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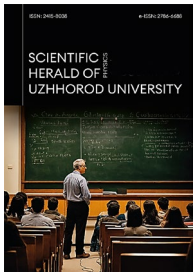

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Development of natural science literacy of students through the use of case technology in chemistry classes

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Abstract

Relevance. Dynamic changes in society affect all areas of life, including education. In Kazakhstan, educational policy reform is based on a competence-based and personal approach, which determines the relevance of using modern innovative educational tools, including for studying natural sciences.

Purpose. The purpose of the study was to examine the features of the formation of natural science literacy of students based on the use of case technologies in their study of chemistry.

Methodology. For this purpose, the methods of analysis, synthesis, comparison, generalisation, deduction, and abstraction were used.

Results. As a result, it is established that case technologies are characterised by high efficiency in the modern educational process. It is proved that their use positively impacts various types of students' skills, namely subject and personal. Thus, educational subjects acquire the necessary skills to use the acquired knowledge of chemistry in everyday life and solve global problems. As a result, it was established that case technologies contribute to the improvement of the student's

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personal qualities and their opportunities for self-development and reflection. The study has developed an algorithm that teachers can use when creating case assignments on their own.

Conclusions. The study also identified the value of natural science literacy of schoolchildren, both for their educational activities and for everyday life. Accordingly, based on the given examples of case tasks, the possibility of their use by teachers when presenting specific subjects in chemistry was demonstrated. It is advisable to use individual results in the process of developing educational and methodological recommendations for chemistry teachers in schools in Kazakhstan and in the process of improving their qualifications.

Keywords: life situations; competence approach; personal development; schoolchildren; innovative learning tools.

Introduction

One of the main goals of Kazakhstan's educational policy is to develop highly skilled and knowledgeable youth who can compete in the global market. In this process, it is the school as an educational institution that is responsible for the formation of a comprehensively developed personality. The educational system is undergoing reforms aimed at increasing functional and natural science literacy among students. This involves not only receiving knowledge from teachers, but also encouraging students to independently acquire necessary skills and educational materials [1; 2]. Based on this, the current educational environment is undergoing constant changes and reforms, for example, the transition to a competency-based approach and the formation of fundamental literacy among schoolchildren [3-5]. The latter, in turn, includes such subspecies as: mathematical, natural science, linguistic, which causes the need to select new teaching methods and tools. Thus, innovative technologies characterised by high functionality, efficiency, and versatility are becoming relevant [6; 7].

In this case, this question is also relevant for chemistry teachers, who face the need to prepare the students for the future solutions to problems in real life based on the knowledge gained during educational activities. To develop adolescents' creativity and responsibility, chemical literacy, motivation, and initiative, it is advisable to use case technologies [8-10]. They allow responding to the modern challenges of the educational environment, namely:

- increase the level of cognitive interest of schoolchildren in the study of chemistry;
- reveal the practical role of chemistry in everyday human activity;
- provide a creative approach to solving problems in chemistry and problems related to it.

This issue of the development of natural literacy of schoolchildren in chemistry is common in scientific pedagogical doctrine. The researchers pay special attention to the discussion about the feasibility of using case tasks in the educational environment. In particular, Yu. Gavronskaya and D. Yamschikova [11], based on didactic approaches, came to the conclusion that the use of innovative technologies in chemistry lessons is a prerequisite for the personal development of students. They established that this approach is aimed at improving the creativity of a teenager and in accordance with their self-development based on the knowledge gained while studying chemistry and solving everyday problems. O.S. Achkinadse and Y.V. Ivankov [12] concluded that memorising educational material is one of the least effective ways of learning since it does not involve the use of the acquired knowledge in the future activities of the student. Therefore, the researchers justified the advantages of using games and situational exercises for studying chemistry, accompanied by the interest of students. In turn, B. Kuanbayeva [13] states that the feature of case technology is the form of presentation of educational information, characterised by a common active research activity of all educational subjects.

