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Importance of digital technology application in the development of professional competence of future chemistry teachers

This article describes the preparation of a virtual laboratory in the subject and its application during the lesson. The aim of this study is to improve the professional competence of future chemistry teachers using digital technologies. Accordingly, the subject of the study is to determine the impact of digital technologies on improving the quality of education. This study is carried out by using experimental method which is a kind of quantitative research method. In the course of the work, a study of the influence of a virtual laboratory on the quality and increase in the level of students' knowledge in a pedagogical experiment was made. The level of students' knowledge was determined by the formula for calculating progress. A group of students who used the virtual laboratory showed a high level of knowledge. These data prove the effectiveness of conducting laboratory classes in chemistry using a virtual laboratory, which is one of the digital technologies. The effectiveness of digital technology application in the development of professional competence of future chemistry teachers is shown:
- chemical experiments were carried out using a virtual laboratory;
- students had the opportunity to self-correct and understand laboratory work at re-watching;
- prepared with the help of animation and color images, a virtual laboratory has increased the interest of students;
- at discussion the results of the lesson, a test was conducted on the "quizizz" program;
- to determine the significance of the virtual laboratory, the lesson was conducted in two groups, at analysis of the lesson results in the group where the virtual laboratory was used, the level of knowledge was high;
- it can be observed that the professional competence of students (motivation, skills, knowledge) has increased.

Key words: digital technology, professional competence, virtual laboratory, informatization of education, digitalization, Macromedia Flash Player program, cations of the second analytical group, qualitative reaction, acid-base classification, analytical chemistry, chemical experiment.

Introduction

At all stages of its historical development, the society has set high standards for specialists in the field of education, as the level of education of the society depends on the ability to create conditions for their further development. These requirements reflect the specifics of a particular era at each time. Today, quality education is the key to success and the main tool for economic development.

At the age of knowledge economy, it is a necessary to make a teacher's role and competence up to date since a teacher is the friend, leader, inventor and guide for learning [1; 12]. Thus, a teacher should be knowledgeable and own a critical and self-view. Competences of teacher include high academic skills, emotional qualities, and skills of challenge and excellence besides ability of justice leadership of a class [2; 46]. In this regard, there is a problem of increasing the professional competence, that is, motivation, skills and knowledge of future chemistry teachers. The use of digital technology is of great importance in solving this problem.

An important area of modern public policy is the development of digitalization in all spheres of society. The issue of digitization in education is provided for in the Resolution of the Government of the Republic of Kazakhstan dated December 12, 2017 № 827 on the approval of the state program "Digital Kazakhstan", which requires the increase of digital literacy in secondary, technical, vocational and higher education [3]. The state program "Digital Kazakhstan" is an important comprehensive program aimed at improving the living standards of every inhabitant of the country through the use of digital technologies. The high role of digital technology in education, high-quality information systems, the availability of electronic devices increase the interest of students and teachers in learning, allowing them to conduct research in today's relevant research areas.

The Law of the Republic of Kazakhstan "On Education" also takes into account issues related to information technology, information support of the education system [4].

One of the leading areas of education reform in Kazakhstan is digitalization. E-textbooks and virtual labs, open educational content, allow each student to create a flexible and individual approach. Students can do their homework together online. Libraries have become information and computer centers. The whole learning process depends on the individual ID of each student, which allows teachers to rate and form ratings.

Currently, the adoption of technologies by universities is related to a paradigm shift, where technology is conceived as a complex and interconnected environment that enables digital learning [5].

In this way, the interest is focused more on the students than on the technology itself, in addition to the learning experiences it allows. In this context, digitalization is a necessity in higher education institutions (HEIs) capable of attracting more and better students, improving the experience of courses, teaching materials, and the training process in general [6].

Theoretical and practical problems of the use of information technology in education have been studied by many researchers Robert I.V. [7], Traynev V.A., and Traynev I.V. [8] and others. In particular, Traynev V.A., and Traynev I.V., defined information technology as "a set of methods and software and hardware integrated into the technological chain, reducing the labor intensity of the collection, processing, storage and use of information, as well as increasing its reliability and operational efficiency" [8; 10].

