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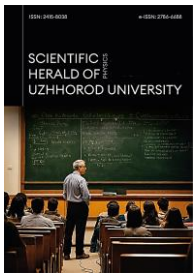

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Experimental competence formation in chemistry teacher training

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Abstract

Relevance. The research relevance is determined by the need to adapt the educational system to the rapidly changing requirements of the labour market and technological progress.

Purpose. The study aims to evaluate the effectiveness of analytical chemistry training programmes in leading universities of Kazakhstan from the point of view of developing the scientific competence of students necessary for employment.

Methodology. The study employs comparative, qualitative, and statistical analyses, questionnaires, surveys and observation.

Results. The study examines the role of universities in training analytical specialists. The requirements of the labour market and academic institutions for candidates for positions in analytical chemistry, as well as the current state of research and development in training, were considered. The findings showed that many university graduates trained in analytical chemistry prefer not to go to work in industry or factory laboratories, but plan to stay in academia and continue their research. This indicates the need to revise curricula to better meet the requirements of the labour market and academic institutions. Problems and gaps in current programmes and methods of teaching analytical chemistry at universities in Kazakhstan have been identified. Approaches to strengthening the practical component of courses have been critically analysed, considering the current requirements and assessments of industry specialists.

Conclusions. The study highlighted the high demand for qualified specialists, emphasizing that the issue lies not in the shortage of vacancies but in the level of training. The practical significance of the study lies in the fact that its results can

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be used to modernise the system of education in the field of analytical chemistry and improve curricula and teaching methods. This, in turn, will help to improve the quality of training of analytical chemists who will be able to meet the needs of the labour market and scientific institutions.

Keywords: active learning; analysis methodology; students; specialist qualifications; researchers.

Introduction

With the development of science and technology, the role of analytical chemistry in sectors ranging from medical diagnostics to food production and pharmaceuticals is steadily increasing. This is particularly important as demands on the skills of specialists, their ability to quickly adapt to new analytical methods, changes in industrial processes and market needs increase. The training of analytical chemists is a complex and multiphase task, requiring a carefully planned training programme that must be encapsulated in several important components. Specialists should be equipped not only with knowledge of current theoretical concepts but also with the ability to apply modern methods of chemical analysis in practice. Research study helps future specialists to better understand the content and structure of chemical science. Teachers with research competencies can approach the teaching of complex topics and concepts in theory and practice in a better and more informed way. They can use a variety of research and experimental data to improve learning. Teachers trained in research methods can better prepare their students to participate in innovative processes by developing their creativity and ability to solve complex problems.

Allowing future teachers to engage in research improves the quality of their training and makes them more professional and competitive in the labour market. This type of research allows for the development of better teaching methods and suggests more effective approaches to training. Intervention in this topic will help to prepare graduates who can easily transition from educational institutions to real study. It is necessary to create an educational environment that promotes not only the acquisition of knowledge, but also the formation of such key skills as critical thinking, the ability to analyse and interpret data, and teamwork skills. A plethora of studies call for addressing this issue, but many are either limited to a particular subject area or do not sufficiently cover all aspects of the problem. The study by G. Abyzbekova et al. [1] aims to develop specific competencies in organic chemistry that are relevant to educational programmes. It showed improvement in planning and performance of students' independent study based on the developed teaching methods. However, the study is limited only to the subject area of organic chemistry and does not consider other disciplines in chemical education, which requires further research.

A. Amirova et al. [2] highlight the role of the teacher in education and suggest five methods for developing the creative and research skills of future teachers. They include creating a comfortable environment, integrating research into the learning process, providing teaching practice, using problem-based learning, and organising independent research work of students. It is suggested to compare educational systems in different countries to improve teacher training. The study by P. Nechypurenko and S. Semerikov [3] focuses on the development of research competencies in high school students through the application of information and communication technologies in chemical education, as well as on the analysis of trends in the educational system and the creation of a system for the formation of research skills. The authors analysed scientific literature, and normative and legislative documents, identified trends in the development of the educational system and developed a system of research competencies. However, as they indicated in the study, all aspects of the problem under consideration have not been fully exhausted.

