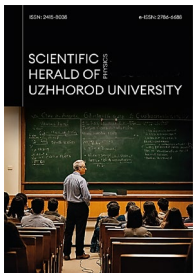
Scientific Herald of Uzhhorod University
Series "Physics"
Journal homepage: https://physics.uz.ua/en
Issue 56, 71–82
Received: 04.08.2023. Revised: 12.11.2023. Accepted: 27.02.2024



DOI: 10.54919/physics/56.2024.7mah1

Modern educational technologies of teaching chemistry in higher education institutions of Kazakhstan

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Abstract

Relevance. The relevance of this study is conditioned by the need to optimise the educational process in higher education institutions of Kazakhstan by introducing modern information and computer technologies in game-based learning of chemistry to improve the effectiveness and attractiveness of the learning process.

Purpose. The purpose of the study was to analyse and evaluate the effectiveness of the use of information and computer technologies in the game-based training of future chemistry teachers during the study of chemistry subjects.

Methodology. To achieve this goal, a formative experiment was conducted among university students to determine the dynamics of the impact of the introduction of game-based learning, including: observation, conversations, complex teaching and research tasks, analyses of the results of current and final control. In the experimental group, modern educational approaches and methods of teaching chemistry using information and computer technologies in a game format were applied; the control group continued training using conventional methods.

Results. The results of the study showed a significant improvement in the level of readiness of students of the experimental group to use information and computer technologies in game-based learning. In particular, there was an increase in the proportion of students with high and average levels of motivation and interest in developing knowledge and skills in chemistry using information and computer technologies. The use of the $\chi 2$ criterion allowed for the assessment of significant statistical changes in the reflexive component of students' readiness to use information and computer technologies in game-based learning.

Suggested Citation:
Almesh D, Meirmanova A, Medetbayeva S, Nurakhmetova A, Chinibayeva N. Modern educational technologies of teaching chemistry in higher education institutions of Kazakhstan. *Sci Herald Uzhhorod Univ Ser Phys.* 2024;(56):71-82. DOI: 10.54919/physics/56.2024.7mah1

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Conclusions. The introduction of modern educational technologies in the teaching of chemistry will improve the quality of education, attract more students to learn chemistry, and ensure more effective assimilation of educational material. The results obtained are of practical importance for the development of the educational process in universities of Kazakhstan.

Keywords: information and computer technologies; game-based learning; efficiency; educational process; chemistry subjects.

Introduction

Modern education plays a key role in the development of society and the training of qualified specialists. In the field of higher education, special attention is paid to the development and implementation of modern educational technologies that allow students to effectively and interactively learn various subjects. One of the important areas where modern educational technologies are widely used is the teaching of chemistry. Chemistry plays a significant role in many scientific and technical fields and is the basis for understanding many processes and phenomena in nature and society. In Kazakhstan, there is a constant need for qualified chemists who are able to apply their knowledge and skills in practice. Consequently, universities in Kazakhstan are actively working to improve methods and approaches to teaching chemistry using modern educational technologies.

The relevance of the study in the field of the application of modern educational technologies in teaching chemistry in Kazakhstan is based on several key arguments. Firstly, it will help meet the need for qualified chemists, which is important for a developing country. Secondly, modern educational technologies allow improving the quality of education by making the learning process more accessible, interactive, and exciting. This approach contributes to a deeper assimilation of the material and the development of creative thinking. Thirdly, adaptation to modern challenges is an integral part of the educational process. Modern technologies create a flexible educational environment that promotes the training of graduates who are able to easily adapt to the requirements of the modern labour market [1-2]. In addition, the use of modern educational technologies in teaching chemistry attracts young people to science and research, which is an important aspect for the future development of the country. Ultimately, the research and application of modern educational technologies in teaching chemistry contribute to the development of educational science in Kazakhstan and attract attention to this important area. The introduction of new technologies and teaching methods allows exploring innovations in the field of education, which is of long-term importance for the development of the country and its competitiveness on the world stage. Thus, modern educational technologies in teaching chemistry are undoubtedly relevant and have a huge impact on the future of Kazakhstan.

Sh.R. Saydaxmetova [3] suggests that in the conditions of the modern educational paradigm based on the competence approach, domestic higher education is experiencing a transition from the traditional "knowledge" model to a model that focuses on activity competence. This transition represents an innovative area in the development of the educational sphere, which reflects the desire of society to improve. In teaching chemistry at the higher education level, the main goal is to provide high-quality, fundamental education that meets the current and future needs of the student, society, and the state as a whole. In light of this, the task of developing and implementing innovative methods of teaching chemistry at the level of higher education becomes urgent.