Avadaeva I.V., showed the basic elements of digital technologies in vocational education: digital processes in the organization of the educational process, digital technologies for monitoring the professional competencies, knowledge, skills, abilities of students in general education. The essence of digital technologies in education is a set of methods, approaches and tools that provide processing, transmission and presentation of information aimed at improving the efficiency of the educational process. Distance learning technologies are technologies in which students and teachers interact using information technology [9; 25]. The use of digital technology also allows you to quickly and objectively determine the level of students' mastery of very important material in the learning process.

The priority of research in this area is explained by the need to adapt the principles of traditional pedagogy to the requirements of the modern information society, to make them operational and instrumental. Not all issues of digital education technology are developed in sufficient detail, which makes it difficult to implement in pedagogical practice. Thus, there was a mismatch between the role and place of the personal computer in the process of teaching chemistry, the limitations associated with the insufficient development of computer coordination with traditional methods of teaching students. This discrepancy determined the relevance of this study.

The purpose of this study is to develop the professional competence of future chemistry teachers using digital technologies.

The following tasks were set to achieve the objectives of the study:

- clarification of the concepts of "competence", "digitization" and "informatization of education" based on the analysis of literary sources;
- development of a virtual laboratory for qualitative reactions of cations;
- use of a virtual laboratory in the laboratory;
- preperation of a test using the program "quizizz" to determine the level of achievement.

Whiddet S. and Hollyforde S. understand competence as the ability to demonstrate the required standards of behavior [10; 67].

Heine P. uses the terms competence and competence. At the same time, in his works, the term competence always refers to the description of the functionality of teachers, and competence refers to the ability of teachers to perform the corresponding functions [11; 28].

Nikulina T.V. showed that the term informatization of education is interpreted as a set of measures for the transformation of pedagogical processes based on the introduction of information products, tools, technologies in teaching and education [12; 107-111].

The pedagogical encyclopedia considers "Informatization of education" in the broadest sense as a complex of socio-pedagogical transformations associated with the saturation of the education system with information products, tools and technologies; introduction of educational organizations based on microprocessor technologies in the narrow sense, as well as information products and pedagogical technologies based on these tools [13].

The term "digitization" appeared in connection with the rapid development of information and communication technologies. Davosse Klaus Schwab, who called the first digital revolution of the 1960s and 1980s

"industrial", believed that its catalyst was the development of semiconductor computers in the 1960s and 1970s. — personal computers, in the 90s — with the advent of the Internet, a virtual world was created, supplemented by new connections such as online games, social networks that connect to the real world [14; 84]. All this reflects the nature of digital literacy.

Vartanova, Vyrkovsky and Makseenko clarified the content of this concept. They explained that it is not only the digitization of information, but also a comprehensive solution of infrastructure, management, behavior, cultural nature [15; 17]. Now the era of digital information and communication does not mean a re-examination of education, pedagogy, its radical change, but an attempt to re-understand the learning process in a new context. Therefore, it is important to make education accessible using digital news.

Experimental section

To determine the effectiveness of digital technology in the teaching of chemistry, a virtual laboratory for "qualitative reactions of cations" in analytical chemistry was developed and used in the classroom.

Virtual laboratory is a computer program that allows you to organize chemical processes on a computer. Such a program provides a great opportunity to implement interactive learning. With the help of virtual laboratories it is possible to simulate a certain state of chemical reactions at a useful and qualitative level.

In modern methods of teaching chemistry, the types of virtual experiments and their application in the classroom are not fully studied in practice. Starodubtsev V.A., showed two main types of virtual experiments — virtual demonstrations (demonstrations) and virtual laboratories. Virtual demonstrations (demonstrations) that is a computer program that mimics the conditions and signs of chemical processes, creates visual effects and repeats dynamic images on a computer. Virtual laboratory is a computer program that simulates (models) chemical processes on a computer, allowing you to change its conditions and parameters [16; 79-87].

In the course of qualitative analysis of the discipline of analytical chemistry, the reagents required for the qualitative reactions of ions are sometimes absent, and sometimes it can be dangerous to perform detection reactions. And in remote schools, laboratory work on chemistry is not carried out, and the teacher is limited to demonstration experiments in order to open the topic. In this regard, a virtual laboratory for analytical chemistry has been developed.