E.E. Kopishev and A.T. Syzdykov [4] consider the possibility of using virtual chemistry laboratories in the learning process of chemistry for undergraduate students in Kazakhstan. Various aspects of the use of virtual laboratories were discussed, including the development of analytical thinking and basic laboratory skills. The importance of using virtual laboratories as a pre-assignment before a real laboratory study is emphasised. Comparisons are made between real and virtual labs and their effectiveness. A.K. Sailaubay et al. [5] discussed the significance of research study and skills for teaching chemistry. Highlighting the role of theoretical research and experimentation in chemistry teaching, the study emphasises the significance of research competence for modern chemistry education. The authors note the importance of choosing the right strategies and methods for building research skills, including planning, problem setting, analysing, and designing the results of the study. The main focus of the article is the role of laboratory classes and chemical experiments in the development of students' research competence.

However, until now, there have not been enough studies exhaustively describing the use of different approaches to teaching analytical chemistry at universities in Kazakhstan. The study aims to evaluate the methods and approaches to teaching analytical chemistry at universities in Kazakhstan for the training of highly qualified specialists and researchers. The obtained data will allow us to formulate recommendations on the optimization of curricula to improve the level of scientific competence of students and readiness for the challenges of the labour market.

Materials and Methods

To assess the quality of students' training in the "Analytical Chemistry" discipline, a comprehensive approach was conducted, including an analysis of training programmes, a survey of students and teachers, an observation of the learning process, as well an analysis of employers' requirements to the qualifications of graduates. A mixed research design was used, including qualitative and quantitative methods to study the process of formation of research competencies in future teachers of chemistry.

The main sources of data on which the experimental part of the study was based were studies and scientific articles on methods of teaching analytical chemistry in

different countries, the curricula taken for analysis included analytical chemistry courses offered by these universities. The main curricula were the educational program "Chemistry" at the Al-Farabi Kazakh National University, Korkyt Ata Kyzylorda University and Abai Kazakh National Pedagogical University. Questionnaires and interview responses from lecturers and chemistry students. The study analysed several coursework and graduation studies of students of chemistry departments of these universities, over the last three years. The studies were randomly selected from the university library database and analysed to assess the depth and quality of research competencies possessed by the graduates.

The sample consists of 100 teachers and 300 students studying in the chemistry departments of three leading universities in Kazakhstan: Al-Farabi Kazakh National University, Korkyt Ata Kyzylorda University and Abai Kazakh National Pedagogical University. Respondents were involved in a qualitative survey to assess their satisfaction with the academic programmes and level of training in research activities. The results of the questionnaire and survey were anonymised to ensure the reliability of the information collected. As part of the labour market survey, interviews were conducted with 20 analytical chemists from the industry to assess employers' actual needs and projections for chemical professionals. These specialists provided important insights into the required competencies, skills, and qualifications in the labour market.

Data were collected through online surveys sent to students and teachers at the selected universities. Information on curricula and programmes was collected from the official websites of the universities. In the questionnaire for teachers, questions were aimed at finding out the specifics of teaching research activities, their approach to integrating research activities into the teaching process, their use of resources and materials for teaching, and possible obstacles and suggestions for improving the quality of teaching.

The student questionnaire, in turn, was designed to obtain information on how effectively students had learnt research skills during their studies, whether it was compulsory for them to participate in the research study, what obstacles they had encountered, and what changes in the learning process they considered necessary. The questionnaire used in the labour market survey included a series of questions aimed at gathering information on professional requirements in the field of analytical chemistry. It covered topics related to study experience, evaluation of training programmes, current trends in the industry and desired improvements in training. The questionnaire was used to interview analytical chemists working in companies to extract valuable data for analysing market needs.

To implement the assessment of the quality of training of future analytical chemists, the methodological part of the study included the analysis of recommendations for the improvement of educational programmes. In this context, the website CHIMACTIV was investigated, which is considered a tool to activate the educational process and strengthen the practical skills of students.

Results

In Kazakhstan, academic education in analytical chemistry occupies an important place, and universities are striving to constantly improve teaching methods to produce qualified specialists. At Al-Farabi Kazakh National University as well as Korkyt Ata Kyzylorda University, research, and development of modern methods of teaching analytical chemistry is carried out. This includes the application of spectroscopic, atomic absorption, and electrochemical methods of analysis. A key issue for the scientific community of Kazakhstan has become the application of modern visualisation learning models in the process of teaching chemistry. A study conducted as part of the educational process at Abai Kazakh National Pedagogical University initiated the active implementation of multimedia and Internet-based educational technologies in the process of teaching chemistry [6]. Thus, the implementation of multimedia and Internet-based educational technologies is a scientifically justified choice of teaching methods that contribute to the maximum development of the individual in the context of the surrounding reality.