S.A. Medetbayeva [4] reports that the uniqueness of chemistry in higher educational institutions is expressed through its integrated nature and orientation to professional and practical training, which requires the introduction of innovative methods and educational technologies. The foundation of modern chemistry teaching methodologies is an integrative competence approach, which is based on the key principles and ideas of personality-oriented, system and activity approaches. The development and implementation of advanced pedagogical technologies and methods of teaching chemistry have become important because of the need to manage the educational process with guaranteed results. A. Karthikeyan and U.D. Priyakumar [5] identified the types of innovative technologies. Radical types of technologies involve the restructuring of the educational process; combined innovative technologies are the combination of various known elements or technologies into a new teaching system or method; modifying technologies are focused on improving existing teaching methods or technologies without radical changes. The researchers also identified key areas for the development of innovative technologies, including reproductive training, research training, models of educational discussions, and models of game teaching methods.

According to M.F. Nishonov et al. [6], innovative pedagogical technologies and methods introduced into chemistry training are classified according to the purpose of their use into three groups: information-developing, activity-enhancing, and personality-oriented. In the context of the content of training, technologies based on the modelling of professional activity in the educational process play an important role. Innovative pedagogical methods and technologies in teaching chemistry take into account the composition of the student group, their age, level of training and degree of development, the size of the group, and the physical condition of students. With regard to the resources and facilities of the educational process, programme training and the use of modern information technologies are highlighted [7; 8].

A.A. Csavdari et al. [9] points out that the effectiveness of the use of innovative methods of teaching chemistry depends on the professional skills of a university teacher, which include: the ability to clearly form and define the goals of the educational process; the ability to develop the content of the curriculum for a specific subject; the involvement of traditional and innovative types of classes in the educational process; the use of information and communication technologies in the use of various forms of pedagogical control over the progress of the educational

process; the ability to search for and use educational resources; and the ability to create methodological manuals and materials for conducting training sessions.

G. Minazheva et al. [10] paid special attention to the effectiveness of the application of the methodology of research laboratory work, which contribute to the improvement of experimental skills and the deepening of the knowledge of chemistry. Various printed resources are used to implement this technique, including synchronous, synoptic, nominal and informational maps, instructional maps for conducting research experiments, chemical texts with interdisciplinary content, cognitive maps, and developmental tasks in chemistry.

The reviewed papers indicate a fairly extensive range of interest in the study of modern educational technologies for teaching chemistry in universities of the Republic of Kazakhstan. That is why the aim of the experiment was to exhaustively characterise the impact of introducing game-based learning in the educational process of one of Kazakhstan's higher education institutions.

Materials and Methods

The study was conducted in the period from 2021 to 2023 at the Department of Chemistry, Abai Kazakh National Pedagogical University, Almaty, Republic of Kazakhstan. The experiment involved 3rd-year students aged 19-21 years, 63 females and 69 males. Of this number, 61 students (25 females and 36 males) were included in the experimental group, while the remaining 71 students (38 females and 33 males) made up the control group.

Practical training of future chemistry teachers included the organisation of game activities during the study of subjects such as "Analytical Chemistry", "General Chemistry" and "Active Teaching Methods". These game-based tasks were performed in different formats:

- individual work: this format included the performance of individual theoretical and practical tasks of the game type in the classroom, the preparation of presentations, messages and reports on a specific topic;
- group gaming activity: this format included work on common tasks and projects related to the use of game-based learning and information and computer technologies.
- various forms of computer educational games: they included online multiplayer games, offline games, single-player games, cooperative multiplayer games, and games that are part of a training course or lesson.

Students were given tasks, the performance of which provided future chemical teachers with the necessary skills for the effective use of educational computer games in their future professional activities. This, in turn, actively stimulated the development of internal motivation for the successful solution of tasks.

The next stage of the study included conducting an introductory stage of the experiment to assess the level of readiness of potential chemistry teachers according to all certain criteria and indicators. Criteria and indicators for assessing the readiness of future chemistry teachers are presented in Table 1.

