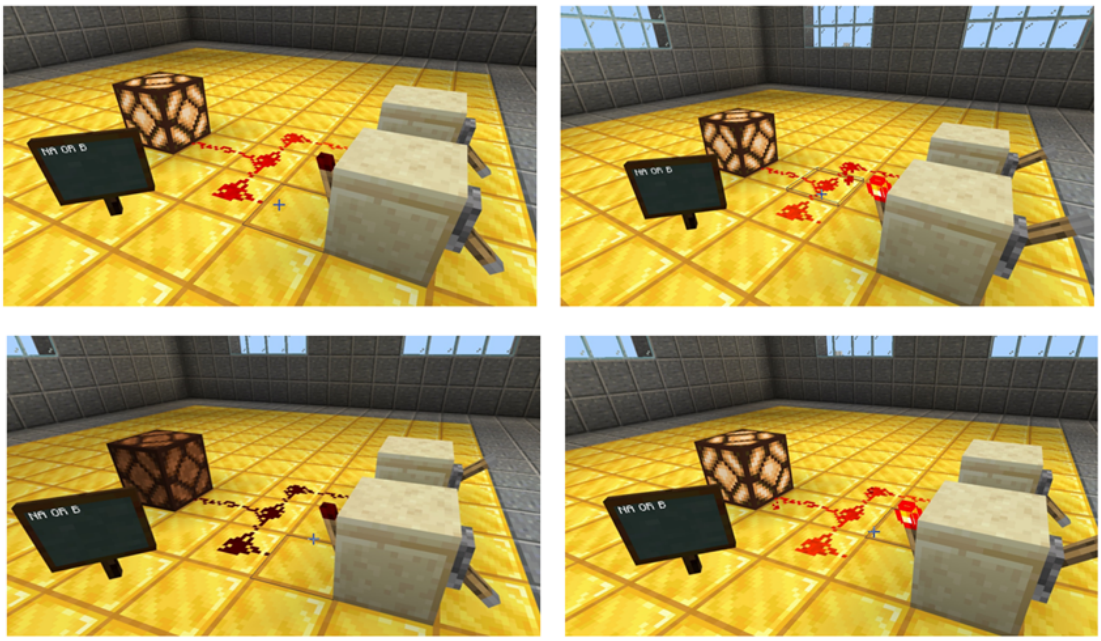

Figure 1: Example of the created world in Minecraft EDU.

result of the group project, several educational tasks were created, and their approbation took place during the internship of students in educational institutions (see figure 1).

Students' reports on internships and their own observations showed considerable interest in the proposed tasks. Despite the fact that the topic "Logical expressions. Variables of logical type. Logical operations" in the 8th grade belongs to the section "Programming" and is usually difficult to understand, the material was studied at a high level. This is evidenced by the fact that the further use of knowledge gained during the study of the topic "Logical expressions. Variables of logical type. Logical operations" in such topics as "Algorithms with branching" and "Cyclic algorithms" did not cause any difficulties in mastering these new topics. In addition, the homework, which students usually do without enthusiasm, was done perfectly and absolutely by all students without exception (boys, girls), which indicates an interest in the presented learning tool. A survey of students found that about 18% of 8th graders have active accounts in Minecraft and participate in joint game sessions. This percentage did not significantly affect the performance of the tasks. Kids who already have accounts in Minecraft coped with tasks faster than their peers.

4. Conclusions

The challenges that occur in real life require the parallel processing of vital data by several cognitive systems. In this regard, the traditional subject approach does not always adequately prepare students to solve problems. The developers of Minecraft EDU offer an optimal platform

for interdisciplinary learning, simulating a complex, multifaceted world in the information and educational space. Every teacher should understand the importance of creating "their own product" as a result of student activity in the classroom. This creative process involves the formation of a sense of confidence in their actions and aspirations in the design of future life, understanding the need for acquired knowledge and the importance of acquired skills and abilities. Children must learn to experiment and create their own product without fear of possible mistakes.

First of all, gamification should be used to form certain skills or behaviors, to visualize and emphasize such actions and skills that are difficult to demonstrate using traditional methods. Gamification is first and foremost a tool designed to improve the quality of education, to facilitate the assimilation of information, which can stimulate children to learn and which should attract rather than distract. This tool should be used in limited quantities. For the effectiveness of traditional forms of learning, it is necessary to gradually introduce this tool into the learning process.

Thus, we conclude that such a new form for Ukraine as gamification of the educational process is a promising tool for improving the quality of education. For successful gamification, you need to follow the basic stages of creating a game mechanism. It is important to gradually adapt teachers and students to the principles of gamification while studying in the Free Economic Zone. Consideration of methods of using digital game content, creating a library of digital electronic educational resources for further use is an all new field for research and development.

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