In the course of the study, the teaching process at universities was observed. While each of these institutions was found to have its unique methodology, the emphasis was always on research-based study. The features applied at each university were highlighted, including the use of interactive learning, problem-based learning, and project-based learning for students. Observation of the teaching process has shown that programmes at universities in Kazakhstan are adapted to meet modern requirements for theoretical knowledge and practical skills. In addition to including traditional areas of study in chemistry, such as organic, inorganic, and analytical chemistry, they also include a wide range of specialised courses in line with the latest scientific and technological developments in chemistry. In any chemistry programme, after the core courses, students enter into more advanced areas of chemistry, often related to advanced scientific and technological developments. These specialised courses may include physical chemistry, biochemistry, medicinal chemistry, polymer chemistry, environmental chemistry, nanochemistry and others. Chemistry programmes at universities in Kazakhstan also include a significant research component. Students have the opportunity to conduct their research under the guidance of experienced faculty members, practising scientific thinking, analytical reasoning, and the use of scientific equipment.

The observation showed that at each university the chemistry course includes a significant amount of scientific research. However, the distribution of time between theoretical and practical components differs. The main share of teaching time in chemistry courses is allocated to research work and independent projects of students, as well as to practical study in the laboratory. However, the proportion of time allocated to research and independent projects varies considerably from university to university. Practical study in the laboratory is a very important part of analytical chemistry education as students learn practical skills. It is also the best way to teach students experimental methods as well as metrology concepts as they can collect and analyse data on their own,

which makes them more aware of errors and inaccuracies associated with experiments [7].

In general, all universities tend to favour a balance between practice and theory. Analysis of students' term papers and final studies revealed that many students successfully demonstrate a high level of scientific analysis and reasoning, as well as the ability to apply complex chemical concepts and theories to solve problems. Nevertheless, the depth of research in most of them leaves much to be desired, which reduces the possibility of applying the acquired knowledge in the educational process. Only 40% of the studies have sufficient depth of research to apply the knowledge gained in practice in the learning process, which may indicate problems with the application of the knowledge gained in practice in the learning process.

A total of 300 people were interviewed, including 200 students and 100 teachers from three different universities in Kazakhstan. Chemistry teachers at universities in Kazakhstan actively use different approaches and resources to teach their students (Figure 1).

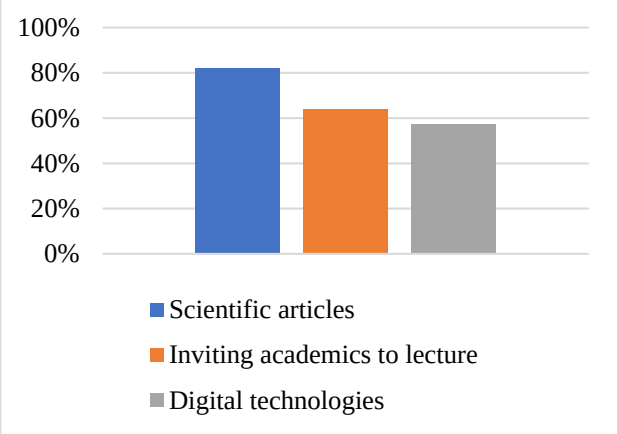

Figure 1. Survey results on teaching methods

Source: compiled by the authors.

One strategy is to incorporate current research materials into the educational process. These information sources help students to keep abreast of the latest innovations and advances in chemistry. They also help deepen students' understanding of complex concepts and theories by presenting different perspectives and stimulating critical thinking. At the same time, many instructors' resorts to collaborating with experts in the field to share their expertise. This non-traditional approach to teaching, allows students to see how theory is applied in practice and helps improve their understanding of the scientific research process. Guest speakers can introduce new ideas, increase student motivation, and even provide opportunities for collaboration and research. Another strategy that faculty members actively employ is the use of modern technology in the educational process. The use of these technologies increases student engagement, makes learning more interactive, and results in more effective information transfer. This may include the use of interactive platforms for discussions, experiments, and group tasks, as well as the use of online resources and specialised programmes to teach certain skills.

