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EXPLORING COMPETENCY-BASED CHEMISTRY TEACHING: TRENDS, CHALLENGES AND PERSPECTIVES

Abstract: The aim of the study is to substantiate the features of active implementation of competence-based chemistry teaching in secondary education institutions of the Republic of Kazakhstan. The methodological approach of the study is based on the following research methods: analysis, synthesis, induction, modelling, comparison, and generalisation. The content of the concept of "competence approach" is defined; its signs and features are revealed, the necessity of introducing the competence approach in the process of teaching chemistry is theoretically proved and the prospects of using the specified approach to improve the study of chemistry among secondary school students of the Republic of Kazakhstan are determined. In the course of theoretical research, the key competences in the process of chemistry teaching, which should be formed in secondary school students of the Republic of Kazakhstan, have been identified. The study identified the contradictions concerning the development of the competence approach in the study of chemistry and outlined ways to solve them. Perspective directions of improvement of competence-based chemistry teaching are defined, and specific recommendations on measures of effective implementation of such an approach in secondary education institutions of the Republic of Kazakhstan are given.

Keywords: secondary education, informatisation of society, individual-differentiated tasks, group laboratory works, innovative technologies

Introduction

Kazakhstan is modernising and aligning its secondary education system with European standards. Competency-based secondary school education is a major revolution. The competency-based approach in Kazakhstan's secondary education makes chemistry more practical, relevant to the job market, and personal growth. The approach emphasises teaching students not only knowledge and skills but also competences - the capacity to tackle real situations. Chemistry teaching has its quirks and obstacles. Understanding and systematically analysing them are crucial to improving education. The main issues are low motivation and interest in chemistry, low schoolchildren's chemistry competencies and practical skills for conducting chemical experiments and solving professionally-oriented

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laboratory problems, imperfect teaching methods, and low use of theoretical knowledge in laboratory practicals. The introduction of the competence method in Kazakhstan's secondary education is urgent and being investigated.

The aspect of competence-based approach to teaching chemistry was investigated by Alimova [1], Sevil and Fatma [2]. At the same time, the authors concluded that the competence approach consists in the following: development of understanding of the world, formation of scientific thinking, preparation for future careers, increasing environmental awareness. As a result of such training, the personality of a future specialist with such qualities is formed: aspiration for self-improvement, readiness for innovative activity, and ability to quickly adapt to changes. At the same time, Maratkyzy et al. [3] believe that chemistry has a leading place in the set of future specialists who should be educated starting from the basic school on the basis of the use of specialised elective courses in the formation of communicative competences, since its role is to prepare specialists who have to solve important issues, among which is the solution of professionally oriented tasks in chemistry. Sadykov et al. [4] substantiated in their works the necessity of this approach and described its main components, which include: the development of new educational standards focused on the formation of competencies in students, updating the content of educational programmes taking into account the requirements of the competency-based approach, the use of innovative teaching methods that promote the development of competencies, professional development and retraining of teaching staff in the field of competency-based approach, the creation of modern materials for the development of competency-based education, and the development of new educational programmes.

Castello et al. [5] noted in scientific papers that at the moment the secondary education of the Republic of Kazakhstan has access to digital technologies, methods, and tools to perform laboratory and practical works on chemistry for secondary school students in the conditions of distance learning. The study of Wesselink et al. [6] of models and principles of curriculum development, teaching, learning, and assessment based on competences confirm the need to teach chemistry using the competency-based approach. Given the analysis of the research level of the outlined problems, it is concluded that the current stage of improvement of the competence-based approach in chemistry teaching is characterised by the active implementation of measures to form a qualitative updated modern educational space in accordance with European principles, norms and standards. At the same time, these studies do not pay enough attention to the methodology of implementation of competence-based chemistry teaching in secondary schools.

Taking into account the above-mentioned, the issue of improving the quality of competence-based chemistry teaching in secondary education institutions is insufficiently researched. That is why there is a need for quality preparation of distance learning course programmes; development and use of necessary software; development of personal information technology infrastructure. Consequently, the aim of the study is to identify effective measures for the implementation of competency-based chemistry education in secondary education institutions of the Republic of Kazakhstan. The objectives of the study are:

1. To study the methodology of teaching chemistry in secondary schools of the Republic of Kazakhstan and compare it with foreign approaches of teaching.
2. To identify the competences necessary for effective implementation of competence-based approach in the process of studying chemistry in secondary education institutions of the Republic of Kazakhstan.