J.W. Mukhamedyarova and N.S. Slivkina [14] provided a definition of the term "case technology". They concluded that this tool covers the process of solving a specific problem based on the analysis and comparison of tools for solving it according to different criteria that are close to real conditions. Z.M. Ozhibayeva and N.N. Nurmukhanbetova [15] state that the task of the modern educational process in Kazakhstan in the context of studying chemistry is to form a high level of natural literacy in students, which is possible through the use of didactic material, case studies aimed at the formation of soft and hard skills among students.

Based on the above, the purpose of the study was to express the influence of case studies on the formation of natural science literacy among students studying chemistry. Tasks were also formed in the study, namely: outline the essence of natural science literacy; establish the advantages of case technology; determine the features of case development; give examples of this type of tasks.

Materials and Methods

The method of analysis in the study was used in the examination of the essence of such components as "natural science literacy" and "case technologies". Based on this method, their properties, signs, and advantages and disadvantages were expressed in the study. Thus, the analysis assumed the expression of their role and place in the modern educational environment of Kazakhstan. In addition, this approach was necessary to establish their characteristics in the context of reforming educational policy and its transition to a competency-based approach. The analysis was applied to express the factors that influenced the reform of education and changes in the vectors of Kazakhstan's educational policy.

The synthesis method in the study influenced the expression of the relationship between case technologies as innovative teaching tools and the natural science literacy of students studying chemistry. Thus, this approach influenced the establishment of the effectiveness of the former in the development of the personal competence of young people. The synthesis was applied to describe the process of formation of a student as a person and the development of their abilities and competencies based on case technologies.

The comparison method in the study was used to compare the advantages of case technologies over other innovative educational tools. Accordingly, the method influenced the process of examining their features and the expression of their role in the process of future development of the educational environment in general. Thus, the comparison presupposed the establishment of the practical importance of natural science literacy in modern schoolchildren. In addition, this method involved comparing various examples of case studies in chemistry presented in the paper. The comparison was necessary to examine the vectors of the future development of case technologies, considering their distinctive features from other tools.

The method of deduction in the study was used to express the essence of natural science literacy of students in the context of their complex development in modern conditions. Thus, the application of this method was necessary to examine the components of the competence approach to the development of the educational environment in Kazakhstan. In addition, it provided for the investigation of the essence of educational case technologies based on general knowledge about the use of life situations and examples during training. This method was used to express specific areas of students' life activity, within which they can use general knowledge of chemistry.

The method of generalisation in the study was applied in the process of formulating the algorithm for the development of case assignments by the teacher. It provided for the use of information obtained during the study to increase the effectiveness of this process and the impact of such exercises on students' minds. Generalisation was necessary for the analysis of conditions favourable to the formation of natural science literacy in schoolchildren.

The abstraction method was used for a separate investigation of the influence of students' natural science literacy on their future academic and professional activities. This method determined the expression of the components of this component and its practical significance for the development of modern society in general. In addition, abstraction was also necessary to highlight the features of case technologies. It was used to reveal the specific impact of these exercises on the learning process, separated from other learning tools and approaches.

Results

The modern approach that determines the development and activity of the educational process in Kazakhstan is competency-based [12; 16]. It involves the transition from the school of knowledge to the school of competencies, which allows combining into a single system such components as knowledge, skill, and the value attitude of students. The change in approaches is reflected in the updating of pedagogical tools, namely the introduction of digital and interactive educational tools. This is necessary to implement different vectors of the educational process, particularly the development of chemistry. Modern educational programmes in Kazakhstan in chemistry provide students with four areas related to environmental safety and sustainable development, civic responsibility, health and safety, entrepreneurship and money literacy. As a result, the process of studying chemistry by students is transformed from a theoretical process into a practical one [11; 17; 18]. Accordingly, students acquire knowledge and a worldview that allows them to use the acquired skills in real life.