A survey of students was also conducted to assess their attitudes towards the importance of research and development as part of their study programme. The majority of students viewed the emphasis on research and development positively, confirming its importance in their studies (Figure 2). However, some students expressed some concerns that the time allocated to research study may not be sufficient. This indicates that, despite the value of the research study, some of the students felt that the initial preparation for it or the scope of the study may be insufficient or sub-optimal.

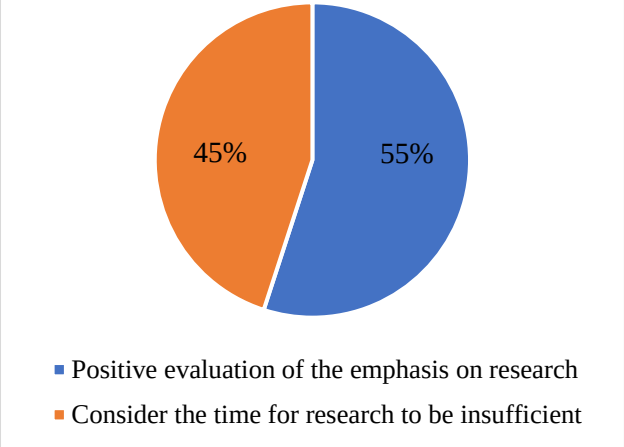

Figure 2. Results of a survey of students' attitudes towards research studies as part of their training programme

Source: compiled by the authors.

While 67% of lecturers positively evaluated the active inclusion of students in scientific research as significantly improving their understanding of the subject. Teachers see that research studies improve students' understanding of the material and regularly contribute to the development of their critical thinking, analysis, and synthesis skills, as well as independence and responsibility. These skills are essential in research and for further academic study. This indicates that students internalise the necessary knowledge from academic courses and actively apply it during research studies. This may include different types of projects ranging from laboratory research to major research projects.

The majority of students (70%) appreciated the level of analytical chemistry teaching at their university. However, only 60% of students felt that their university training would be sufficient to start a study in analytical chemistry, and 40% expressed doubts about their abilities. If university training is too focused on theoretical material and does not provide enough time and resources for practical work, students may not feel confident and competent in the face of real-world study. 29% of students pointed to the lack of timely and adequate feedback as the main reason for their doubts. The problem of inadequate disclosure of course content was cited by 5% of students. If course materials are not clear or connected to reality, students may not understand how to apply them in practice. Almost 34% of students stated that they do not fully understand the requirements of the labour market.

Based on the survey, a large proportion of students were found to expect to start a career in academia after graduation (Figure 3). For many of them, the idea of continuing academic activities after their studies seems to be particularly attractive: either in a research career with the possibility of more in-depth research or in the field of higher education. This choice is usually driven by several factors. Some students may be interested in pursuing research at a deeper level. Others may feel that an academic career promises more opportunities for professional development. At the same time, some may simply prefer scholarly research to teaching. However, not all students see themselves in academia: some plan to work in industry. While a small percentage are still undecided about their career path. This may be due to insufficient application of practical training in training programmes or to students' lack of confidence in their professional abilities.

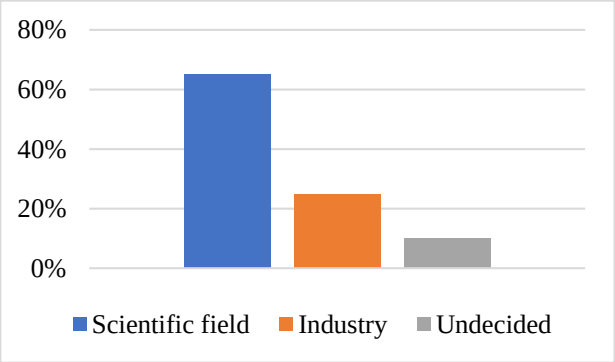

Figure 3. Results of the survey of students about their future career

Source: compiled by the authors.