According to the acid-base classification, cations are divided into six analytical groups, including a virtual laboratory for performing qualitative reactions of cations of the second group. This group consists of cations Ag^{+}, Pb^{2+}, Hg_2^{2+}, chlorides of which are poorly soluble in water, so in the systematic analysis, a solution of hydrochloric acid was used as a group reagent. To prepare a virtual laboratory, first prepare a methodical part of laboratory work, analyze the effects of group reagents and individual reagents, reaction conditions, reaction equations and results, depending on the analytical group of cations, and then design reagents and chemical containers used in laboratory work. Only after this section will be used 3D graphics and Macromedia Flash Player to virtualize laboratory work. In this program, each reagent and vessel is animated. When choosing the right reagent for a qualitative ion reaction, the reagent is moved with the cursor as shown in Figures 1, 2 and 3, dropping a few drops into the test tube, at which point the color of the precipitate formed by the reaction is clearly visible.

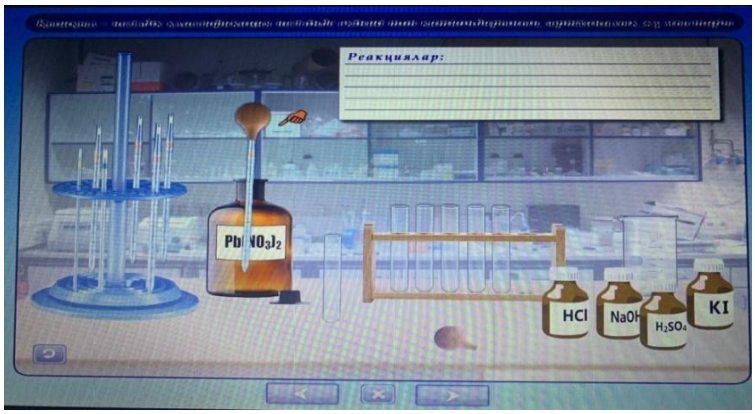

Figure 1. Accumulation of the reagent in the pipette with the help of the cursor in a virtual laboratory work prepared for the qualitative reactions of cations of the second group

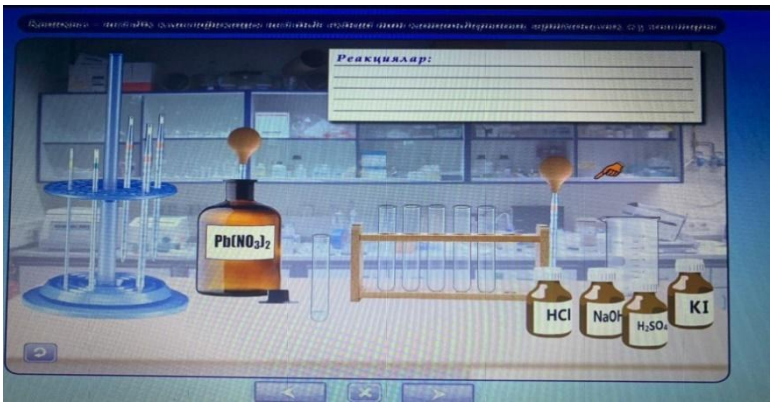

Figure 2. Accumulation of the reagent in the pipette with the help of the cursor in a virtual laboratory work prepared for the qualitative reactions of cations of the second group

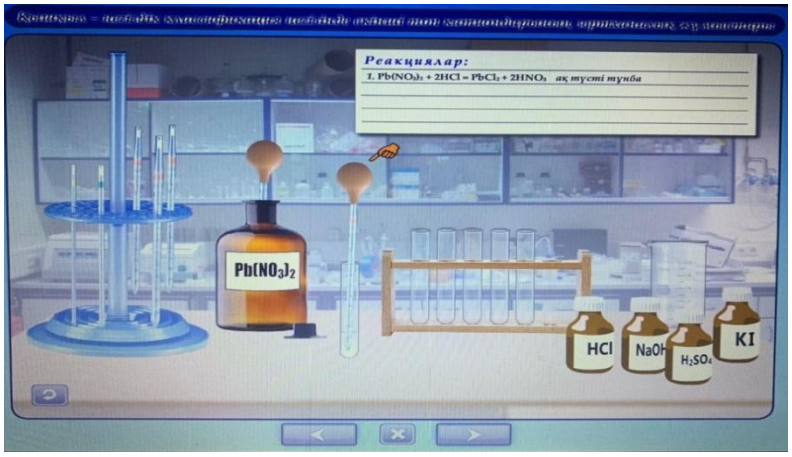

Figure 3. The course of the reaction in a test tube with the help of the cursor in a virtual laboratory work prepared for the qualitative reactions of cations of the second group