Table 1. Methods for determining various characteristics of the readiness of future chemistry teachers

Criteria	Indicators	Methods of determination
Motivational	Availability of motivation and needs to acquire knowledge, skills, and abilities to use information and communications technology (ICT) in gam-based learning	Testing using the methodology of determining the orientation to the acquisition of knowledge in chemistry with the help of educational computer games [11]
	The presence of persistent interest, independence, and creativity in the performance of game tasks	Methods of observation, conversation, questioning, and testing
	Striving for self-improvement and increasing the level of readiness to use ICT in game-based learning	The Trait Meta-Mood Scale 24 [12], survey, observation
Cognitive	Awareness in the field of game-based learning using ICT in the chosen subject	Methods of observation, conversations, complex educational and research tasks, analysis of the results of the current and final control
	Understanding the structure of the gameplay	
	Knowledge of ways and methods of organising the productive use of game-based learning using ICT	
Activity-based	Full mastering of game-based learning technology using ICT	Analysis of practical actions of students when performing individual game tasks, the method of expert assessments
	The level of perseverance, responsibility, and creativity when performing game tasks	Observation methods, conversations, problem-based learning methodology [13]
Reflexive	Awareness of the importance of using ICT in game-based learning	Observation methods, conversations, Reflective Functioning Questionnaire [14]
	Determining the level of readiness to use ICT in game-based learning	Methods of observation, conversations, written determination of the level of development of reflexivity

	Ability to have a deep awareness of responsibility for the actions performed	Methods of observation, conversations, written self-assessment of students' game activity

Source: compiled by the authors.

As part of the experiment, the homogeneity criterion (1) was used to evaluate, compare, and confirm that the experimental and control groups are a single set:

$$\chi^2 = \sum\left[\frac{(f'_\epsilon - f'_k)^2}{f'_k}\right], \qquad (1)$$

where: f'_ϵ – relative frequency of the interval of the first row; f'_k – relative frequency of the interval of the second row.

The analysis of the level of readiness for the use of information and computer technologies in teaching through the game among future chemistry teachers according to the motivational criterion at the initial stage of the study was developed.

Results

At the initial stage of the study, it was found that a significant proportion of students, future chemistry teachers, have a low level of readiness to use information and computer technologies in game-based learning of chemistry. This is manifested in their lack of motivation and the need to develop chemical knowledge, skills, and abilities. According to the data, 61% of students in the experimental group and 48% of students in the control group have a low level of readiness. In addition, observations and conversations with future chemistry teachers confirm that their motivation to develop their own knowledge, skills, and abilities is poorly expressed. There is little student involvement in the learning process, which makes it difficult to fulfil learning objectives and limits the full absorption of learning material. There is a possibility that students may stop working and fail to complete their studies if difficulties arise during the educational process.

As a result of the study, it was revealed that only a small part of students show an average level of interest, independence, and creativity when using information and computer technologies in game-based learning. In the experimental group, this level is 27.8%, and in the control group – 36.6%. Such results indicate a low level of motivation of students to perform tasks related to the development of methods of game-based learning using information and computer technologies and conducting experimental research. Students are more inclined to give priority to ready-made knowledge than to show initiative and creativity.

In the course of the study, it was found that only a small percentage of students show a high level of striving for self-improvement and increasing their readiness to use information and computer technologies in game-based learning. In the experimental group, this percentage was 11.2%, and in the control group – 15.4%. Thus, only a small number of students show interest and creativity when performing educational tasks and actively work on the development and improvement of their readiness to use information and computer technologies in game-based learning. This result indicates that the level of motivation and dedication of these students differs from most of their colleagues (Figure 1).