3. To define methodological tools aimed at the use of competence-based approach during the study of chemistry by secondary school students in the Republic of Kazakhstan.

Methodology

In the process of conducting the research aimed at competence-based study of chemistry with the help of analysis, the study of scientific works aimed at improving the teaching of chemistry in secondary schools of the Republic of Kazakhstan was carried out. Synthesis was used to combine different views of scientists on the process of studying chemistry in secondary schools and to build on their basis a unified methodology of studying the outlined subject. The method of induction was used to establish a connection between methods and technologies of studying chemistry and highlighting their role in using the competence approach of studying the outlined subject. Modelling took place in the formation of a methodological system of teaching chemistry to secondary school students on the basis of the competence-based approach. The comparison was used in the study of approaches to the construction of the educational process in secondary schools during the study of chemistry in the Republic of Kazakhstan and foreign countries. The comparison was used during the study of researchers' opinions concerning competence-based chemistry teaching both in Kazakhstan and abroad, as well as identifying problems in this process and finding ways to solve them.

In the course of the study, based on the Concept of Development of Preschool, Secondary, Technical and Vocational Education of the Republic of Kazakhstan for 2023-2029, the principles of improving the secondary education system were identified. The Organisation for Economic Co-operation and Development (OECD) Programme for the International Assessment of Adult Competencies (PIAAC) [7] has been analysed. The defined programme is aimed at helping governments to assess, monitor and analyse the levels of availability of professional skills formed among citizens, to carry out their distribution among the adult population, as well as to assess the degree of use of these skills in different situations. Based on the implementation of this programme, groups of competencies that are recommended to be developed in secondary school students, namely literacy, reading and problem-solving in a highly technical environment, have been identified. The following inclusion and exclusion criteria were used during the study. The literature search for the study was carried out using the keywords: secondary education, informatisation of society, individual-differentiated tasks, group laboratory work, innovative technologies, and sources from the same field of study but for different directions were excluded. The criterion of credibility was that the author must have publications in peer-reviewed journals, the information that the author presents must be credible with references to certain sources. Works written by authors without a scientific degree were not considered in the study. The criterion of objectivity envisaged the use of information from scientific articles and dissertations regarding the use of competence-based approach in teaching chemistry, which was carried out in practice and confirmed by research results.

The criterion of completeness was used to search for information that does not contain contradictions and also corresponds to other reliable sources of information. The relevance criterion was used to select publications with dates no older than 5-10 years. Sources older than five years and which are not publicly available on the Internet were excluded.

The criterion of accessibility in the work was to use sources with an available electronic version of the full text of the publication.

Results and discussion

Rationale for the theoretical foundations of competence-based chemistry education in secondary schools

Kazakhstan's secondary education emphasises 21st-century life skills. Competency-based chemistry education drives its modernisation. Instead of general knowledge, it emphasises qualitative education. Competency-based education goes beyond the traditional emphasis on knowledge, skills, and talents. It emphasises the learner's capacity to apply knowledge. Sadykov et al. [4] explored the use of contextual tasks in chemistry as a basis for the competency approach in education and found that it is closely related to the person-centred and activity-based approaches. The competence-based approach emphasises life skills, personal activity, and action in combination with person-centred and activity-based approaches. This strategy is helping modernise school education by giving every student a quality education needed for 21st-century success.

According to Resolution of the Government of Kazakhstan No. 249 of 28 March 2023, a concept has been established to improve educational outcomes [8]. Equal rights (all people have the right to quality education, regardless of origin or social status); accessibility (education at all levels should be accessible to all, taking into account individual characteristics); and prioritisation of values (human life, health, and free development of the individual are the most important values) constitute the new Concept of Education. The Concept will reorganise the education system to provide quality education, modern infrastructure, teacher status, future preparation, Kazakhstani education competitiveness, and education quality. The Concept's expected results until 2030: equal access to quality education for children from 2 to 6 years old, 1.5 times the gap between urban and rural areas, a shortage of educational places, conditions for each student's creative, intellectual, and physical development, and 80 % of graduates with technical and vocational education to meet labour market needs [8].

