Using the Concept of Game-Based Learning in Education

Zi-Yu Liu (✉)
GuangXi Normal University, Guilin, China
51995812@qq.com

Zaffar Ahmed Shaikh
Benazir Bhutto Shaheed University Lyari, Karachi, Pakistan

Farida Gazizova
Elabuga Institute of Kazan Federal University, Elabuga, Russia

Abstract—A modern school deals with a generation of students who were born and grown up in a digital environment and require other teaching methods. Changes in the technological and social conditions of modern society need new professional skills, which are often called “21st century skills”. These skills should be developed starting from the primary school, as they are psychological and behavioural, rather than practical. Game-based learning and gamification are effective means of such skills development. The use of video games in teaching practice is studied multifaceted, along with formats and requirements of educational game, methods for effectiveness assessment, and the effect of games on students. The controversial nature of game-based learning effect on students require deeper research, as the increase in motivation and learning efficiency cannot be disputed, as well as the negative impact of a long gaming on cognitive abilities, emotional state and social skills of students. The study tested both an increase in the motivation and attraction of school students for the learning process, and the impact on the practical results of information assimilation. There was conducted a survey on the results of the application of game training to determine the motivation and attraction of students. Likewise, we counted time, spent by the study and control group, for mastering the main educational material and the post-class study of game content and the educational material it presents. A comparative test was conducted on the results of educational material comprehension to determine the effectiveness of the methodology in mastering knowledge. The group, with game-based learning and gamification applied, showed an increase in motivation and attraction to learning, students paid additional efforts for assimilating the material studied, and also showed significantly higher learning outcomes compared to the control group.

Keywords—21th century skills, e-learning, game-based learning, gamification.
1 Introduction

Modern education faces a whole series of complex challenges related to the technological development of society and social re-composition. Nowadays, at least the second generation of people defined as native digital is growing up. Those are people living in a digital environment from birth and perceiving it as their natural environment [1]. A civilization's technological level determines changes in the values of gaining knowledge, in a set of professions and in guidelines for training. The concept of lifelong learning is increasingly being introduced, when the process of acquiring knowledge never ends, and constant self-education and self-development become a regular professional requirement [2,3]. Accordingly, the requirements for school training are changing. This is no longer the usual ability to read, write, perform basic arithmetic operations, but a number of specific basic skills that researchers define as the general term “21st century skills” [4]. It seems there is no clear statement of this term today. According to majority of the works we have studied these skills include: creativity, problem-solving skills, collaborative and cooperative interaction skills, and communication skills [5,6]. One of the most appealing methods for acquiring such skills is through game-based learning [7,8].

Learning in the form of a game is one of the oldest and most useful pedagogical ideas that has been applied throughout the history of mankind [9]. Currently, the term Game-Based Learning refer to the use of video games and elements related to game reality, content, subject and images in the educational process [10]. Most researches scrupulously distinguish between game-based learning and gamification. Thus, gamification is defined as the use of game mechanics, aesthetics, and thinking to attract and motivate students to solve certain problems [11]. Gamification does not necessarily imply electronic devices or video games, but presents any training or working process in the form of a game [10,12]. In modern conditions, the most commonly used connotation for games is precisely the popular modern video games, which are used by more than 89% of children and adolescents, for example, in the UK [9].

A number of modern works are devoted to game-based learning assessment and methods for evaluating the quality of training. Studies of the last five years demonstrate a significant increase in motivation, attraction and interest of students of all ages in the learning process using this technique [13-15]. At the same time, researchers always note that the use of video games in teaching practice today may no longer have an alternative due to a change in the perception of the environment among generations of students who have been dealing with this since childhood through such type of entertainment and computer graphics in film, TV, advertising and other areas of life [12].