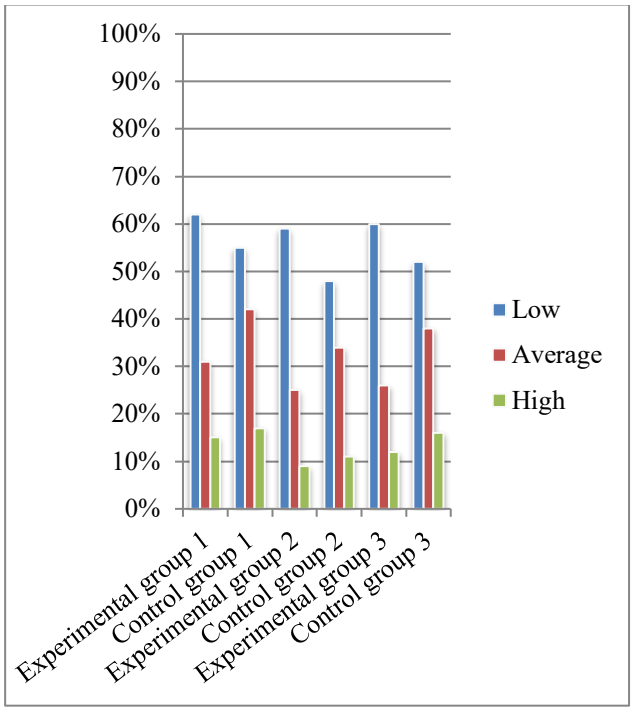

Figure 1. The initial level of motivation of future teachers to use information and computer technologies in game-based learning

Note: 1 – Motivation and needs for the development of chemistry knowledge, skills and abilities when using information and computer technologies in game-based learning; 2 – Sustained interest, independence and creativity when using information and computer technologies in game-based learning; 3 – Level of striving for self-improvement and increased readiness to use information and computer technologies in game-based learning.

Source: compiled by the authors.

The results of the experiments showed the need to motivate future chemistry teachers to use information and computer technologies in game-based learning. Only 15.21% of students show a high level of motivation and interest in developing knowledge and skills in this field. The level of sustained interest, independence, and creativity in the use of information and computer technologies is low in 53.11% of students, while only 13.54% of students show a high level of striving for self-improvement and readiness to use these technologies. Only 18.97% of students have a high level of awareness to form a cognitive component of the use of information and computer technologies in game-based learning in the field of chemistry. 44.05% of students have a low level of understanding of the structure of the gameplay, and 66.11% of students have a low level of knowledge of ways and methods of organising the productive use of information and computer technologies in game-based learning. To develop an activity component, 49.87% of

students have a low level of mastery of game-based learning using information and computer technologies, while only 27% of students show high perseverance, responsibility, and creativity in performing game tasks. Regarding the reflexive component, 20.55% of students do not realise the importance of using information and computer technologies in game-based learning, while 36.58% show a deep awareness of responsibility for their actions. Readiness to use information and computer technologies in game-based learning is 42.24%.

As a result of the formative experiment, a significant increase in the proportion of students with a high and average level of readiness to use information and computer technologies in game-based learning was noted. In particular, in the experimental group, there was an increase in the number of students with a high level of readiness by 21.89%, while in the control group, this indicator increased by only 4.63% in terms of motives and needs for the development of knowledge, skills of using information and computer technologies in game-based learning (Table 2).

Table 2. Longitudinal study of the effectiveness of the development of competencies of future chemistry teachers in the field of information and computer technologies through game-based learning

Criteria	Levels	Experimental group (%)	Control group (%)
Motivational criterion: The presence of motives and needs for the development of knowledge, skills, and abilities in the use of computer technology in game-based learning	Low	-41.55	-19.48
	Average	+15.69	+20.14
	High	+18.31	+4.03
Presence of sustained interest, independence, and creativity in the use of computer technology in game-based learning	Low	-52.41	-18.47
	Average	+28.36	+17.47
	High	+25.16	+5.02
Striving for self-improvement and increasing the level of own readiness to use information and computer technologies in game-based learning	Low	-40.32	-6.14
	Average	+16.56	+2.24
	High	+23.19	+3.84
Cognitive criterion: Awareness of the use of information and computer technologies in game-based learning in the subject under study	Low	-60.02	-27.54
	Average	+34.78	+18.42
	High	+24.57	+12.47
Understanding the structure of the gameplay	Low	-63.29	-41.89
	Average	+28.86	+23.72
	High	+63.03	+13.48
Knowledge of ways and methods of organising the productive use of information and computer technologies in game-based learning	Low	-57.29	-28.48
	Average	+36.76	+26.74
	High	+19.55	+10.74
Activity criterion: Completeness of mastering the technology of game-based learning using information and computer technologies	Low	-38.98	-4.89
	Average	+16.48	+3.22
	High	+26.53	+4.17
Degree of perseverance, responsibility, and creativity in the process of performing game tasks	Low	-35.66	-10.01
	Average	+18.34	+7.54
	High	+14.56	+2.99
Reflexive criterion: Awareness of the importance of using information and computer technologies in game-based learning	Low	-27.77	-4.76
	Average	+17.87	+2.08
	High	+5.55	+3.26
Determination of the level of readiness for the use of information and computer	Low	-21.04	-4.17
	Average	+7.98	+2.14
	High	+7.75	+3.66

technologies in game-based learning			
Ability to have a deep awareness of responsibility for the actions performed	Low	-26.57	-4.11
	Average	+7.89	+2.17
	High	+20.65	+1.99

Source: compiled by the authors.