Almost all teachers (88%) support the principle of "learning through research". According to this approach, students conduct their research and gain knowledge through practical study. However, almost all teachers (92%) believe that modernisation of the analytical chemistry course is necessary. They believe that there is a need to expand the curriculum following the modern requirements of the labour market. As a result of the questionnaire survey of specialists, it was found that employers note a consistently high demand for qualified specialists in the field of analytical chemistry. However, at the same time, 67% of respondents pointed out the problem of compliance of graduates' qualifications with the market requirements, which underlines the importance of updating and adapting training programmes. They believe that there is a lack of educational institutions that include in their training courses the necessary mastery of specialised technologies and processes relevant to modern industry.

This confirms that the problem is not a lack of jobs, but rather the level of specialist training. Many employers are looking for candidates with specific skills and experience studying specific technologies and processes that are not currently a mandatory part of the curriculum. In addition, 68% of employers surveyed emphasised the importance of soft skills such as teamwork, communication, and problem-solving abilities. They consider these skills to be critical for a successful professional career. At the same time, the importance of integrating both traditional scientific methodologies and innovative approaches, including statistical analysis and Big Data interpretation, is emphasised to train competent analysts able to work with a wide range of analytical tools and techniques.

Experts have noted that graduates rarely have sufficient experience in the statistical processing of experimental data and the development of analytical methods in real laboratory practice [8]. The current labour market requires knowledge and competence in key areas such as the study of high-performance chromatographic systems, spectroscopic methods of analysis, and mass spectrometry. Skills in the study of bioanalytical and molecular biological technologies, as well as structural analysis techniques, are critical. Experts noted that graduates rarely have sufficient experience in the statistical processing of experimental data and the development of analytical methods in a real laboratory practice setting. The market is constantly changing, and new roles and vacancies are emerging that require students to be flexible and able to learn on the go. With new specialisations and vacancies emerging, 73% of respondents highlighted that students must demonstrate flexibility and the ability to adapt quickly to new environments and challenges. The results of the questionnaire indicate that the lack of integration of specialised technologies and processes into the curriculum highlights the need for reform.

Reducing the lack of practical experience for students challenges universities to rethink their curricula and course structure. By placing more emphasis on practical learning, universities can provide students with more opportunities to practice skills that will help them later on in the real workplace. Better feedback is also critical to student learning. Teachers need to provide it regularly and thoroughly so that students can know how they are doing and what skills they should still be developing. Another improvement relates to instructional materials. To help students better understand how theoretical knowledge can be applied in practice, universities may need to create clearer and more visual learning modules. This could also mean incorporating real-world context into examples and casual notes, or even inviting industry representatives to give guest lectures or seminars.

For example, there is research and practice of a learning approach such as the use of online resources. In particular, this can be illustrated by the example of the CHIMACTIV website, the central theme of which is analytical chemistry [9]. Based on the results of the study, it can be argued that the CHIMACTIV website has the potential for use in educational institutions in Kazakhstan. This online resource focusing on analytical chemistry can provide both teachers and students with the right teaching materials and practical exercises that promote an in-depth understanding of important concepts and skills related to analytical chemistry. Teachers, depending on their educational goals and their students' programmes of study, can, using these resources reinforce their prior knowledge, build new scientific understanding, or analyse data. These resources can be used before, during, or after class and lab sessions. They are ideal for students who wish to learn material independently, for interns in research laboratories, and professionals working in the field of chemical analysis.

Universities may also consider the use of active learning methodologies. In active learning, classroom

lectures are significantly reduced and replaced by small group activities that encourage student engagement with the material being learned [10]. Students are given more opportunities to make decisions during the design process and laboratory experiments, which typically involve small teams completing multi-week projects.

Lastly, to help students navigate the demands of the labour market, universities can organise career guidance events. At these events, students can meet industry professionals, learn about different career paths and get an idea of what skills and knowledge they may require in their future studies. Overall, the findings of the study highlight the need to mainstream the learning process and incorporate modern approaches and innovative technologies. This will help to further improve the level of training of specialists in the field of analytical chemistry. As for the employer survey, it confirmed the results of the vacancy analysis, showing that employers often have difficulties in hiring graduates due to existing gaps in their knowledge and skills.

Discussion

The discussion centres on the results of a study of teaching methods in universities, with a focus on research study and its impact on students' careers in analytical chemistry. Analysing the data, it is possible to argue that research study is central to student learning, but some problems in the organisation of this process have been identified.