One of the advantages of virtual work is that students can work independently, the student selects the desired reagent to determine each cation, sees the result, if the specific reagent is not selected correctly, the cursor does not move. In this way you can get used to the qualitative reactions of all ions, the reaction equations are written on the screen after the experiment (Fig. 4).

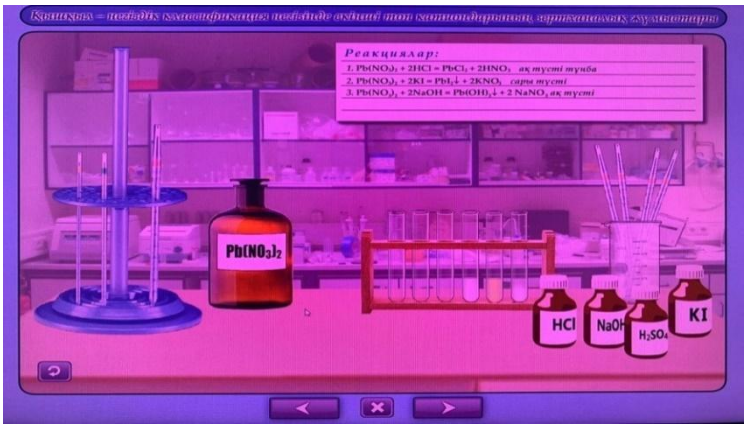

Figure 4. Demonstration of reaction equations on the screen in a virtual laboratory work prepared for qualitative reactions of cations of the second group

In the laboratory lesson on qualitative reactions of cations of the second group, a virtual laboratory based on this topic was used. The effect of the virtual laboratory on students' mastery of the properties of the second group of cations was studied experimentally. Experimental work was carried out at the South Kazakhstan State Pedagogical University, the second year of the Department of Chemistry, group 1504-10 in chemistry and group 1507-10a in chemistry and biology. In the first group, a laboratory lesson on "Qualitative reactions of cations of the second group" was conducted using a virtual laboratory. In the second group, laboratory classes on this topic were conducted in the traditional way. In the first group, students not only created qualitative reactions of the second group of cations, but also used virtual laboratories, repeated experiments and tested the reactions. Each student has the opportunity to use a virtual laboratory during the lesson, as shown in Figure 5.

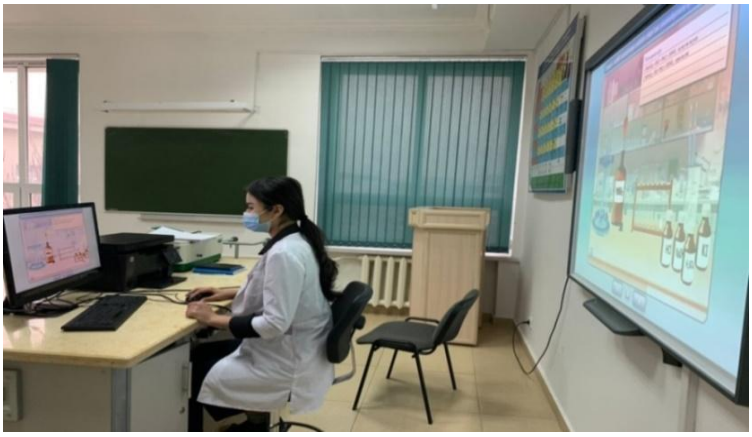

Figure 5. Students' use of a virtual laboratory during the lesson

In order to properly perform a virtual laboratory, students must be fully aware of the properties of cations of this group. As shown above, the reaction proceeds to the end only when the correct reagent for the qualitative ion reaction is selected, and the reaction equation is displayed on the screen. If the specific reagent is not selected correctly, the cursor will not move. In this case, they will be able to fully master the topic by repeating the experience.