The presented data indicate the positive effect of the conducted formative experiment, which is aimed at developing the readiness of future chemistry teachers to use information and computer technologies in game-based learning. There is a noticeable increase in the proportion of students with a high and average level of readiness to use these technologies in game-based learning.

Thus, in the experimental group, the number of students who showed a high willingness to use information and computer technologies in game-based learning has significantly increased. For example, the level of students with motivation and the need to develop their knowledge, skills, and abilities in this area increased by 18.31%. In the control group, this indicator increased by only 4.03%.

According to the indicator of the presence of sustained interest, independence and creativity in the implementation of game-based learning technology using information and computer technologies, the number of experimental group students demonstrating a high and average level of readiness to use information and computer technologies in game-based learning increased by 25.16% and 28.36%, respectively. In the control group, this indicator increased by only 5.02% and 17.47% for students with high and average levels of readiness, respectively.

A diagnostic study of students' readiness to use information and computer technologies in game-based learning showed significant changes in the structure of readiness. Students who demonstrated a low level of readiness in the experimental group decreased by 40.32%, while in the control group, their share decreased by only 66.14%.

At the same time, the number of students with a high and average level of readiness in the experimental group has increased significantly: by 23.19% and 16.56%, respectively. In the control group, such growth was more modest: by 3.84% for students with a high level of readiness and by 2.24% for students with an average level.

The study on the cognitive criterion revealed a decrease in the proportion of students with low readiness to use computer technology in game-based learning by 60.02% in the experimental group and by 27.54% in the control group. This is due to an increase in the number of students with a high and average level of readiness: in the experimental group, this figure was 24.57% and 34.78%, respectively, while in the control group – 12.47% and 18.42%. This indicates an increase in the level of awareness of students about the use of computer technology in teaching in the chosen subject.

The study showed an increase in students' understanding of the structure of the gameplay. Thus, the number of students with a low degree of understanding decreased by 63.29% in the experimental group and by 41.89% in the control group. There was an increase in the number of students with an average and high level of understanding by 28.86% and 63.03% in the experimental group, and 23.72% and 13.48% in the control group, respectively. Similar changes have occurred in terms of knowledge of methods of effective use of computer technology in game-based learning: the number of students with a low level of knowledge has decreased, while the number of students with an average and high level of knowledge has increased.

The results showed an improvement in the completeness of mastering game-based learning using computer technology among experimental group students: a decrease of 38.98% of students with a low level, and an increase of 16.48% and 26.53% of students with average and high levels, respectively. However, the changes in the control group were less noticeable. Perseverance, responsibility, and creativity in performing game tasks were also measured. In the experimental group, the number of students with low levels decreased by 35.66%, while the number of students with high and average levels increased by 18.34% and 14.56%, respectively. In the control group, these changes were less pronounced.

A decrease of 27.77% was found in the experimental group of students with a low level of awareness of the importance of using information and computer technologies in game-based learning, while in the control group, this number decreased by only 4.76%. The number of experimental group students with a high level of this indicator increased by 5.55%, and with an average – by 17.87%. The level of readiness of students for the implementation of game-based learning using information and computer technologies was also diagnosed. In the experimental group, the number of students with a low level of readiness decreased by 21.04%, while in the control group, this indicator decreased by only 4.17%.

According to the indicator of deep awareness of the actions performed, the number of experimental group students with a low level of formation of research competence decreased by 26.57%, and in the control group – by 2.17%. The number of students with a high level in the experimental group increased by 20.65%, in the control group – by 1.99%.

During the formative experiment, a significant improvement in the awareness of responsibility for their actions was observed among the students of the experimental group. This is confirmed by statistical data collected as a result of the experiment. The use of χ^2 criterion helped to assess the level of readiness of future chemistry teachers to use information and computer technologies in game-based learning, considering the level of reflexivity.