The Swedish experience shows that universities follow a strategy of actively integrating research into the teaching process. A study conducted by J. Bergquist et al. [11] shows that analytical chemistry in Sweden is experiencing changes both in the academic environment and at the industrial level, where it is often perceived as instrumental support for other branches of science. The survey reveals that analytical chemists in Sweden fulfil a variety of tasks ranging from basic research and university teaching to method development and quality assurance in industry. Training in analytical chemistry at Swedish universities covers a wide range of analytical methods that are actively used in both industry and university research. The teaching style and content of chemistry courses at universities are closely related to the actual study of analytical chemists, which has a positive impact on student training. However, many universities are reducing the number of courses in analytical chemistry, which may lead to problems in the future given the importance of the discipline. Industrial analytical chemists responded that method development, routine analysis and project management are their main work tasks, while academics focus more on teaching, basic research and applying for research grants. For university employees, teaching typically occupied 11-30% of total working time.

However, there is a problem with a lack of qualified candidates to study as an analytical chemist. The percentage specifically for Sweden is not stated, but the general result of the survey shows that 70-77% of respondents in universities and industry face this problem. This can be interpreted as an indication that the training of analytical chemists needs to be improved so that they meet the requirements of employers. Research in analytical chemistry in Sweden has been carried out, emphasising development methods, routine analysis, and project management in industry. The importance of the structure of educational programmes including skills such as good manufacturing practice (GMP), validation, instrument technology and method development is emphasised. The findings of this study emphasise the need for further discussion and strategic decision-making regarding analytical chemistry in both academic and industrial contexts [12].

W.R. Furlong et al. [13] presents a quantitative analysis laboratory experiment they designed for first-year general chemistry students. Both studies focus on the learning and teaching of analytical chemistry. They both emphasise the importance of practical skills and experimental study in learning and emphasise reinforcing theoretical knowledge practically. However, the research approach and breadth of enquiry are different. The experiment aims to determine the formula of an ionic compound by determining the molar ratios of its constituent ions. The authors tested the experiment for three years on 31 second-year students in three areas of quantitative analysis chemistry. The final version of the experiment was performed by students in a first-year general chemistry class of 50 students. Analytical chemistry students experimented individually. The general chemistry students worked in pairs. It was found that the general chemistry students became more confident in performing calculations of limiting reagents as this laboratory experiment reinforced the chemical principles they had learnt in class during the same week. In the case of analytical chemistry students who had not performed this experiment during the previous year, the calculations served to reinforce previously learned concepts.

The study by S. Avsec et al. [14] discusses the introduction of systems thinking into chemistry education, particularly in the context of catalysis education. This approach offers significant opportunities to transform how more advanced chemistry courses are taught and, according to the authors, could lead to a paradigm shift in catalysis education. They analyse in detail the implications of adopting a systems approach to catalysis teaching and offer several examples for its implementation. Overall, both studies call for improvements in the teaching of chemistry, although the focus and exact approach of each study differ. The broader perspective presented in this study, combined with the specific, practical approach of the article, can provide valuable insights into transforming the way chemistry is taught.

The study by A. Juniar et al. [15] aimed to find out whether there were significant differences in the results of applying the guided enquiry learning model and the traditional learning model in practical classes in analytical chemistry, in particular in conducting titrations by redox reactions, argentometry and complexometry. There was a statistically significant improvement in the skills of students in the experimental group, which emphasises the benefits of innovative approaches in teaching. The scientific process skills of trainee teachers are better in the experimental class (group investigation (GI) model teaching) compared to the control class (traditional model teaching). These results contribute to chemistry education, especially by improving the quality of future chemistry teachers and reducing the number of students who often have difficulties in learning analytical chemistry.

D.N. Pakpahan et al. [16] evaluated a new approach to teaching analytical organic chemistry based on an innovative project method. This method aims to develop students' skills in analysing organic compounds. The authors developed and implemented educational resources that enabled students to independently plan and implement projects for the determination of flavonoids in real samples. The study results showed a significant improvement in students' learning outcomes, which confirms the effectiveness of the proposed approach in teaching analytical organic chemistry. The present study in turn goes beyond the case study and takes a broader picture of chemistry teaching in a modern educational context. These studies would complement each other when discussing modern chemistry teaching practices.