Based on the above, it is necessary to determine the essence of specifically natural science literacy, which should be understood as the ability of a person to express an active civic position regarding problems related to the natural sciences (chemistry) and to be interested in naturally valuable ideas for the development of society. Therewith, according to conventional educational approaches, the process of studying chemistry consists of memorising thematic educational information and, accordingly, does not always cover the development of mental and analysing activities. In this regard, changing the foundations from general to competence-based is of particular importance for chemistry. In this case, it provides for innovations related to changing the role of the student in the educational process, which begins to express an active position [19; 20].

Thus, the essence of natural science literacy in the context of studying the subject of chemistry by schoolchildren is to acquire skills for analysing and evaluating various life phenomena related to substances and skills for safely handling them [21-23]. In addition, an important component of this is monitoring the level of compliance with environmentally safe behaviour in society, public health, and the environment in general. Based on this, the task of a chemistry teacher is to provide students with knowledge about the competent handling of substances they encounter daily and can be used in future professional activities.

One of the relevant and effective teaching tools aimed at ensuring the development of natural science literacy of students during chemistry training is case technology. Their advantage is the ability of the teacher to solve the issue of organising educational activities in such a way as to ensure the improvement of both creative and mental and analysing skills of adolescents. It is necessary to create appropriate educational conditions and situations aimed at the formation and development of the student's personality, strengthening their motivation for learning, and improving subject competencies. All this is necessary for the realisation of the development of the personal properties of the educational subject since the independent cognition of the student presupposes the formation of positive emotions in them and reflections that affect their cognitive interest [24-26].

It is advisable to introduce innovative technologies into the educational process, namely the case technologies mentioned above to ensure the covered processes. The advantage of this approach is to provide students with opportunities to independently solve problems of a natural nature, for example, by solving real situations and cases based on the knowledge gained while studying chemistry. Therefore, the main task of this tool is to form and improve the analytical skills of schoolchildren, their ability to solve problems quickly, using both educational materials and additional resources. As a result, teenagers not only acquire a high level of subject knowledge but also develop their own soft skills of independently searching for resources to

solve a specific case during training and in the future in real life [27-29].

Based on the above, case technologies are aimed at the formation of subject competencies and natural science literacy, including students' cognitive interest in various ideas and proposals for solving global natural problems. This method of teaching is active because it involves giving students conditions in which they can independently find ways to solve practical problems developed based on various life situations in which it is necessary to have knowledge of chemistry. Comparing this teaching method with others, it has substantial differences from repetition and providing answers to the questions posed by the teacher. That is, it opposes approaches that are not aimed at the formation of the student's competence qualities. Notably, a characteristic feature of cases is that such tasks usually have several solutions that differ in approaches to their justification. This is the advantage of such a tool for conventional educational exercises, which allows analysing and independently modelling the response by students.

Comparing case technologies and other innovative technologies used while studying chemistry, it is possible to identify other reasons that prove the effectiveness of the introduction of the former. In particular, this approach determines the development and improvement of knowledge, skills, and competencies of schoolchildren aimed at the implementation of active thinking, the elaboration of information, and the ability to analyse and generalise it. In addition, case tasks provide for the formation of a volume of special knowledge among schoolchildren, which systematically combines soft and hard skills and can be applied in non-standard or everyday life circumstances. An increase in the positive attitude of adolescents to educational activities, in particular, an increase in the role of their cognitive activity and conscious reflection on the examined material. In addition, in solving cases, the student is not only obliged to choose the correct answer but also to clearly justify their choice, which increases the practical value of the acquired skills.

Analysing the described advantages of case technologies, notably, their main role is to provide students with opportunities to apply new knowledge on a daily basis both in the course of educational activities and outside of it. However, to obtain the above advantages, it is necessary to create appropriate conditions, including the availability of developed high-quality cases and a fixed methodology for their implementation. In this regard, special attention needs to be paid to the direct process of forming tasks and case exercises for studying chemistry at school, which it is advisable to present based on three stages (Figure 1).