In addition, virtual laboratories were displayed on an interactive whiteboard for the rest of the students to see and monitor the work done by each student (Fig. 6).

Figure 6. View of a virtual laboratory on an interactive whiteboard

Results and discussions.

The effectiveness of the virtual laboratory and their impact on improving the level of knowledge of students was tested by using data that is obtained by the program "quizizz". In Figure 7 it is shown that the view of test tasks prepared using the program "quizizz" on the interactive whiteboard. In Figure 8, the participation of the students in the test tasks prepared with the program "quizizz" is shown.

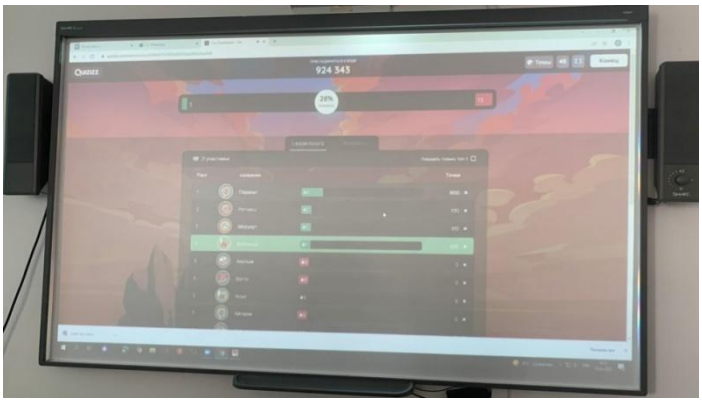

Figure 7. View of test tasks prepared using the program “quizizz” on the interactive whiteboard

Figure 8. Participation of students in test tasks prepared by the program “Quizizz”

According to the results of the test, the progress of students was determined.
Success was calculated according to the following formula:

$Y = (K_5 + K_4 + K_3)$ x100 % / N;
Where: K_5 is the number of grades “5”;
K_4 is the number of grades “4”;
K_3 is the number of grades “3”;
N is the number of students.
The obtained performance values and test results are shown in Figures 7 and 8.