Maratkyzy et al. [3] studied cognitive challenges in chemistry. The researchers recommend selecting educational content for the competence-based approach based on the following didactic principles: reliance on students' subjective experience; practice-oriented situations; intellectual and emotional-value components of education; and closed and open-ended tasks. Teaching based on the competency method emphasises pupil constancy, individual, group, and collective cognitive activity, opportunity for students to generate their own educational product, and reflection. The competence-based approach makes learning dynamic, interactive, and personally orientated, preparing students for a successful existence in society where they will need knowledge and abilities like independence, creativity, and communication [9].

Comprehensive and systematic approaches are needed to resolve these conflicts and improve secondary school competency-based chemistry instruction. These include updating secondary school student training programs (review and modernisation of curricula and programs, taking into account current labour market needs, new competencies, and chemical industry standards), implementation of innovative methods and technologies (active use of modern teaching methods, simulation technologies, online courses, and other innovative approaches to implementing a competency-based approach in the process of

teaching chemistry), enhancing the qualifications of chemistry teachers (organising ongoing professional development for teaching staff, training, seminars, and qualification improvement courses to master innovative methods and technologies for studying chemistry), increasing funding (allocating additional resources for the modernisation of the material and technical base of educational institutions, updating teaching equipment, and implementing innovative technologies and programs).

Gortz et al. [10], investigating secondary school chemistry instruction, found that this subject develops theoretical (laws, theories, ideas, concepts) and empirical knowledge. Chemistry class teaches chemistry and develops students' personalities [11]. It is determined that chemistry solves cognitive and practical problems, has a lot of scientific information, and has a clear logic of creation and knowledge structure. The school chemistry course is tailored to kids' ages and cognitive capacities, provides restricted information, and follows didactic principles. Chemical knowledge and achievements are constantly expanding. Chemical science is a well-established system of fundamental knowledge with a definite logic of formation, therefore modern positions are used to explain its outcomes [12, 13]. Secondary school chemistry is taught step-by-step in a logical order. The presentation of the outlined approach is considered to be correct, as the research has revealed that the content of the school chemistry course is built on other principled principles and reflects in general terms the logic and system of scientific chemical knowledge [8].

Chen et al. [14] recommend using chemical labs in distance teaching. The procedure and results of chemistry lab work help teach future specialists. They receive special attention in distance education. The quality of laboratory experiments affects the development of special skills (applying knowledge in practical situations, analysing and summarising information, formulating research conclusions) and chemical equipment skills. Secondary school students must learn the system of chemical and polytechnic knowledge, leading ideas and theories, the essence of the laws of chemistry, basic chemical concepts, the most important scientific facts, chemical language, and the formation and development of special and general academic skills. The school chemistry course develops students' independence, observation, cognitive interest, and chemical skills. Chemistry education aims to instil a scientific, labour, artistic, and environmental attitude in students [15-17].

Educational trends in Kazakhstan require forming a set of professional competences in secondary school students in a short period of time, to ensure highly effective work of both teachers and students. The use of modern equipment and software will allow: organising full-fledged communication between teachers and students, demonstrating a variety of visual material, increasing students' motivation to learn new knowledge, and teaching them how to work with modern software and services. This, in its turn, will be the key to the successful implementation of the competence approach in the process of studying chemistry.

Features of improvement of competence-based chemistry teaching in secondary schools

Modern social and educational changes need to revisit Kazakhstan's secondary education goals. The traditional secondary school chemistry curriculum does not address the current issues of implementing a competency-based approach. Competences - complexes of knowledge, skills, and abilities - are needed for success and self-realisation

[18, 19]. Sadykov et al. [4] found that secondary school students must learn certain skills while teaching chemistry using contextual assignments. These skills include knowledge mastery, decision-making, constructive action for problem-solving, self-learning, and communication. PIAAC was created by the OECD to help governments assess, monitor, and analyse citizens' occupational skills, distribute them across adults, and evaluate their application in diverse scenarios. According to this program, secondary school pupils should learn literacy, reading, and problem-solving in a technical setting [7].

According to the above studies, the "competence-based approach" is an innovative way to modernise school education, meet societal needs, and prepare graduates for success and self-realisation. School emphasises individual requirements and interests. It prepares students for informed choice, independent decision-making, and social involvement. Under changing situations, a new school education model is needed. This strategy should integrate Kazakhstan's best traditions with global education. Its goal is to raise a well-educated, active, multinational competitor. A new secondary education model in Kazakhstan should strengthen value education, form key competences, change the structure and content of education, use active teaching methods, introduce new assessment principles, and transform the relationship between educational participants. All these factors determine education quality. The country's educational policy prioritises Nazarbayev Intellectual Schools. They want to help kids reach their greatest potential. Senior classes in intellectual schools prepare students for top national and international universities. The Cambridge Council for International Education Assessment developed the educational program of the Autonomous Educational Organisation "Nazarbayev Intellectual Schools" with its strategic partner to implement natural science education [20].

