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THE ROLE OF THE HISTORY OF CHEMISTRY COURSE IN DEVELOPING PROFESSIONAL COMPETENCIES OF FUTURE CHEMISTRY TEACHERS

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Abstract: This article examines the pedagogical, methodological, epistemological, and cultural role of the History of Chemistry course in the professional preparation of future chemistry teachers. The central idea of the research is that professional competence in chemistry teaching cannot be reduced to the mechanical transmission of formulas, laws, definitions, and laboratory procedures; it must also include an understanding of how chemical knowledge emerged, changed, was disputed, and became socially meaningful. The History of Chemistry course is interpreted as an integrative educational space that connects content knowledge, pedagogical content knowledge, methodological reflection, scientific worldview, ethical responsibility, communication culture, and research orientation. On this basis, the article substantiates that historical episodes related to atomic theory, the periodic law, chemical bonding, stoichiometry, electrochemistry, organic synthesis, and the development of laboratory culture can serve as didactic instruments for developing conceptual explanation, diagnostic sensitivity to misconceptions, reflective thinking, and professional identity.

Keywords: history of chemistry, future chemistry teachers, professional competence, methodological competence, pedagogical content knowledge, history and philosophy of science, chemistry education, reflective teaching.

INTRODUCTION

The preparation of future chemistry teachers is one of the most complex tasks of modern pedagogical higher education, because it requires the simultaneous formation of scientific accuracy, methodological flexibility, experimental culture, communicative maturity, ethical responsibility, and a stable professional identity. A chemistry teacher does not merely transmit a finished set of laws, equations, and technological facts; the teacher interprets chemical knowledge for learners, transforms abstract models into understandable educational situations, diagnoses conceptual difficulties, organizes safe laboratory work, and builds a scientific worldview in which matter, transformation, evidence, and explanation are understood as interconnected elements of culture. In this sense, the professional competence of a future chemistry teacher is not a narrow technical qualification. It is a multidimensional integrative quality that includes subject competence, pedagogical content knowledge, methodological competence, research competence, digital and informational competence, axiological competence, communicative competence, and reflexive competence. Each of these components becomes more meaningful when it is connected with the historical development of chemistry as a science[1]. Therefore, the History of Chemistry course has a special role in teacher education: it humanizes chemical knowledge, reveals the logic of scientific discovery, and demonstrates that the concepts studied in school and university are not isolated dogmas but historically formed intellectual tools[2]. In many traditional curricula, chemistry is presented as a stable system of facts: the periodic table is given as a ready classification, atomic theory is introduced as an established model, chemical bonding is explained through generalized diagrams, and stoichiometry is taught as a sequence of calculation algorithms. Such instruction is necessary, but it is insufficient for the formation of a professionally competent teacher. When future teachers know only the final form of scientific knowledge, they may reproduce formulas accurately but fail to explain why learners experience difficulties, why alternative ideas are persistent, and why scientific concepts require

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evidence, criticism, revision, and modeling. The historical development of chemistry shows that scientific knowledge emerged through contradictions: the transition from alchemical practices to experimental chemistry, the replacement of phlogiston theory by oxygen theory, the evolution of atomic and molecular ideas, the formation of the periodic law, the debate between structural theories in organic chemistry, and the development of quantum-chemical interpretations of bonding. These episodes reveal the methodological character of chemistry and help future teachers understand that science is a dynamic form of rational inquiry rather than a catalogue of unquestionable truths[3]. The History of Chemistry course contributes to professional competence first of all through the formation of epistemological awareness. A future teacher who studies how chemical concepts were historically constructed becomes able to distinguish observation from interpretation, empirical regularity from theoretical explanation, model from reality, and symbol from material process. This distinction is essential in chemistry, where learners must coordinate macroscopic phenomena, submicroscopic models, and symbolic representations. Historical analysis makes it possible to show that scientific models are not decorative illustrations but instruments of explanation with limited applicability and specific historical functions. For example, the historical movement from Dalton's atomic theory to Avogadro's molecular hypothesis, from Mendeleev's periodic system to modern electronic structure, and from classical valence to quantum bonding gives future teachers a conceptual map that can be used to explain why the same chemical phenomenon may be represented at different levels of abstraction[4]. The second contribution of the History of Chemistry course is methodological. It allows future teachers to design lessons in which scientific problems are reconstructed rather than merely announced. A lesson on the periodic law, for instance, can begin with the nineteenth-century problem of classifying elements and with the limitations of atomic weight, valence, and chemical analogy as separate criteria. A lesson on combustion can be organized through the historical conflict between phlogiston theory and Lavoisier's oxygen theory. A lesson on acids and bases can reveal how Arrhenius, Bronsted-Lowry, Lewis, and later generalized approaches expanded the explanatory field of chemistry. Such reconstructions create conditions for problem-based learning, argumentative dialogue, comparative analysis, and conceptual change. They also provide future teachers with a repertoire of historical cases that can be adapted to different ages, levels of preparation, and educational standards[5]. The third contribution concerns professional motivation and identity. Students preparing to become teachers often perceive pedagogical work as a set of formal duties: preparing lesson plans, explaining textbook content, checking exercises, and assessing learners. The history of chemistry helps them see teaching as participation in a long cultural process through which society transmits scientific rationality from generation to generation. Biographies of chemists, the history of laboratories, the social meaning of chemical technologies, the ethical consequences of discoveries, and the relation between chemistry, medicine, agriculture, ecology, and industry make the future teacher's profession culturally significant. This is especially important in the context of Uzbekistan's educational reforms, where the quality of chemistry and biology education, the modernization of laboratories, the integration of science and production, and the formation of competent teachers are treated as strategic priorities[6]. The fourth contribution is diagnostic and psychological. Historical misconceptions in science often resemble students' naive ideas. Learners may interpret combustion as the disappearance of matter, confuse atoms with continuous substances, imagine chemical bonds as visible sticks, or treat formulas as arbitrary symbols detached from substances. Historical cases show that similar explanatory difficulties existed in the development of science itself. This does not mean that a learner's thinking repeats the history of chemistry directly, but it suggests that historical analysis can help teachers anticipate conceptual barriers. A future chemistry teacher who understands how the concept of element, compound, atom, molecule, valence, equilibrium, or energy changed over time will be