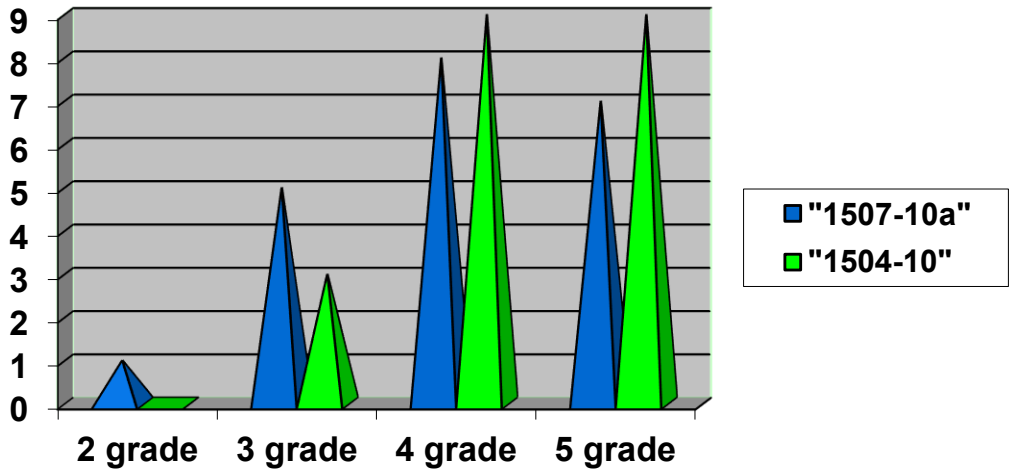

Figure 9 — Assessment of students’ knowledge

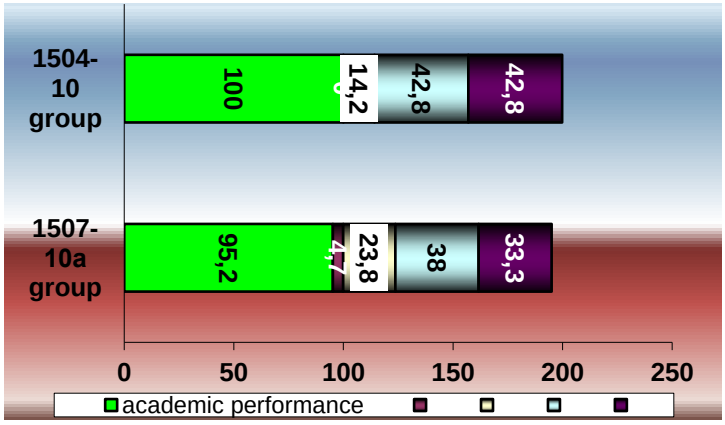

Figure 10 — Students of groups 1504-10 and 1507-10a
Percentage of knowledge

The results of the assessment (Fig. 9, 10) show an increase in the dynamics of the level of achievement. These data show the effectiveness of using a virtual laboratory in laboratory classes in the course of qualitative analysis of analytical chemistry. In addition, the use of virtual laboratory work in the teaching of chemistry provides the following opportunities:

1) expands the volume of material covering different sections of the studied chemistry;

2) reading information on the computer screen, including the reaction equations with the group reagent and individual reagents of the second group of cations Ag^{+}, Pb^{2+}, Hg_2^{2+}, the resulting precipitate and its solubility, and the color of the solution and precipitate. For example:

a) The reaction of the group reagent of the cation Ag^{+} with hydrochloric acid and the reaction equations for the dissolution of the resulting precipitate in ammonium hydroxide:

$AgNO_3 + HCl \rightarrow AgCl + HNO3$

$AgCl + 2NH_4OH \rightarrow [Ag(NH_3)_2]Cl + 2H_2O$.

b) The reaction equations for the interaction of the cation Ag + with the individual reagent potassium iodide and the dissolution of the resulting precipitate in sodium thiosulfate:

$AgNO_3 + KI \rightarrow AgI + K NO_3$

$AgI + 2Na_2S_2O_3 \rightarrow Na_3[Ag(S_2O_3)_2] + NaI$.

Students fully mastered the properties of cations of this group by making qualitative reactions to all ions and using the possibility of replication in a virtual laboratory.

3) Possibility to show some harmful chemical reactions that affect the health of students (for example, mercury salts);

4) students had the opportunity to self-correct (repeat);

5) due to the increased interest in the lesson, the qualification and level of education of the students increased.

Conclusion

In conclusion, it should be noted that the measures taken in the context of digitization of the education system are aimed at the use of new advanced technologies that accelerate and improve the organizational processes in education. It is necessary not only to actively implement these processes, but also to improve them as new technological and social changes occur in society.

The use of virtual work not only increases the visibility of learning and makes it easier to master, but also completely changes the process, which allows you to more deeply identify the important connections of the object under study, its laws, which helps to better master the material. Students can study the phenomena, change their parameters, compare, analyze and draw conclusions. Virtual experiments allow to demonstrate chemical experiments that can not be performed in the school chemistry laboratory for any reason (shortage of chemical reagents and drugs, expensive reagents, toxicity, danger of working with them, time constraints). It also saves on chemical reagents. Students are usually particularly interested in virtual labs in the form of computer simulations. Such activity opens up great cognitive opportunities for them; students can be seen not only as observers, but in some cases as active participants in experiments.

In addition, virtual laboratories, which are one of the digital technologies, can be rationally used in the distance learning system through Internet platforms.

So, the effectiveness of digital technology in the development of professional competence of future chemistry teachers is as follows:

- promotes the development of information culture and free work with the media;
- the level of skills and knowledge increased due to the increased interest of students by using the virtual laboratory;
- having the ability to quickly and qualitatively pass the test and self-assess in order to take into account the students' knowledge.

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Болашақ химия мұғалімдерінің кәсіби құзыреттілігін дамытуда цифрлық технологияны қолданудың маңызы

Мақалада пән бойынша виртуалды зертхананы дайындау және оны сабақ барысында қолдану сипатталған. Бұл зерттеудің мақсаты — цифрлық технологияларды пайдалана отырып, болашақ химия мұғалімдерінің кәсіби құзыреттілігін арттыру. Тиісінше, зерттеу пәні цифрлық технологиялардың оқу сапасын жақсартуға әсерін анықтау болып табылады. Зерттеу мәселесі бойынша психологиялық-педагогикалық және әдістемелік әдебиеттерге шолу жасалған. Оқу процесінің мониторингі, студенттердің жаңа материалды игеру сапасын талдау, тестілеу және диагностикалық жұмыс пайдаланылды. Жұмыс барысында педагогикалық эксперимент жағдайында виртуалды зертхананың студенттердің білім деңгейіне және сапасына әсері зерттелді. Студенттердің білім деңгейі оқу үлгерімін есептеу формуласымен анықталды.