Research revealed didactic conditions for selecting competence-based education content. These conditions include resistance to students' subjective experience (taking into account their knowledge, skills, experience, and personal qualities when creating educational content); introduction of practice-oriented situations (to better understand and apply knowledge); connection of intellectual and emotional-value components of education; and introduction of lea Competency-based chemistry instruction helps secondary school students see the connections between subjects and use knowledge from different disciplines to solve problems, develop functional reading literacy, understand context and draw conclusions from indirect data, and critically analyse information presented in different formats. The competency-based approach teaches pupils how to use information in real life, making them capable and competitive. For the most thorough chemistry program analysis and lesson planning, use this method. Clarification of each learning element with emphasis on its necessity in learning chemistry [21-23].

As the era of information and communication technology is evolving, new approaches to learning chemistry are opening up [24-26]. Since mostly all students have gadgets with access to the global Internet on their desktops, which can be used when viewing any chemical phenomena that cannot be observed in the laboratory during classes. Furthermore, with the help of mobile phones, it is possible to find the necessary information as in the laboratory it is not always possible to carry out some chemical reactions to illustrate a certain process, carry out a particular chemical transformation, review its results, and consequences [27]. The study supports the opinion that the implementation of competency-based learning in chemistry in secondary education institutions of the Republic of Kazakhstan is recommended to be carried out by using interactive learning methods (discussions, projects, research, role-playing games, cases); orientation to practical tasks

(design, research, modelling, problem-solving); formation of assessment (assessment of not only knowledge, but also the ability to use them in practice, critical thinking, communication, teamwork).

Competencies should be formed to implement the competence method in basic school. Social competence: creating problem circumstances with chemical experiments, offering experimental tasks of varying difficulty, organising experimental group activities of students, and using life situations connected to substance attributes and applications. Multicultural competence: the student uses poems, proverbs, and excerpts from works to depict chemical phenomena; historical facts about chemical experimentation; and chemical experimentation to emphasise the relevance of chemistry for civilisation. Communicative competence: develops monological and conversation speech by discussing chemical experiment results and using academic language and chemical nomenclature. Information competence: encourages students to use information technology and virtual chemical laboratories to gather factual data for chemical experiments, and to evaluate data using algorithms, plans, and schemes. Self-education and self-development competence: chemical experiment teaches autonomous work, research experimental skills, and sustainable motivation to study and self-educate. Competence in creative, productive work: allows students to independently add tasks, tests, and questions to the topic and create creative, experimental work and projects [10]. Use competence-oriented tasks to encourage active, creative activity in the classroom, self-organisation, a unique perspective, and the ability to apply knowledge, skills, and abilities in certain situations when implementing the competence approach in chemistry teaching.

Table 1

Evaluation criteria for competence-oriented tasks in chemistry

Levels of learning achievement	**Criteria for assessing learning achievements**
Elementary	Pupil recognises some chemical objects and names them at everyday level; describes some chemical objects according to certain attributes.
Medium	The student performs some chemical experiments independently; describes individual observations of the flow of chemical experiments.
Sufficient	The pupil compares and classifies chemical objects; identifies understanding of underlying chemical theories and facts, giving examples to support this; describes observation of chemical experiments.
High	The pupil applies knowledge in standard situations, is able to analyse, summarise and systematise the provided information, draw conclusions; uses knowledge in non-standard situations, establishes connections between phenomena; independently finds and uses information according to the task at hand; analyses additional information; uses knowledge reasonably, including in problem situations; independently evaluates phenomena related to substances and their transformations.

The most important method in chemistry is the problem-development experiment, which aims to create a problem situation, for example, investigating the possibility of copper interacting with iron(III) chloride solution. According to the majority of pupils, the reaction will not take place. Such opinions are based on the data from the table “Activity series of metals”. This is followed by an observation and explanation: adding copper filings to a solution of iron(III) chloride causes the colour of the salt solution to change to blue. Pupils observe the reaction and explain it in terms of redox processes, taking into account the strong oxidising properties of iron(III) ions. They conclude that a low-active metal is

oxidised in a solution of a salt containing ions with high oxidising power. This experiment extends pupils' knowledge of the chemical properties of metals. Table 1 suggests the following criteria for evaluating competence-oriented tasks.