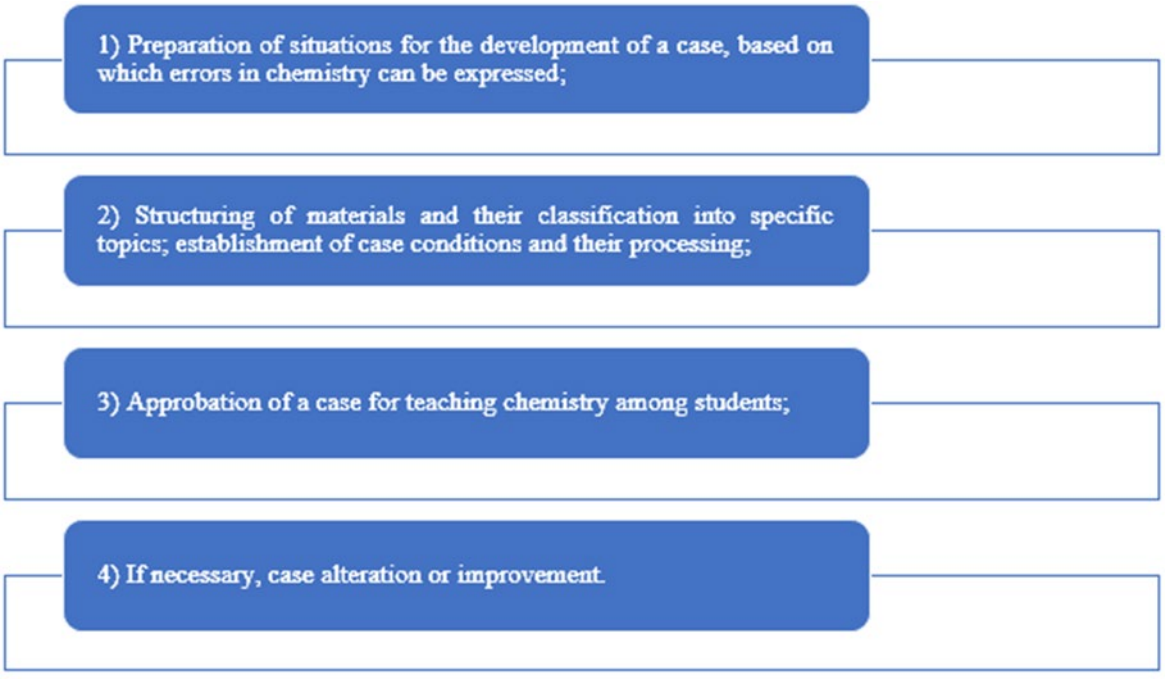

Figure 1. Stages of case task preparation
Source: compiled by the authors.

As a result of the development of cases, they can be differentiated by different characteristics, for example:

- by the source and form of educational materials;
- by volume;
- by subject;
- by degree of complexity;
- by context.

Notably, the solution of such tasks is aimed at developing students' chemical competence and, accordingly, chemical literacy. Accordingly, their role is expressed in the study and use by adolescents of different categories, for example: chemical elements and substances, pure substances, mixtures, and methods of their purification. The essence of case technologies is revealed not only in assessing the level of knowledge of schoolchildren during the process of studying chemistry but also in the development of their broader abilities, which go beyond the educational process and consist of setting and solving problems related to human life and its impact on the environment. Students should justify their ideas and proposals not only with theoretical knowledge but also with calculations, for example, the mass fraction. Based on the above, it is advisable to form examples of case

problems that can be used in schools in Kazakhstan when students study chemistry.

First of all, it is advisable to give an example of a case that can be used in the first chemistry lessons, in particular, on the subject "pure substances and mixtures". Task condition: The result of human activity is a huge amount of household waste of various types. Their composition may include substances such as gold, aluminium, tin. This indicates that the garbage in its composition is a specific mixture of different types of elements. The process of waste recycling is popular all over the world, and it is characterised by labour intensity and high cost to clean the environment. There is no common approach to recycling garbage to get valuable components from it. In this case, it is advisable to explore different ways of separating garbage items. The essence of the task for schoolchildren is to provide them with mixtures of table salt, sawdust, iron powder, and these substances in pure form and suggest identifying simple methods for separating this mixture. In addition, students must determine the mass fraction of each substance in this mixture. Students should also be asked to determine whether their approaches will change if the wood sawdust in the mixture is replaced with copper shavings.