The main indicators exceeded the established values: the importance of game-based learning ($\chi^2_{surv.}$=21.35), readiness to implement game-based learning ($\chi^2_{surv.}$=32.65), the ability to have a deep awareness of responsibility for the actions performed ($\chi^2_{surv.}$=40.99). These results exceed the tabular value of $\chi^2_{0.95}$=8.68, indicating statistically significant and not random changes in the data. Summary results of experimental work at the

initial and final stages of the formative experiment are given in Table 3.

Table 3. Aspect of the evaluation of the criterion χ^2 at the initial and final stages of the experiment on the development of skills

Evaluation aspect	Indicator χ^2 before	Indicator χ^2 after
Motivational criterion		
Interest in the development of ICT knowledge, skills and abilities in game-based learning	3.25	69.65
Showing sustained interest and creativity in learning with ICT	6.42	20.08
Striving for self-improvement and readiness to use ICT in learning	7.31	26.62
Cognitive criterion		
Awareness of the use of ICT in game-based training in the subject being studied	0.55	17.31
Understanding the structure of the gameplay	0.98	27.45
Knowledge of ways and methods of organising the productive use of ICT in learning	1.02	20.04
Activity-based criterion		
Completeness of mastering game-based learning using ICT	3.26	51.73
Degree of perseverance, responsibility, and creativity in game-based learning using ICT	2.25	15.31
Reflexive criterion		
Awareness of the importance of using ICT in game-based learning	4.58	21.35
Determining the level of readiness to use ICT in educational games	3.39	32.65
Ability to deep awareness in the course of educational activities	8.94	40.99

Source: compiled by the authors.

The summary data of the study presented in Tables 2 and 3 confirm significant statistical changes in certain metrics among the students of the experimental groups. These changes occurred after the use of information and computer technologies in the game-based training of future teachers in the process of studying chemistry.

The level of preparation for the use of information and computer technologies in game-based training of future chemistry teachers changed due to a decrease in the number of students with a low level and an increase in the number of students with an average and high level of readiness.

The growth in the number of students with a high level of the studied quality confirms the effectiveness of the integration of theoretically grounded and methodically developed pedagogical technology into the educational process. This technology is aimed at forming readiness for the use of information and computer technologies in the game-based training of future chemistry teachers in the process of studying chemistry subjects.

Discussion

The results of the study showed an unambiguous improvement in the performance of future chemistry teachers during game-based training. Nevertheless, the topic of the objectivity of such experiments remains open, so it is very important to compare them with the results of other studies.

American researcher A. Lutfi et al. [15] states that after the introduction of the game Hydrocarbons Chem-Rush for the study of hydrocarbons by students, the percentage of educational motivation has increased significantly in the range from 69.9% to 94.7%, which corresponds to the categories “good” and “very good”. This indicates a high effect of the game on the motivation of students, showing an increase in motivation from 3.1% to 21%. Thus, the game Hydrocarbons Chem-Rush successfully stimulates students’ motivation to learn, which is of great interest for further research, since motivation is an important factor for students to succeed in their educational goals.

One of the advantages of the game is to create a pleasant learning atmosphere and increase the educational motivation of students. Such conclusions are supported by the studies cited above, which note that games can stimulate the development and improvement of learning skills. Moreover, the use of games motivates students, turning them from passive recipients of knowledge into active creators of knowledge, thereby contributing to more meaningful learning [16-18].

In turn, F.O. Ezeudu et al. [19] and K. Brassinne et al. [20] note that games for Android devices are increasingly seen as a promising tool for motivating students. By designing the educational environment so that students’ knowledge and skills are acquired during the game, it is possible to significantly increase their interest in the educational material. Many previous studies in the field of gamification indicate that a motivating approach using awards can significantly improve learning skills and, as a result, increase students’ educational achievements [21-23].

To assess the benefits of using games as educational tools, they must meet the criteria of validity, practicality, and effectiveness. Such analytics will help to determine the effectiveness of educational games and their significance in the educational process. These studies show a possible way to develop modern educational technologies for teaching chemistry at universities in Kazakhstan.

The results of the study by W.K. Chiu [24] and M. Kalogiannakis et al. [25] show that the use of games as a learning tool demonstrates better effectiveness in student retention than other teaching methods. These results are confirmed by studies that claim that learning that corresponds to the individual characteristics of students contributes to more effective memorisation of information.

Retention or memory plays an important role in learning and has three main functions:

- inserting into stored memories ideas that have been experienced by someone;
- preservation of information, providing the possibility of repeating the acquired knowledge at a certain time;
- re-emergence of information that allows recreating memories that are stored in memory [26].