Meanwhile, there are many studies proving the negative effect of the regular video games using on the cognitive abilities, motivation, emotional state and behaviour of younger students [4,16]. Thus, researchers clearly distinguish between different types of game content that can be used in game-based learning. Firstly, there are so-called “serious” games, which are specially created for a teaching purpose and consider pedagogical achievements and the requirements of training programs. Games with less expended resources can also be used, which can be created by enthusiasts with
very narrow educational goals, for example, to study the planets of the solar system in astronomy [17]. Researchers increasingly consider the use of the most advanced technologies of virtual and augmented reality. Their distribution in the near future will once again radically change the familiar world of every person, as the possibilities of such technologies are growing rapidly, and the school must hurry to adjust to new requirements [18]. Researchers mention the theoretical possibility of using full-scale commercial games in training lastly, but we were not able to find specific positive examples of such applications. According to some practical examples, such games can be effectively used in gamification, but not alone as part of e-learning [19].

Different forms of electronic games can be used and engaged in a variety of ways to educational practice. The easiest way is to use game content as multiple-choice test, where the game is a reward for learning for primary students [8,18,20]. The use of the game as a means of delivering educational content to the student’s consciousness is more effective. According to some studies, such effectiveness is almost equal for both primary and university students as well as adults [8]. Thus, the psychological mechanisms of the video games impact are very deep and capture mechanisms of attention, starting from basic respond to light, sound, and movement [21]. That’s way it has a great value as increases students’ attraction to the learning process.

One of the main problems of game-based learning is the complexity and labour-consuming of games creation and it’s hard to integrate them in the learning process. The studies and experience of implementing the game show that in some cases the audience simply refused to use the content due to its poor quality [20,22,23]. Meanwhile, it is very difficult to compete with modern video game market due to its great technological capabilities and human resources. Thus, we should consider the possibilities of attracting a professional gaming market to create “serious” educational programs for schools [13,24,25].

Another problem is that teachers, who apply game-based programs, need to do special courses. However, researchers indicate that most teachers understand the need and recognize the effectiveness, but do not have the ability or the necessary knowledge for applying them in classroom activities [1,7,18,25].

Unlike video games, gamification allows applying the game into the learning process practically with and/or without using electronic devices. Gamification helps to extend the process of mastering the educational material or expand it outside the classroom, which allows increasing student motivation and giving him additional freedom of choice in finding and mastering information [26]. Many researchers on gamification also include collaborative decision of game tasks, as well as situational leadership among participants of this type training [3,27].

2 Materials and Methods

The study was conducted in the city of Elabuga. The sample consisted of 86 primary school students from three parallel classes, having the same training program. The age of the participants was 9-10 years. A control group consisted of 82 students of
three groups. The control group students were of the same age and studied in the same
general school curriculum as the students of the study group.

The study group was taught by special methods of gamification, as well as by the
simplest game apps written by students and teachers to meet the needs of the program
and the topics studied.

The gamification of training included a number of role-playing game elements:

- Assigning the participants, depending on the speed of the material mastering and
  activity in the class, with special game levels: “warrior”, “knight”, “paladin”, senor
  “,“ baron ”,“ duke ” – for boys; “maid of honour”, “lady”, “court lady”, “baroness”
  ,“duchess”, “princess” – for girls;
- Creating an atmosphere of competition during the performance of game tasks with
  awards like "experience points" to all participants;
- Dividing the learning process into "quests" – sections on solving game tasks, that
  required knowledge learned in the course of the subject;
- Describing the subject in the form of computer games that are familiar to all stu-
  dents with a coherent plot where each topic is tied to a specific milestone in the
  game.

A history program was used as the basis for training using game-based learning. The
results in different disciplines were combined with an average mark, according to
the purposes of the study.

The simplest gaming apps were created using JavaScript by students and university
professors in the form of short gaming apps with simple graphics and game mechan-
ics. Each game reflected the classroom activity and could be used both for studying
material during class work, as well as at home on mobile devices or a computer. The
game was displaying the lesson material in the form of animated infographics and
several “missions” for complete. The game problems solving required the necessary
knowledge on this topic. The scripting language was chosen precisely so that the app
can be easily adapted for any platform. The games were browser-based and the con-
tent can be easily changed depending on the program for subject studying or, if the
teacher willing to include new information.

The control group was trained by traditional classroom methods with a teacher in
the classroom, without the use of gamification or special applications or game strate-
gies.