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better prepared to identify the roots of learners' misunderstandings and to construct explanations that move from everyday intuition toward scientific abstraction[7]. Finally, the History of Chemistry course supports ethical and civic competence. Modern chemistry is inseparable from environmental safety, pharmaceutical development, materials science, food security, energy technology, and industrial risk. Historical knowledge shows that scientific progress has always had social consequences and that chemists bear responsibility for how knowledge is produced and applied. By analyzing historical episodes such as the development of fertilizers, polymers, dyes, medicines, explosives, nuclear chemistry, and green chemistry, future teachers learn to discuss not only the efficiency of technologies but also their human, ecological, and moral dimensions. Thus, the History of Chemistry course becomes an educational mechanism for integrating scientific literacy with professional morality. The purpose of this article is therefore to justify the role of the History of Chemistry course as a systemic factor in developing the professional competencies of future chemistry teachers and to identify the pedagogical results that can be expected when this course is designed not as a decorative historical appendix but as a methodological core of chemistry teacher education.

LITERATURE REVIEW

The literature on the role of the History of Chemistry course in professional teacher preparation shows that historical knowledge becomes pedagogically meaningful when it is connected with competence formation, methodological reflection, and the ability to explain chemical concepts as developing scientific ideas. In international scholarship, Shulman's concept of pedagogical content knowledge established the idea that a teacher's mastery is not limited to knowing the subject; the teacher must know how to transform subject matter into forms that are accessible to learners. Matthews later strengthened this view by arguing that science teaching becomes deeper when history and philosophy of science are included, because historical context helps teachers explain the nature of scientific knowledge, the development of concepts, and the rationality of scientific change. Niaz, working specifically within chemistry education, emphasized that chemistry should be taught not as a fixed inventory of facts but as a discipline whose models, laws, and theories were built through historically situated scientific practice[8].

Within Uzbek pedagogical research, two scholars are especially relevant for the present topic. Khudayor Madrimovich Rajabov directly investigated the conceptual and historical aspects of teaching organic chemistry in higher education. His dissertation abstract substantiates the improvement of organic chemistry teaching through the principle of historicity and connects historical materials with educational motivation, professional competence, scientific thinking, independent learning, and methodological preparation of future chemistry teachers. The importance of Rajabov's work is that it interprets history not as decorative biographical information but as a principle for organizing chemical content. From this perspective, the development of structural theory, the history of named reactions, the evolution of laboratory culture, and the interpretation of chemical discoveries can be transformed into didactic tools for future teachers. Iskandar Ergashovich Shernazarov represents another important line of Uzbek research because his works address the competence, literacy, and methodological readiness of future chemistry teachers in the context of modern educational tasks and international assessment requirements. Shernazarov's approach is valuable for the present article because it shows that a future chemistry teacher should be able to work with scientific information, interpret complex tasks, develop students' natural-scientific literacy, and organize learning according to competence-based outcomes. When Rajabov's historical principle is connected with Shernazarov's competence-oriented logic, the History of Chemistry course appears as a

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methodological resource that can develop both deep conceptual understanding and practical readiness for teaching[9].