The following example of a case problem should be used in the process of studying the subject "physical and chemical phenomena". The essence of the task: determine the processes implemented during the operation of the samovar, namely, to distinguish them based on belonging to physical and chemical phenomena (from the process of filling the samovar with water, igniting it to brew the mixture and dissolve additional substances in it, in particular, sugar and milk). In addition, students should identify changes in the angle and copper lid of the samovar. Thus, when performing this case, teenagers will be able not only to give a theoretical definition of physical and chemical phenomena but also to compare them with each other in the example of a real-life situation.

The case "food through the eyes of a chemist" concerns such an element of natural science literacy of students as health and safety. Description of the condition: chemical compounds are encountered daily in all types of activities. Food is no exception because it consists of compounds such as carbohydrates, fibre, proteins, lipids, vitamins, and minerals. Most of them are safe for the human body and organic. However, some of them can be used by food manufacturers for their own commercial purposes, for example, to enhance flavour or extend shelf life. In this regard, food additives appear in the compositions of almost all food products and can pose a threat to human health. The essence of the task: schoolchildren should investigate the content of organic substances in food and, using the example of their favourite sweet bar, describe the danger of food additives contained in it.

Based on the above examples of case tasks and their impact on the educational activities of schoolchildren, it can be established that they positively affect the level of cognitive activity of educational subjects. By increasing the student's interest, their motivational abilities are realised: independent examination of the material and obtaining knowledge. Thus, in the course of solving cases, the students conduct an analysis, during which they separate important information from secondary while using creative abilities and critical thinking. As a result, their self-realisation occurs, which affects not only their educational activities but also the process of personality formation. This indicates that the competence approach involves the transition of a student from a passive position to an active involvement in the educational process, which indicates their personal interest in using the acquired knowledge of chemistry in everyday life. In addition, the above examples of case technology differ in different ways, allowing students to develop cognitive interest and critical thinking, creative approaches and initiative to solve problems, which forms their natural literacy.

Discussion

There are discussions among researchers in the pedagogical doctrine about the effectiveness and advantages of some educational tools over others. In particular, case technologies are also the object of many studies that allow revealing the features of their implementation from different sides. For example, S.R. Shavkatovna [30] is a supporter of the above approach, as she considers it to meet the modern requirements of the educational environment. In particular, the researcher states that case technologies aim to solve problems presented in life situations. In her opinion, this has a substantial impact on the level of cognitive activity of the student and, accordingly, their academic record. In addition, it is noted that this approach goes beyond the scope of educational activities since it plays an important role in forming the student's personality and daily activities. The author emphasises that the main vector of case technologies is the improvement of students' ability to quickly and efficiently find ways to solve problems through working with information. It is important that the researcher highlighted that the main purpose of using case technologies is not to acquire new subject knowledge in chemistry by schoolchildren but to improve it based on establishing the relationship between existing skills and existing problems. As a result, the student acquires the ability to implement the knowledge acquired during the educational process, including in non-standard and critical conditions. Common in the described conclusions and results of this study is the approach to determining the essence of case technologies and their impact on the consciousness of adolescents. This is expressed in the fact that in both papers, the involvement of an educational tool involves the implementation of both research and search, problematic and creative approaches.

In turn, A. Parpala et al. [31] investigated the features of the transition of the modern educational environment to a personality-oriented (competence-based) approach, also mentioned in this study. Thus, they described the essence of innovative pedagogical activity, which directly affects the preparation of schoolchildren. The researchers pointed to the reformation of the function of mechanical learning in the mental development of educational subjects. This approach was also mentioned in the framework of this study, in particular, it was noted that it consists in fixing educational information in the minds of students through associations and a systematic method of acquiring skills. In addition, the researchers noted changes in students' motivational ideas for learning activities, which are characterised by a more responsible and conscious attitude

towards it. They also investigated the specific features of changing the educational system in connection with the challenges of the 20th century. The necessity of developing students' subject competencies in chemistry and their personal abilities to use them in real life were highlighted. The researchers paid special attention to the importance of developing students' abilities to obtain information based on mental activity and self-improvement independently. Thus, they revealed the idea, which was also described in this study and discussed the reform of the educational system from classical (subject-object) to developmental and personal. The general results of this paper and the conclusions in the study are the position that it is the active forms of educational activity that contribute to the development of the student as a conscious person in the form of their creative potential and critical thinking.