The process of using individually differentiated tasks allows analysing the level of preparation and individual characteristics of pupils. It is recommended to use tasks of different levels of complexity, which promote the development of communicative skills and imply a creative approach to the task. The study proposes tasks of three levels of complexity: high, medium and low. For example, for students who excel in chemistry at the high level, it is suggested that they investigate the effect of the concentration of ferric(III) chloride solution on the rate of reaction and make a presentation on the chemical properties of copper. Medium-level tasks aim to write a report on an experiment and to create a table with the results of the investigation. Low-level tasks involve the use of ready-made instructions for conducting an experiment and questions on the topic of research. Advantages of using individually differentiated tasks: increasing motivation to learning, pupils' performance of tasks directly proportional to their level of preparation, feeling of success and confidence in their abilities, development of independence and responsibility, the ability to independently choose tasks and ways of their fulfilment, responsibility for the results of their work, formation of group work skills.

The advantages of group learning activities include increased motivation for learning, development of communication skills, formation of critical thinking, development of self-organisation skills. Thus, group learning activities are an effective method of learning, allowing students not only to acquire knowledge and skills, but also to develop their personal qualities. It is important to note that the organisation of group learning activities should begin with defining goals and objectives, selecting appropriate methods and techniques of work, creating conditions for cooperation and mutual assistance in the group, monitoring the progress of work and providing assistance in case of difficulties [28, 29]. Group laboratory works must include setting and realising the goal (definition of the general group task, understanding by each participant of the goal and his/her role in its achievement); performance of individual tasks (each group member performs tasks that meet common goals, the tasks can be different in complexity and volume); and mutual checking and assistance. Only an integrated strategy can teach students social skills. Group lab work can develop social competence as part of the process of the competence approach to teaching secondary school chemistry [30].

The laboratory and practical elements of the program instruct students in the use of chemical apparatus and the execution of experiments. This will improve chemical process understanding and application. New educational technologies and methodologies. These tools and strategies will motivate students to learn chemistry and make learning more engaging and successful [31, 32]. Online video demonstrations, computer models, virtual experiments, and chemistry laboratories should be employed in Kazakhstan secondary schools to teach chemistry. Learning should incorporate theoretical material, lab tasks, and virtual resources. Students can learn and develop chemistry abilities better with virtual laboratories, theory, and practice.

Conclusion

The study concluded that the qualitative organisation of the process of competence-based chemistry education in secondary education institutions of Kazakhstan

should be based on a system of methodological tools aimed at the qualitative implementation of this process. The application of competence-based approach in the process of teaching chemistry in secondary education institutions of the Republic of Kazakhstan requires teachers thorough training, which will allow them to adapt to pedagogical innovations, to consider trends, challenges, and prospects in the field of the identified issue. The study confirms that knowledge of theoretical and practical foundations of chemistry learning will contribute to the development of its competence-based learning in secondary education institutions of the Republic of Kazakhstan.

The results of the study suggest that, based on PIAAC, it is proposed to expand the range of professional skills required for citizens to successfully carry out their professional activities. Based on the implementation of this programme, the groups of competencies that are recommended for formation, namely: literacy, reading and problem-solving skills in a highly technical environment, are identified. In the process of the research, the concept of "competence approach" was defined. Theoretical analysis of scientific literature allowed systematising the idea of the application of competence-based chemistry teaching and identifying the main ways of solving the studied issue. The presented methodological system of ensuring the competence approach in the process of chemistry teaching is defined as a professional necessity in the training of secondary school students. Perspective directions of improvement of the process of realisation of the competence approach in chemistry teaching are formed. It is determined that such a trend requires the creation of the necessary methodological system that contributes to the improvement of secondary school students' training level.

The introduction of digital resources for the organisation of educational activities, in particular, in the conditions of distance education, deepening the study of the structure and features of the implementation of competence-based approach on the basis of PIAAC is a promising direction for improving the competence-based teaching of chemistry in secondary education institutions of the Republic of Kazakhstan. The obtained research is aimed at the development of a wider range of methodological tools for the implementation of a competence-based approach in the process of teaching chemistry to secondary school students. The obtained primary results require expansion and deepening of the developed problem, so the development of a wider set of scientific and methodological support will ensure the formation of systemic knowledge of future activities, as well as the development of the ability and skills to use them in practice.