The study by J. Hernández-Ramos et al. [17] focuses on how chemistry learning can be enhanced by deepening the understanding and application of knowledge of chemical kinetics. In their approach, they propose an integrated curriculum that incorporates the use of spreadsheets and a problem-based approach to model scientific data and solve real-world environmental problems. This approach helps students to apply theoretical knowledge in practice and develops skills that they can use in scientific study.

B.E. Bicak et al. [18] conducted a study at the Department of Science Teaching Methods in Germany in which the organic chemistry laboratory study course was revised to include problem-solving experiments and video lessons aimed at developing scientific reasoning skills in future chemistry teachers. They developed a self-assessment questionnaire and adapted experimental problem-solving tasks for assessment in undergraduate students. The study found that the new approach was more effective in developing some scientific skills, particularly hypothesis generation and experiment planning, than traditional laboratory studies. Both studies aim to improve students' scientific competence. However, the present study is more broadly focused on evaluating the effectiveness of analytical chemistry teaching programmes at leading universities in Kazakhstan, while the study by these authors focuses on a specific teaching methodology in an organic chemistry course and its impact on the development of scientific reasoning skills in future teachers.

The study by M.H.H. Chan et al. [19] addresses the problem of teaching symmetry in chemistry. They find that many students consider the details of the process without fully understanding the big picture. Therefore, they propose a new approach to teaching this fundamental aspect of chemistry by using grid-based methods to illustrate the implications of symmetry. Both studies emphasise the need to move towards a more objective and practical teaching of chemistry. They draw attention to the challenges of teaching fundamental chemical concepts and propose solutions to enhance teaching and learning.

The study by H. Bao et al. [20] emphasises the importance of teaching advanced calorimetry methods to students. The authors introduce a new method for determining the ternary phase diagram using isothermal titration microcalorimetry, which has a great impact on teaching undergraduate students. The authors discuss the need to revise and expand teaching objectives based on faculty beliefs. This offers students a unique opportunity to put theoretical knowledge into practice and acquire scientific practical skills that they can utilise in their future research careers. The study emphasises the importance of epistemological and social context in teaching and suggests that teachers should consider these elements when planning and implementing courses. Both emphasise the importance of understanding students' and teachers' attitudes to the material being taught and to learning in general. This points to the need for continued research in this area to further improve chemistry and physics teaching methods to create more fruitful and positive learning environments.

The study by F. Alkan [21] aimed to investigate the effect of experiential learning on the success of chemistry students in practical analytical chemistry analysis and identify the mistakes that students make in the process of experimentation. The results of the study showed that the use of experiential learning significantly improves the success of future chemistry teachers. However, despite their success in performing the answer choice tests, the students were not always successful in explaining the theoretical basis of the experiment and detailing the calculation sections. It was also found that chemistry instruction requires not only an understanding of concepts, symbols, terminology, and theories but also the ability of students to meaningfully interpret the instructional language or material that teachers use in chemistry. Teachers should provide meaningful explanations to students and do their best to change students' misconceptions. The study by the researcher emphasises the importance of practical aspects in chemistry teaching and identifies problems with theoretical understanding in students, which is also reflected in the present study where students perceive a lack of practical skills despite satisfactory mastery of theory. The present study also draws attention to the importance of integrating theoretical knowledge and practical skills to produce competent professionals.

The research approach proposed by M.A.S. Ribeiro et al. [22] emphasises the use of advanced technological methods in the teaching laboratory study. They simplify the process of analysing amino acid samples using electrospray ionisation mass spectrometry. This allows students to focus on learning basic chemical concepts instead of getting tangled up in complex preparatory steps. Unlike other reviewed articles that emphasise more active and problem-based learning, this study focuses on adapting technological methods to enhance students' understanding of fundamental chemical theories. It demonstrates the application of mass spectrometry in practice and explains how the application of this technique in practice helps students in their understanding of theory.

However, despite the differences in approach, the goal of all these articles is to help students better understand and apply the basic concepts of chemistry. They all point to the importance of active learning and the practical application of theoretical knowledge for a successful chemistry education. In general, all of these studies emphasise that teaching in chemistry and physics should be implemented by methods that help students not just to learn science, but to understand it by connecting new information to old knowledge and, more broadly, to the problems of scientific development in general.