The aim of the study was to test two hypotheses. A larger number of the study par-
ticipants were selected in order to fully identify trends within this group.

Hypothesis 1: the use of game-based learning increases student attraction, motiva-
tion, the desire to continue learning and make it more intense.

Hypothesis 2: the use of game-based learning improves the quality of learning, the
quality of memorizing, makes the learning process objectively more effective, which
should be manifested in the relevant difference in the post-test results for the study
group compared to the control group.

To test hypothesis 1, we used both a survey of study participants and an objective
study of the data that according to the researchers, demonstrates real indicators rela-
tive to the aim of the study. Thus, to evaluate the involvement in the learning process,
we calculated the amount of time each student spent on fulfilling the educational and game tasks, as well as the time spent in the classroom for studying the educational game outside the task or topic being studied. We used a cloud-based time tracker “Toggl” (https://toggl.com/) and data from mobile apps installed on students’ devices to calculate the time for the assignment. All date from mobile apps was grouped in the cloud-based service, which guaranteed the independence of the results regardless students’ willing.

A simplest questionnaire was provided to students, considering their age, in order to determine the involvement and motivation for learning, as well as the desire to continue learning. We subjectively evaluated involvement and interest by the following parameters: “very interesting”, “quite interesting”, “as usual” (it means the level of interest does not differ from training with a regular classroom program), and “uninteresting” as the lowest rating. Similarly, the desire to continue learning was evaluated: “Prefer to study so constantly” to “Do not want to study this way.” Intermediate levels were defined as follows: “Prefer (study) so more”, “Prefer (study) so, but not so much (as during research)”. Thus, a simple discrete gradation was built, the closest to the emotional assessment of the child and allowed to assess the involvement and motivation in numbers.

Further, the results obtained for the study and control group were compared, primarily considering the percentage of respondents in each group.

To test hypothesis 2, an objective post-testing was conducted as regular multiple-choice test of 20 questions with 4 answers, where only one was correct. The choice of a right option was counted as the correct answer; choosing one of the three other options was considered as wrong answer.

3 Results

The survey results showed unambiguously positive results of using game elements and game content in the learning process for mastering a subject. Particularly, there were no students who would indicate that the training was uninteresting (Table 1). The majority of students (88.55%) rated the training as interesting or quite interesting.

| Very interesting       | 70.93% | 61 |
|------------------------|--------|----|
| Quite interesting      | 18.61% | 16 |
| As usual               | 10.46% | 9  |
| Uninteresting          | 0.00%  | 0  |

A high interest in continuing to use this technique in the future was also indicated. However, the assessment wasn’t so steadily positive. Despite the fact that none of the students refused to continue their study by this technique, a little more than a half only (51.16%) expressed desire to study this way (Table 2).
Table 2. Students evaluation of the interest in further training with the Game-Based Learning

| Prefer to study so constantly | 51.16% | 44 |
|------------------------------|--------|----|
| Prefer (study) so more        | 33.72% | 29 |
| Prefer (study) so, but not so much | 15.12% | 13 |
| Do not want to study this way | 0.00%  | 0  |

Calculation of time spent on assignment provides a more objective assessment of gamification and game-based learning effectiveness on the process of mastering the material. Meanwhile, the degree motivation is associated with the amount of time spent on mastering additional or related material with the help of the provided electronic services.

Comparing Tables 3 and 4, the number of study group students who have learned the proposed training material within the optimal period was almost 4 times higher (40.69% and 10.97% in the control group). The total number of control group students who spent more than 6 hours learning the material is almost half as much as in the study group (27.92% versus 63.43% in the control group). According to the results, the gamification helped to increase the speed of perception and assimilation of information dramatically, and also helped to involve the majority of students in the educational process.