References

[1] Alimova FA. On the role and significance of information and communication competence of future chemistry teachers. Web Sci Int Sci Res J. 2023;4(04):1158-62. DOI: 10.17605/OSF.IO/WHK75.

[2] Sevil A, Fatma AT. STEM images revealing STEM conceptions of preservice chemistry and mathematics teachers. Int J Educ Mathem Sci Technol. 2016;4(1):56-71. DOI:10.18404/ijemst.44833.

[3] Maratkyzy N, Unerbaeva Z, Kulumbetova O, Kaumbaev S. Theoretical foundations of cognitivetasks in teaching chemistry. Bull Abai Kazakh Nat Ped Uni Ser Natur Geogr Sci. 2023;78(4):55-67. DOI: 10.51889/3005-6217.2023.78.4.006.

[4] Sadykov TM, Kokibasova GT, Ospanova AS. The development of interactive chemistry lessons on the topic: "Mineral fertilizers". Bull Toraighyrov Uni Ped Ser. 2023;1:53-68. DOI: 10.48081/LAMR4051.

[5] Castelló E, Santiviago C, Ferreira J, Coniglio R, Budelli E, Larnaudie V, et al. Towards competency-based education in the chemical engineering undergraduate program in Uruguay: Three examples of integrating essential skills. Educ Chem Eng. 2023;44:54-62. DOI: 10.1016/j.ece.2023.05.004.

[6] Wesselink R, Biemans H, Gulikers J, Mulder M. Models and principles for designing competence-based curricula, teaching, learning and assessment. In: Competence-Based Vocational and Professional Education:

Bridging the Worlds of Work and Education. Cham; Springer: 2017, pp. 533-53. DOI: 10.1007/978-3-319-41713-4_25.
[7] OECD Programme for the International Assessment of Adult Competencies. 2024. Available from: https://www.oecd.org/skills/piaac/.
[8] The concept of development of pre-school, secondary and vocational education for 2023-2029 was approved in Kazakhstan. 2023. Available from: https://bilimdinews.kz/?p=232686.
[9] Kurylo V, Karaman O, Bader S, Pochinkova M, Stepanenko V. Critical thinking as an information security factor in the modern world. Soc Leg Stud. 2023;6(3):67-74. DOI: 10.32518/sals3.2023.67.
[10] Gortz JS, Taty SR, Fecury AA, Dendasck CV, Oliveira E, Dias CAGM. High school chemistry technician and ENEM: A comparison of curriculums. Revista Científica Multidisciplinar Núcleo do Conhecimento, 2021;3(3):89-99. DOI: 10.32749/nucleodoconhecimento.com.br/education/curricular-comparison.
[11] Zarrabi M, Mohammadi M. Reflective teaching as an agent of reform in teacher education: Inhibitors, motivators, and tools. Int J Educ Ref. 2024;33(4):503-21. DOI: 10.1177/10567879241255312.
[12] Lyubchik SB, Galushko LYa, Rego AM, Tamarkina YuV, Galushko OL, Fonseca IM. Intercalation as an approach to the activated carbon preparation from Ukrainian anthracites. J Phys Chem Sol. 2004;65(2-3):127-32. DOI: 10.1016/j.jpcs.2003.10.006.
[13] Makarova TL, Zakharchuk I, Geydt P, Lahderanta E, Komlev AA, Zyrianova AA, et al. Assessing carbon nanotube arrangement in polystyrene matrix by magnetic susceptibility measurements. Carbon. 2016;96:1077-83. DOI: 10.1016/j.carbon.2015.10.065.
[14] Chen X, Wang L, Shao X, Wei R. An analysis of Chinese chemistry curriculum standards based on OECD Education 2030 Curriculum Content Mapping. Discip Interdscip Sci Educ Res. 2024;6:2. DOI: 10.1186/s43031-023-00091-4.
[15] Yeraliyeva ZhM, Kunelbayev M, Ospanbayev ZhO, Kurmanbayeva MS, Kolev TP, Kenesbayev SM, et al. The study of agricultural techniques of cultivation of new varieties of winter wheat under drip irrigation. Asian J Microbio Biotech Envir Sci. 2016;18(3):779-85. Available from: https://www.researchgate.net/publication/316886361_The_study_of_agricultural_techniques_of_cultivation_of_new_varieties_of_winter_wheat_under_drip_irrigation.
[16] Rexhepi BR, Rexhepi FG, Sadiku MK, Dauti B. Ecosystem services of forests and their economic valuation: Prospects for sustainable development. Ukr J For Wood Sci. 2024;15(1):109-25. DOI: 10.31548/forest/1.2024.109.
[17] Lyubchyk A, Filonovich SA, Mateus T, Mendes MJ, Vicente A, Leitão JP, et al. Nanocrystalline thin film silicon solar cells: A deeper look into p/i interface formation. Thin Solid Films. 2015;591:25-31. DOI: 10.1016/j.tsf.2015.08.016.
[18] National development strategy of the Kyrgyz Republic for 2018-2040. 2024. Available from: https://mfa.gov.kg/en/osnovnoe-menyu/vneshnyaya-politika/gosudarstvennye-programmy/nacionalnaya-strategiya-razvitiya-kyrgyzskoy-respubliki-na-2018-2040-gody.
[19] The strategy for development of the Republic of Kazakhstan. 2024. Available from: https://www.akorda.kz/en/official_documents/strategies_and_programs.
[20] Autonomous educational Organization "Nazarbayev Intellectual Schools". 2024. Available from: https://www.nis.edu.kz/en/o-nas.
[21] Correa ML, Dias CAGM, Fecury AA, Oliveira E, Dendasck CV, Fernandes EF. Strategies for teaching chemistry at secondary professional and technological levels. Revista Científica Multidisciplinar Núcleo do Conhecimento. 2021;7(3):113-23. DOI: 10.32749/nucleodoconhecimento.com.br/education/medium-professional.
[22] Galarce-Miranda C, Gormaz-Lobos D, Hortsch H. An analysis of students' perceptions of the educational use of ICTs and educational technologies during the online learning. Int J Eng Ped. 2022;12(2):62-74. DOI: 10.3991/ijep.v12i2.29949.
[23] Law N, Chow A, Yuen AHK. Methodological approaches to comparing pedagogical innovations using technology. Educ Inf Technol. 2005;10:7-20. DOI: 10.1007/s10639-005-6744-7.
[24] Dudar V, Nosachenko V, Vasenko O, Pochtarov S, Yakuba V. Legislative regulation of online and remote learning in higher education institutions. Soc Leg Stud. 2024;7(2):222-3. DOI: 10.32518/sals2.2024.222.
[25] Gangmei N, Thomas KA. Teachers' technology proficiency for quality learning and teaching - a scoping review. Int J Educ Ref. 2025. DOI: 10.1177/10567879251316213.
[26] Voloshina A, Panchenko A, Titova O, Milaeva I, Pastushenko A. Prediction of Changes in the Output Characteristics of the Planetary Hydraulic Motor. In: Lecture Notes in Mechanical Engineering. Cham: Springer; 2021. pp. 744-54. DOI: 10.1007/978-3-030-68014-5_72.
[27] Akmeşe ÖF, Kör H, Erbay H. Use of machine learning techniques for the forecast of student achievement in higher education. Inf Technol Learn Tools. 2021;82(2):297-311. DOI: 10.33407/itlt.v82i2.4178.

[28] Azizi M, Rassaei E, Bagheri MS. Mobile medical training in language classrooms: Student satisfaction, predicting learning usefulness and classroom achievement. Inf Technol Learn Tools. 2020;79(5):139-53. DOI: 10.33407/itlt.v79i5.3520.
[29] Copriady J. Teachers competency in the teaching and learning of chemistry practical. Mediterr J Soc Sci. 2014;5(8):312. DOI: 10.5901/mjss.2014.v5n8p312.
[30] Oroszi T. Competency-based education. Creat Ed. 2020;11(11):2467-76. DOI: 10.4236/ce.2020.1111181.
[31] Barrick RK. Competence-based education in the United States. In: Competence-based Vocational and Professional Education. Technical and Vocational Education and Training: Issues, Concerns and Prospects. Cham: Springer; 2017. pp. 255-72. DOI: 10.1007/978-3-319-41713-4_12.
[32] Picardo K. Competence learning brought to life: how Finnish teachers actualize a new curriculum. ASSERT, 2024;1(5):33-40. DOI: 10.29173/assert70.