Thus, games as a teaching method contribute to the assimilation of material and its maintenance in the memory of students, which contributes to a more successful and productive educational process. These data are almost completely confirmed in the study cited above.

Also important are the observations of F.O. Ezeudu et al. [27], A. Lutfi and R. Hidayah [28], which imply that effective quality control of education is an integral part of the rating system throughout the educational process. Traditional control methods can be overloaded for teachers, so a set of tests has been developed for each module of the course. These tests allow testing in the format of a blitz test, not only in the control, but also in the training mode, with subsequent analysis of the results. In addition to traditional control and testing, the authors presented an innovative type of test tasks for the synthesis of organic compounds that allow solving variable tasks.

These tasks are classical synthetic tasks where students are asked to obtain compound A from compound B. The tested students are provided with 15-20 standard conversion schemes, and by combining them it is possible to achieve the desired results specified in the task. In addition, the answers to such tasks may have several correct options (synthetic schemes) [29].

This test structure provides coverage of all sections of organic chemistry and allows creating complex tasks that can be useful and necessary for students. This is an innovative approach to knowledge control, which contributes to a more effective educational process and supports students in their academic achievements. Similar observations were found in an experiment with the participation of future chemistry teachers of Abai Kazakh National Pedagogical University, the control of knowledge has really become simpler and more objective [30-32].

E.G. Villamor and M.R.C. Lapinid [33] note that the results of the analysis of student retention in the experimental group showed a satisfactory level of 89%. It is interesting to note that one student demonstrated even better results after using games than before. This was probably due to their interest in the game approach and their desire to try playing outside of training sessions again. In the control group, the results of the analysis of the retention ability of students amounted to 45%. In comparison with the experimental group, the results of the control group show a lower ability to memorise without using games in the learning process. Thus, data analysis confirms that the use of games as a means of learning has a higher ability to retain information and memorise than learning without games. This allows for the conclusion that the integration of game elements into the educational process can significantly improve the learning experience and results of students.

H.A. Alamri et al. [34], and also E.A. Al Ghawail and S.B. Yahia [35] report that the integration of artificial intelligence (AI) and computational tools into chemical education has another important advantage – stimulating innovative research and collaboration. The use of advanced computational methods, such as quantum chemistry modelling and molecular modelling, is becoming increasingly important in the field of chemistry, allowing researchers to predict the properties and behaviour of molecules and materials with unprecedented accuracy.

The inclusion of these tools in the curriculum allows students to gain hands-on experience using advanced research methods, preparing them for successful careers in academia, industry, and beyond. In addition, artificial intelligence contributes to the expansion of cooperation between students and researchers around the world, overcoming geographical and cultural barriers and contributing to the creation of a more inclusive and diverse scientific community [36-37].

Online platforms based on artificial intelligence connect students with experts in their field, providing opportunities for mentoring, networking, and collaborative research projects [38-39]. In addition, artificial intelligence-based tools help democratise access to advanced computing resources, which allows students and researchers with limited resources to participate in high-level research and contribute to the global scientific community. This is confirmed in the study cited above.

However, J. Westermayr and P. Marquetand [40] have different data. They claim that a study of the impact of gamified differentiated homework on students' academic performance showed that the introduction of an experience system in the learning process did not lead to an improvement in learning performance for several weeks. It turned out that students' productivity depends more on the complexity of lessons than on the system of experience. Students showed a significant improvement in academic performance in the first week's lesson compared to other lessons. Regarding homework, the influence of gamified differentiated tasks on the percentage of premature, timely, late, and unfulfilled tasks has become more negative with each passing week.

The discussion in the focus group showed that the volume of work and the increasing complexity of lessons were the reasons for lateness and unfulfilled assignments for students. Assessment of students' motivation using the questionnaire "Chemical Motivation" showed that there was no significant change before and after the introduction of gamified differentiated homework. However, the students positively perceived the use of such tasks in a playful way, considering it fascinating and interesting. It was also noted that the differentiation of homework assignments or the provision of options were specifically mentioned by students in the focus group discussion. This should be taken into account when developing educational materials for students.

This information is the opposite of the data obtained at Abai Kazakh National Pedagogical University. This may be due to an incorrect approach to students, their mentality or a poorly developed evaluation system, because most studies on this topic show positive results and significant progress.