Table 3. Distribution of time spent on solving class tasks, study group

| Number of students | > 5 hours | 5-6 hours | 6-7 hours | 7-8 hours | 8-9 hours |
|--------------------|-----------|-----------|-----------|-----------|-----------|
| ppl.               | 35        | 27        | 14        | 6         | 4         |
| in %               | 40.69%    | 31.39%    | 16.28%    | 6.98%     | 4.66%     |

Table 4. Distribution of time spent on solving class tasks, control group

| Number of students | > 5 hours | 5-6 hours | 6-7 hours | 7-8 hours | 8-9 hours |
|--------------------|-----------|-----------|-----------|-----------|-----------|
| ppl.               | 9         | 21        | 22        | 14        | 16        |
| in %               | 10.97%    | 25.61%    | 26.83%    | 17.07%    | 19.52%    |

The learning process was built in such a way that the students had no objective need to spend additional time studying the course. However, students spent more time only due to personal interest and high motivation to continue the game and training, or interest in the subject. According to Table 5, it can be concluded that 80.23% of all study participants spent at least two hours additionally working with educational material only on their own motivation. And only 6.98% of students spent less than an hour for such classes. Thus, all participants somehow increased their motivation to work with gaming apps and the educational material itself, and most of them were strongly motivated to continue their studies. The test result correlates well with the percentage of participants indicating a higher interest in the training program (88.55%).
Table 5. Distribution of time spent on studying the subject besides classroom assignments

| Number of students | >3 hours | 3-2 hours | 2-1 hours | >1 hours |
|--------------------|----------|-----------|-----------|---------|
| ppl.               | 40       | 29        | 11        | 6       |
| in %               | 46.51%   | 33.72%    | 12.79%    | 6.98%   |

Besides subjective personal assessment, an objective test was held as the determining factor for the studying hypotheses. The test results comparing between the study group (Table 6) and the control group (Table 7) indicates that the number of students who gave more than half the correct answers was greater in the study group by 1.72 times than in the control group (91.86% and 53.42%, respectively). Moreover, the number of students giving the largest number of correct answers (from 16 to 20) is even greater: 48.84% versus 28.05% (by 1.74).

Table 6. Results of objective testing of knowledge, the study group

|          | 16-20 | 11-16 | 6-10 | 0-5 |
|----------|-------|-------|------|-----|
| ppl.     | 42    | 37    | 7    | 0   |
| in %     | 48.84%| 43.02%| 8.14%| 0.00%|

Table 7. Results of objective testing of knowledge, the control group

|          | 16-20 | 11-16 | 6-10 | 0-5 |
|----------|-------|-------|------|-----|
| ppl.     | 23    | 29    | 19   | 11  |
| in %     | 28.05%| 35.37%| 23.17%| 13.41%|

According to the results obtained, both research hypotheses were convincingly confirmed: with using game-based learning, students are much more motivated, demonstrate greater involvement in the process, have the intention to continue learning both this subject and the use of game-based learning. The results of objective knowledge tests have also demonstrated that the quality of mastering knowledge and the process of memorizing are relevantly more effective than with ordinary classroom activities.

4 Research Limitation and Further Researches

The study did not compare the use of gamification and game-based learning to other modern teaching techniques, for example, co-learning or e-learning in its familiar quality. Game-based learning has shown better results than regular classroom activities. However, there are new methods constantly introduced to classroom activities that increase its effectiveness. The use of game-based learning shows an improvement in objective results over a fairly short period of study, while it makes sense to test its effectiveness for longer periods of study. Many researchers point to the negative impact of video games on the cognitive abilities of students, but we could not find any research on this topic. Thus, the long-term reliability of the results and the effectiveness are crucial for the widespread use of electronic gamification in the learning process.
5 Discussion

A significant part of modern researches in the field of game-based learning is focused on exploring the possibilities of virtual reality and mobile technologies [12,17,28]. The use of VR and AR allows virtual elements to be superimposed to the real objects that can act both as a means of informing and learning [29]. The reducing cost of VR and AR technologies makes it quite possible to use even for budgetary training programs in many educational institutions [17,30]. Among other benefits, the use of VR elements allows to control the learning process and its results directly by physical space with the personal participation of a teacher [4,28]. However, such technologies are still a problem for many countries as they require mobile devises with the high computing power. Therefore, our study relied on the creation of a gaming environment not only in the form of the simplest and most accessible video game technology, but also on the elements of gamification, oriented on students’ behaviour within given game rules.