Виртуалды зертхананы пайдаланған студенттер тобы білімнің жоғары деңгейін көрсетті. Бұл деректер цифрлық технологиялардың бірі болып табылатын виртуалды зертхананы пайдалана отырып, химия бойынша зертханалық сабақтарды өткізудің тиімділігін дәлелдейді. Болашақ химия мұғалімдерінің кәсіби құзыреттілігін дамытуда цифрлық технологияларды қолданудың тиімділігі көрсетілген:
- химиялық эксперименттер виртуалды зертхананың көмегімен жүргізілді;
- студенттер қайта қарау кезінде зертханалық жұмыстардың мәнін өз бетінше түзетуге және түсінуге мүмкіндік алды;
- анимация және түрлі-түсті суреттер арқылы дайындалған виртуалды зертхана студенттердің қызығушылығын арттырды.
- сабақ нәтижелерін талқылау кезінде "Quizz" бағдарламасы бойынша тест өткізілді. Тест тапсырмалары алдын ала дайындалды;
– виртуалды зертхананың маңыздылығын анықтау үшін сабақ екі топта өткізілді, виртуалды зертхана пайдаланылған топтағы сабақ нәтижелерін талдау кезінде білім деңгейі жоғары болды;
-студенттердің кәсіби құзыреттілігі (мотивация, дағдылар, білім) артқанын байқауға болады.

Кілт сөздер: цифрлық технология, кәсіби құзыреттілік, виртуальды зертхана, білім беруді ақпараттандыру, цифрландыру, Macromedia Flash Player бағдарламасы, екінші аналитикалық топ катиондары, сапалық реакция, қышқыл — негіздік классификация, аналитикалық химия, химиялық эксперимент.

А.С. Карманова, Г.М. Мадибекова, Н. Кавак

Значение применения цифровых технологий в развитии профессиональных компетенций будущих учителей химии

В статье описана подготовка виртуальной лаборатории по предмету и ее применение во время урока. Цель данного исследования — повышение профессиональной компетентности будущих учителей химии с использованием цифровых технологий. Соответственно, предметом исследования является определение влияния цифровых технологий на повышение качества обучения. Проведен обзор психолого-педагогической и методической литературы по проблеме исследования. Использованы мониторинг учебного процесса, анализ качества усвоения студентами нового материала, тестирование и диагностическая работа. В ходе работы было проведено исследование влияния виртуальной лаборатории на качество и повышение уровня знаний студентов в условиях педагогического эксперимента. Уровень знаний студентов определялся формулой расчета успеваемости. Высокий уровень знаний показала группа студентов, воспользовавшихся виртуальной лабораторией. Эти данные доказывают результативность проведения лабораторных занятий по химии с использованием виртуальной лаборатории, которая является одной из цифровых технологий. Показана эффективность использования цифровых технологий в развитии профессиональной компетентности будущих учителей химии:
– химические эксперименты проводились с помощью виртуальной лаборатории;
– студенты имели возможность самостоятельно корректировать и понять суть лабораторных работ при повторном просмотре;
– подготовленная с помощью анимации и цветных изображений виртуальная лаборатория повысила интерес у студентов.
– при обсуждении результатов урока был проведен тест по программе «Quizz». Тестовые задания были подготовлены заранее;
– для определения значимости виртуальной лаборатории занятие проводилось в двух группах, при анализе результатов урока в группе, где использовалась виртуальная лаборатория, уровень знаний был высоким;
– можно отметить, что профессиональная компетентность студентов (мотивация, навыки, знания) повысилась.

Ключевые слова: цифровая технология, профессиональная компетентность, виртуальная лаборатория, информатизация образования, цифровизация, программа *Macromedia Flash Player*, катионы второй аналитической группы, качественная реакция, кислотно-щелочная классификация, аналитическая химия, химический эксперимент.

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