C. Granberg et al. [32] examined skills, the development and improvement of which are influenced by the case method. They established that the involvement of this innovative tool in the educational process involves the formation of students' abilities, such as:

- analysis of the situation and phenomena;
- evaluation of different options for their solution;
- establishing the most effective and rational ways to solve the problem;
- planning and management for the implementation of their project ideas.

The researchers also established that the use of case assignments in the educational process should be systematic, not one-time. This approach is explained by the fact that it is repeatability that allows teenagers to consolidate opportunities to solve practical problems. The researchers note an increase in the interest of schoolchildren in the subject, which was also mentioned in this study. The common rationale is that case tasks are aimed at strengthening teenagers' skills, such as social activity, sociability, and the ability to justify and prove their opinions. As a result, the researchers came to a conclusion similar to the one obtained in this study, namely that innovative learning tools contribute to the formation of students' awareness that they can use the knowledge acquired during training in real life. Based on this, the researchers outlined the goals that allow the implementation of case technologies, namely:

- improving the intelligence of students;

improving their communication skills;

- formation of possibilities for finding the optimal way to resolve the situation.

The common thing in the case of the results of this study is that this type of task determines the student's independent work and allows for self-reflection.

E. Tremblay-Wragg et al. [33] investigated the tasks of the teacher in the implementation of case technologies. The task is assigned to the teacher to select the material and to adapt it to a specific educational subject. This is a prerequisite for students to be able to successfully complete the task, and receive a criterion assessment. This stage was also mentioned in the scheme developed in this study on the formation of case tasks. The researchers also noted that students should be notified beforehand about the rules for working with cases, for example, that there may be several correct answers. They paid special attention to the role of the teacher in the modern educational process, which, according to the authors, consists in coordination. They indicate the priority of regulating the conversation and the discussion in the necessary vector in accordance with the subject of the training session. Similarly to this study, they highlight that the case should include facts, situations, and real events. According to the researchers, it is important that the problem underlying the case problem can be both complex and separate. They also recommend not to state the events in full so that the task is short and understandable for schoolchildren. Therewith, the researchers note the need to create a complete picture of the situation, which provides, if necessary, the addition of separate facts and clarifications to the case. This was also noted in the framework of this study and highlighted as an optional stage in developing case assignments. The general conclusion of this study and the described one is that the educational subject, when solving this type of exercise, not only works on the material but can independently predict various options for the development of the case while arguing their position.

D. Pruthi et al. [34] and F.A. Abdunabievich et al. [35] conducted the classification of case tasks according to various criteria. For example, D. Pruthi et al. [34] focused on situations with illustrations and educational situations. The purpose of the first cases is to prepare the student to solve problems and tasks based on a certain algorithm. This approach involves the development of schemes and visualisation of the correct solution in a particular situation. The second kind, according to the researchers, suggests examining the problem of a well-defined period of time with a description of the situation. It is necessary to highlight the problem in the task and search for effective ways to solve it by comparing different solutions. This type of case was also considered in the framework of this study, in particular, when modelling examples of tasks aimed at the systemic activity of schoolchildren for their successful implementation. F.A. Abdunabievich et al. [35] drew attention to information cases concerning the problems expressed in the task using figures and statistical data. Their essence lies in the fact that schoolchildren independently find a problem and, accordingly, select resources to solve it. In addition, they identified such a type of case tasks as applied tasks, which, in their opinion, allow imagining a specific life situation through different ways out of it. Thus, the results of the study coincide with the positions of these authors since the first one also proved the possibility of classifying case tasks. The approaches to expressing their differences, reflected in the examples above in the study, are joint.