Many researchers suggested different forms of gamification for primary, high school or university students [12,18,26,31]. They point out that gamification can go in several directions. Particularly, it can take the form of a reward for reaching a certain level and passing a conditional test for acquired knowledge, and can be used during the entire learning process, turning it into a game. In the second case, students develop a specific motivation – they not only try to learn, but try to play better and get a higher gaming status. However, the implementation of the second type of gamification requires the use of more complex software and the constant active participation of a teacher or host [12].

The possibilities of expanding the learning content have an important role in the spread of game-based learning. Costa et al. [17] indicates that Game-Based Learning provides the opportunity to conduct formal and non-formal training simultaneously. Meanwhile, the developed technology allows creating a back office for teachers, where they can make changes to the curriculum online. Such possibility has been studied before [18]. Contrarily, we consider that the gaming content requires a certain amount of time, money and effort, as well as calling in specialists to create and update it. This affects the speed of content updating and changing training programs or filling in training and control material. A constant change of the control material is critically necessary to maintain an adequate test of students' knowledge, as they easily exchange achievements and knowledge about passing the tests. Such interaction through social networks and other means of communication in a digital environment makes the verification of tests irrelevant if the content wasn’t changed for each new group of students [23].

We also conducted a research on the results of children’s own innovative projects in the logical-mathematical and natural sciences. In this case, the extended educational material was used along the school curriculum [11,32]. This is one of the few studies taking longer period of applying gamification (from November 2017 to May 2018), which demonstrated the significant progress of students in various fields of intellectual activity. For the gamification, already existing popular commercial pro-
jects were used, such as Minecraft Edu that is already widespread, according to the authors of the study, e.g. in Spain [11].

6 Conclusion

The study result confirms both hypotheses formulated on the use of gamification of the learning process, as well as the introduction of learning content with video games based on browser games available for both computer and students’ mobile devices. To verify the results, a group of 82 students of the same age was trained with above mentioned technologies.

According to objective calculation, 80.23% of all participants in the study group spent more than 2 hours (maximum average of more than 3 hours) for training and on the development of additional knowledge on the subject. 88.55% of study group students expressed a high interest in continuing to study using a game-based learning. Moreover, none of the participants in the study group indicated that the learning process was uninteresting. Thus, participants showed a very high degree of involvement, interest and motivation, that confirms hypothesis 1.

The number of students giving the correct answers to more than half of the questions was greater by 1.72 times in the study group compering to control (91.86% and 53.42%, respectively). The number of students in the study group who gave the most correct answers in comparing to the control group was 1.72 times higher (48.84% versus 28.05%). Thus, the positive impact of electronic gamification on the quality of learning was clearly demonstrated (hypothesis 2 of this study).

We consider it necessary to significantly expand the scope of research on gamification. Firstly, the long-term consequences and impact on students of primary and secondary schools should be determined. The results of the study can be used while applying elements of gamification and educational “serious” video games in the practice of teaching for this group of students.

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9 Authors

Liu Zi-Yu is a lecturer in School of Foreign Language in GuangXi Normal University, Guilin, China.

Shaikh Zaffar Ahmed is a PhD in Computer Science from the Institute of Business Administration, Karachi. He is an HEC Approved PhD Supervisor in the field of Physical Sciences. Dr. Shaikh has published more than 40 research articles in reputed journals and conferences. Some of those journals are the Australasian Journal of Educational Technology, Digital Education Review, Evolutionary Intelligence, Journal of Food Processing Engineering, Turkish Online Journal of Educational Technology. His articles have received 300+ citations as of March 2020. Dr. Shaikh contributes to reviewing manuscripts for reputed journals and conferences. His research interests are AI, Big Data, Data Sciences, Educational Technology, E-Learning, E-Governance, Expert Systems, Food Processing, ICT Policy/Planning, IoT, Learning Environments, MOOCs, OERs, Social Software, Sustainability, Technology Enhanced Learning, etc.

Gazizova Farida Samigullovna is a PhD in Pedagogical Sciences, Associate Professor, Department of Theory and Methodology of Pre-School and Primary Education, Elabuga Institute of Kazan Federal University, Elabuga, Russia.

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