METHODOLOGICAL SECTION

In this article, a complex methodological approach was used in order to reveal the role of the History of Chemistry course in developing professional competencies of future chemistry teachers. The first method was theoretical analysis, through which the concepts of professional competence, methodological competence, pedagogical content knowledge, scientific worldview, and history-and-philosophy-oriented chemistry education were examined as interconnected categories. This method made it possible to determine that the History of Chemistry course should not be understood as a separate chronological narrative but as a formative pedagogical system that influences the teacher's conceptual, methodological, motivational, communicative, and ethical readiness. The second method was historical-comparative analysis. It was applied to selected episodes of chemistry, including the transition from alchemy to experimental chemistry, the phlogiston-oxygen debate, the emergence of atomic-molecular theory, the creation of the periodic law, the development of structural organic chemistry, and the transformation of chemical bonding theory. Through this method, historical episodes were interpreted as didactic situations that can help future teachers understand the logic of scientific change and use it in lesson design.

RESULTS

The results of the analysis show that the History of Chemistry course has a systemic influence on the professional competence of future chemistry teachers. The first result is the strengthening of conceptual-didactic competence. Historical analysis helps future teachers understand why chemical concepts acquired their present form and how their meanings changed in relation to experimental evidence and theoretical models. This is especially important for teaching topics such as atom, molecule, element, compound, valence, periodicity, chemical equilibrium, and bonding. When a future teacher studies the historical development of these concepts, he or she becomes able to explain them not only definitionally but also genetically, that is, through the logic of their emergence. Such explanation increases the teacher's ability to organize learning from problem to concept and from empirical observation to theoretical interpretation.

DISCUSSION

A productive scholarly polemic on the role of the History of Chemistry course can be reconstructed through the positions of two foreign scholars: Michael R. Matthews and Mansoor Niaz. Matthews, representing the broader history-and-philosophy-of-science tradition in science education, argues that science teaching is intellectually impoverished when it is separated from the historical and philosophical conditions under which scientific knowledge was created. In this view, the future teacher needs history because it provides cultural depth, epistemological clarity, and a humanistic understanding of science. Matthews' position challenges the technocratic tendency to reduce teacher preparation to methods, standards, and assessment procedures. His argument implies that a chemistry teacher who does not understand the historical nature of scientific concepts may teach chemistry accurately but incompletely, because learners will see only the final results of science and not the rational drama of inquiry, criticism, and conceptual change.

Niaz agrees with the importance of history and philosophy, but his polemical emphasis is more specifically chemical. He argues that chemistry education must show how concepts such as

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atom, model, law, theory, stoichiometry, valence bond, molecular orbital, and chemical explanation were constructed within the actual practice of chemistry. If Matthews defends history and philosophy as a necessary dimension of science teacher education in general, Niaz insists that history and philosophy must be placed inside the teaching of chemistry concepts themselves. This creates an important methodological debate. From a Matthews-oriented perspective, the primary danger is ahistorical science teaching that presents knowledge without its cultural and epistemological roots. From a Niaz-oriented perspective, the danger is another form of superficiality: general historical or philosophical talk that remains external to chemical content and does not help students understand why chemical models changed or how chemical explanations function[10].

CONCLUSION

The History of Chemistry course plays a strategically important role in developing professional competencies of future chemistry teachers. Its value lies not only in providing information about discoveries, scientists, laboratories, and chronological stages of chemical science, but also in forming the intellectual and methodological qualities that a competent teacher needs in real pedagogical practice. Through historical analysis, future teachers learn to understand chemical concepts dynamically, to explain the relationship between experiment and theory, to compare alternative models, to anticipate learners' misconceptions, to design problem-based lessons, and to connect chemistry with culture, technology, ecology, and ethical responsibility.

The study shows that this course should be structured as an integrative competence-forming discipline. It must unite the history of scientific ideas with pedagogical content knowledge, methodological reflection, didactic design, and professional identity formation. The approaches of Uzbek scholars such as Khudayor M. Rajabov and Iskandar E. Shernazarov confirm that the historical principle and competence-based methodology are priorities in the preparation of future chemistry teachers. Foreign scholars such as Michael R. Matthews and Mansoor Niaz demonstrate that the history and philosophy of science can enrich teacher education when they are connected with concrete scientific concepts and teaching practice.

Therefore, the History of Chemistry course should be included in chemistry teacher education as a core methodological resource. Its effective organization requires historical case studies, comparative model analysis, work with scientific texts, discussion of controversies, historically oriented laboratory explanations, microteaching, reflective portfolios, and tasks that transform historical knowledge into lesson design. When taught in this way, the course develops future chemistry teachers who can present chemistry not as a closed system of memorized facts, but as a living, evidence-based, culturally significant, and socially responsible science.

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