Thus, case technologies in pedagogical doctrine appear as an effective tool in the conditions of the present. This is due to its high practical value and positive complex influence on the consciousness of schoolchildren as a future state. As a result, this allows determining the close relationship between the implementation of case tasks and the natural science literacy of students.

Conclusions

As a result of the conducted study, it was possible to form methodological foundations for the use of the case method during the teaching of chemistry to schoolchildren in Kazakhstan and the development of their natural science

literacy. Thus, the study highlighted the conditions for the effective implementation of the above process, namely, it was established that it is closely related to the self-development and formation of the student's personality. Attention was also paid to the specific features of the educational process of chemistry and the formation of natural science literacy of adolescents based on the development of their creative, mental, and analytical skills. Accordingly, the actual advantages inherent in case technologies in the study of chemistry and the application of skills in this subject by teenagers in real life were revealed. This was due to the fact that modern society, including Kazakhstan, is characterised by dynamic changes, which in turn affects the competence and social mobility of educational subjects and their ability to make effective decisions independently.

Special attention in the study was paid to the development of case tasks by chemistry teachers. Accordingly, a scheme has been formed reflecting the algorithm for creating this type of exercise and its improvement. It is established in the study that the teacher must first determine the educational goals based on which to choose a problem situation from real life. They should also finalise them for the design of the case and presentation to students when studying a specific academic subject. If there are shortcomings or obstacles in the process of testing a case assignment, the teacher should edit and improve it. Compliance with the above principles will affect the practical value and effectiveness of the use of the case method in the development of natural science literacy of students studying chemistry. In addition to positive changes in the level of theoretical knowledge of schoolchildren in chemistry, they will be able to improve their own skills by using them in the process of solving modern local and global problems. This indicates the influence on the personality of the student, their public position, and awareness of changes in the environment. Thus, in future research, it is advisable to consider ways to increase students' natural science literacy through artificial intelligence.

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Conflict of Interest

None.

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Розвиток природничо-наукової грамотності учнів шляхом використання кейс-технології на уроках хімії

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Анотація

Актуальність. Динамічні зміни в суспільстві впливають на всі сфери життя, в тому числі і на освіту. У Казахстані реформування освітньої політики базується на компетентнісному та особистісному підході, що визначає актуальність використання сучасних інноваційних освітніх інструментів, у тому числі для вивчення природничих дисциплін.

Мета. Метою дослідження було вивчення особливостей формування природничо-наукової грамотності учнів на основі використання кейс-технологій при вивченні ними хімії.

Методологія. Для цього використано методи аналізу, синтезу, порівняння, узагальнення, дедукції та абстрагування.

Результати. У результаті встановлено, що кейс-технології характеризуються високою ефективністю в сучасному освітньому процесі. Доведено, що їх використання позитивно впливає на різні види компетентностей студентів, а саме: предметні та особистісні. Так, суб'єкти навчання набувають необхідних умінь використовувати набуті знання з хімії у повсякденному житті та вирішувати глобальні проблеми. У результаті було встановлено, що кейс-технології сприяють покращенню особистісних якостей студента та його можливостей до саморозвитку і рефлексії. У ході дослідження було розроблено алгоритм, який викладачі можуть використовувати при самостійному створенні кейс-завдань.

Висновки. Дослідження також виявило цінність природничо-наукової грамотності школярів як для їхньої навчальної діяльності, так і для повсякденного життя. Відповідно, на основі наведених прикладів кейс-завдань було продемонстровано можливість їх використання вчителями при викладенні окремих тем з хімії. Окремі результати доцільно використовувати в процесі розробки навчально-методичних рекомендацій для вчителів хімії шкіл Казахстану і в процесі підвищення їх кваліфікації.

Ключові слова: життєві ситуації; компетентнісний підхід; розвиток особистості; школярі; інноваційні засоби навчання.