Conclusions

In this study, an analytical assessment of modern educational technologies for teaching chemistry in

universities of Kazakhstan was carried out with an emphasis on the use of information and computer technologies in game-based learning. The relevance of this topic is conditioned by the rapid development of information technologies and the need to adapt educational processes to modern requirements and challenges of the time.

The main purpose of the study was to determine the level of readiness of future chemistry teachers to use information and computer technologies in the context of game-based learning and to evaluate the effectiveness of a formative experiment in this field. To achieve this goal, various research methods were used, including analysis of the results of diagnostic tests, surveys, and observations in experimental and control groups of students engaged in chemistry at universities in Kazakhstan.

As a result of the conducted research, a significant increase in the level of readiness of students to use information and computer technologies in the context of game-based learning was revealed. The experimental group of students who were involved in the formative experiment showed significant positive changes in relation to the use of information technology in the process of game-based learning.

For example, the level of students with motivation and the need to develop their knowledge, skills and abilities in the field of information and computer technology increased by 18.31% in the experimental group, while in the control group, this indicator increased by only 4.03%.

The main results of the study indicate the success of the integration of modern educational technologies in the process of teaching chemistry. The students who passed the formative experiment showed a higher level of readiness to use information and computer technologies in game-based learning compared to the control group. In particular, the number of students who showed high readiness to use information and computer technologies increased by 23.19% in the experimental group, while in the control group, such an increase was only 3.84%. In addition, the study highlights the importance of continuing work in this area.

The presented results determine the main areas for further research in the field of development and optimisation of information and computer technologies for game-based chemistry teaching. Further research can be aimed at developing new educational programmes, creating interactive educational platforms, and evaluating their effectiveness in teaching chemistry at universities in Kazakhstan.

Thus, this study represents an important contribution to the development of educational technologies in the field of chemistry and substantiates the prospects for further work in this field using information and computer technologies and game-based learning. The findings of the study confirm the effectiveness of the use of information and computer technologies in the educational process and a positive impact on students' readiness to use technologies in their future professional activities as chemistry teachers.

Acknowledgements

None.

Conflict of Interest

None.

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meth-oxy-phen-yl)diazene and (E)-1-[1-(4-tert-butyl-phen-yl)-2,2-di-chloro-ethen-yl]-2-(3-methyl-phen-yl)diazene. *Acta Crystallograph Sect E Crystallograph. Commun.* 2023;79:637-643.

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Сучасні освітні технології навчання хімії у вищих навчальних закладах Казахстану

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Анотація

Актуальність. Актуальність цього дослідження обумовлена необхідністю оптимізації освітнього процесу у вищих навчальних закладах Казахстану шляхом впровадження сучасних інформаційно-комп'ютерних технологій у навчання хімії у формі гри для підвищення ефективності та привабливості процесу навчання.

Мета. Метою дослідження було проаналізувати та оцінити ефективність використання інформаційно-комп'ютерних технологій у навчанні майбутніх вчителів хімії під час вивчення предметів з хімії.

Методологія. Для досягнення цієї мети був проведений формативний експеримент серед студентів університету для визначення динаміки впливу впровадження навчання на основі гри, включаючи: спостереження, розмови, складні викладацько-дослідницькі завдання, аналіз результатів поточного та заключного контролю. У експериментальній групі застосовувалися сучасні освітні підходи та методи навчання хімії з використанням інформаційно-комп'ютерних технологій у формі гри; контрольна група продовжувала навчання за традиційними методами.

Результати. Результати дослідження показали значне покращення рівня готовності студентів експериментальної групи до використання інформаційно-комп'ютерних технологій у навчанні на основі гри. Зокрема, спостерігалося збільшення частки студентів з високим та середнім рівнем мотивації та інтересу до засвоєння знань та навичок у хімії з використанням інформаційно-комп'ютерних технологій. Використання критерію $\chi 2$ дозволило оцінити значні статистичні зміни у рефлексивному компоненті готовності студентів до використання інформаційно-комп'ютерних технологій у навчанні на основі гри.

Висновки. Впровадження сучасних освітніх технологій у навчання хімії сприятиме підвищенню якості освіти, залученню більшої кількості студентів до вивчення хімії та забезпеченню більш ефективного засвоєння освітнього матеріалу. Отримані результати мають практичне значення для розвитку освітнього процесу у вишах Казахстану.

Ключові слова: інформаційно-комп'ютерні технології; навчання на основі гри; ефективність; освітній процес; предмети з хімії.