Conclusions

As a result of the study, it was found that the training of analytical chemistry in universities of Kazakhstan requires optimization considering the requirements of the labour market and research needs. The problem of inconsistency of educational programmes with the requirements of the modern labour market and research needs has been identified. Despite the importance of research studies, students face time constraints, which limit their opportunities in this area. Increasing resources for research activities seems to be an urgent task to ensure full-fledged training of specialists.

Although lecturers appreciate the active inclusion of students in research, students, in turn, express doubts about the adequacy of their training for study in analytical chemistry. This indicates a possible gap between theoretical learning and practical skills, which may reduce students' confidence in their competence in a real professional environment. The choice to pursue an academic career after training may be driven by several factors, such as an interest in in-depth research, a belief that an academic career will provide more opportunities for professional development or a preference for academic research over teaching. However, it is important to note that not all students see their future in academia. Some plan to work in industry, which emphasises the diversity of professional interests among students. It is also worth paying attention to those who have not yet decided on a professional path. This may be due to the insufficient level of practical training within educational programmes or insufficient confidence in their professional abilities.

A significant point is the identification of potential gaps between modern requirements for analytical specialists and the level of training of such specialists in higher education institutions. Employers have commented on the lack of educational institutions that include in their programmes the mastery of specialised technologies and methods relevant to modern practice. An important conclusion is also the need for more flexible and adaptive curricula that can effectively respond to the emergence of new specialisations and vacancies. The ability of students to adapt quickly to new conditions and challenges is seen as a critical requirement of today's labour market. This gap highlights the need for urgent curriculum reform to integrate modern technologies, develop soft skills and provide more flexible learning that responds to the dynamics of today's labour market. The need to create a crossroads between the academic world and industry is also emphasised to ensure that students are effectively employable and that their preparedness meets the requirements of employers.

In conclusion, the study confirmed the necessity of integrating physicochemical methods into the educational process to deepen students' understanding of practical aspects of chemistry. The development of sequential and step-by-step teaching methods will create a holistic system of knowledge in students, stimulating activity and independence in the learning process. The application of new methods and technologies such as virtual laboratories, simulations and interactive learning platforms can create a more dynamic and educationally interesting environment.

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Conflict of Interest

Not applicable.

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Формування експериментальної компетентності в підготовці вчителя хімії

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Анотація

Актуальність. Актуальність дослідження зумовлена необхідністю адаптації освітньої системи до швидкозмінних вимог ринку праці та технологічного прогресу.

Мета. Метою дослідження є оцінка ефективності навчальних програм з аналітичної хімії в провідних університетах Казахстану з точки зору розвитку наукової компетентності студентів, необхідної для працевлаштування.

Методологія. Дослідження використовує порівняльний, якісний та статистичний аналіз, анкетування, опитування та спостереження.

Результати. Дослідження розглядає роль університетів у підготовці аналітичних спеціалістів. Було розглянуто вимоги ринку праці та академічних установ до кандидатів на посади з аналітичної хімії, а також поточний стан досліджень і розробок у підготовці кадрів. Висновки показали, що багато випускників університетів, які навчаються аналітичній хімії, вважають за краще не йти працювати в промисловість або фабричні лабораторії, а планують залишитися в наукових колах і продовжувати свої дослідження. Це свідчить про необхідність перегляду навчальних програм, щоб вони краще відповідали вимогам ринку праці та наукових установ. Виявлено проблеми та прогалини в сучасних програмах і методиках викладання аналітичної хімії в університетах Казахстану. Також критично проаналізовано підходи до посилення практичної складової курсів з урахуванням сучасних вимог та оцінок спеціалістів галузі.

Висновки. У дослідженні підкреслено високий попит на кваліфікованих спеціалістів та наголошено на тому, що проблема полягає не в дефіциті вакансій, а в рівні підготовки. Практичне значення дослідження полягає в тому, що його результати можуть бути використані для модернізації системи навчання в галузі аналітичної хімії та вдосконалення навчальних програм і методик викладання. Це, у свою чергу, сприятиме підвищенню якості підготовки хіміків-аналітиків, які зможуть задовольнити потреби ринку праці та наукових установ.

Ключові слова: активне навчання; методологія аналізу; студенти; кваліфікація спеціаліста; дослідники.