FACTORS INFLUENCING THE IMPROVEMENT OF METHODOLOGY FOR DEVELOPING RESEARCH COMPETENCE OF MASTER'S STUDENTS IN CHEMISTRY

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Annotatsiya: Maqolada oliy ta'lim muassasalari magistrantlarining ilmiy-tadqiqot kompetentligining mazmuni va metodologik asoslari unga ta'sir etuvchi omillar asosida tahlil qilingan. Shakllantirilgan xulosalar asosida oliy ta'lim magistrantlarida ilmiy-tadqiqot kompetentligini rivojlantirish bo'yicha taklif va tavsiyalar ishlab chiqilgan.

Tayanch so'z va tushunchalar: tashkiliy, pedagogik, metodik, texnologik va psixologik omillar, **ilmiy tajriba, metodologik savodxonlik, ta'lim metodlari, ilmiy maktablar, virtual laboratoriyalar**.

Факторы, влияющие на совершенствование методики развития научно-исследовательской компетентности магистрантов химической специальности

Аннотация: В статье проанализированы содержание и методологические основы научно-исследовательской компетентности магистрантов высших учебных заведений на основе факторов, оказывающих на неё влияние. На основе сформулированных выводов разработаны предложения и рекомендации по развитию научно-исследовательской компетентности магистрантов высших учебных заведений.

Ключевые слова: организационные, методические, технологические и психологические факторы, научный опыт, методологическая грамотность, методы обучения, научные школы, виртуальные лаборатории.

Factors influencing the improvement of methodology for developing research competence of master's students in chemistry

Annotation: The article analyzes the content and methodological foundations of research competence of master's students in higher education institutions based on the factors influencing its development. Based on the formulated conclusions, proposals and recommendations for developing research competence among master's students in higher education institutions have been developed..

Key words organizational, methodological, technological, and psychological factors; research experience; methodological literacy; teaching methods; scientific schools; virtual laboratories.

In the modern higher education system, deep integration of research activities into the educational process is not only a means of enhancing educational effectiveness, but also a strategic direction for developing students' scientific thinking, analytical approach, and creative competencies. For this integration to be successful, a range of organizational, methodological, technological, and psychological factors must operate in a coordinated and complementary manner.

Below, each of these factors is examined on a scientific basis.

Pedagogical and methodological factors in developing the research competence of master's students in chemistry: The development of research competence among master's students in chemistry is a multifaceted, complex, and systematic process that is closely linked to the creation of an effective educational environment. At the core of this process are pedagogical and methodological factors. The teacher's scientific capacity, the selected teaching methods, integrative approaches, and the assessment system contribute to the development of master's students' scientific culture, analytical thinking, experimental skills, and motivation for scientific inquiry. Below, these factors are subjected to an in-depth scientific analysis.

1. The teacher's scientific capacity as the foundation of master's students' research competence.

The teacher’s scientific capacity is the fundamental basis for developing the research competence of master’s students. It serves as the main driving force guiding master’s students’ research activities. This capacity is manifested through the following components:

a) Research experience. Research experience is formed through the teacher’s participation in scientific projects, authorship of articles and monographs, involvement in grants and academic internships, and the establishment of a scientific school. An experienced scientific supervisor can effectively guide a master’s student in formulating research problems, developing hypotheses, and selecting appropriate research methodologies.

b) Methodological literacy. For master’s students, the selection of scientific methods, experimental design, statistical data processing, and the formulation of scientific conclusions rely heavily on the teacher’s methodological knowledge. A methodologically literate scientific supervisor contributes significantly to the development of the master’s student’s scientific thinking.

c) Knowledge of modern analytical methods. The advancement of chemistry is closely linked to the application of advanced techniques such as GC–MS, HPLC, UV–Vis, AAS, FTIR spectroscopy, electroanalytical methods, and molecular modeling tools (Gaussian, Avogadro). A scientific supervisor proficient in these methods is capable of preparing master’s students in accordance with international scientific standards.

d) Scientific supervision (mentoring) skills. Mentoring encompasses motivating students, providing scientific guidance, fostering reflective thinking, and developing independence in master’s students. Scientific supervision is one of the most powerful pedagogical mechanisms for shaping research competence.

2. Teaching methods as pedagogical mechanisms oriented toward research activities. Teaching methods act as pedagogical mechanisms oriented toward scientific inquiry, and the methods selected for master’s students in chemistry directly contribute to the formation of their research competence. We consider the following methods to be the most effective:

a) Research-Based Learning (RBL). Within this method, master's students do not merely acquire ready-made knowledge; instead, they formulate research questions, develop hypotheses, conduct experiments, and analyze results. As a result, master's students are formed as genuine researchers.

b) Project-Based Learning (PBL). This method involves organizing project activities such as laboratory projects, the development of chemical models, and the solution of real industrial problems. Project-based learning strengthens the scientific and practical competence of master's students.

c) Problem-Based Learning (PrBL**).** In this method, master's students are presented with ambiguous, complex, and scientifically debatable problems that require independent solutions. This approach fosters the development of critical thinking and creative analysis.

d) Experiential Learning. According to D. Kolb's learning cycle, this method involves deeper learning through the stages of experience, reflection, theory, and practice. For chemistry students, laboratory experience constitutes the core foundation of research competence.

3. Integrative approach: interdisciplinary synthesis and systems thinking. Since chemistry is a complex discipline, the integrative approach significantly enhances educational effectiveness.

a) Interdisciplinary synthesis. Master's students should be able to work at the intersections of chemistry and physics (thermodynamics, spectroscopy), chemistry and biology (fermentation, biochemistry), chemistry and computer science (modeling, big data), and chemistry and ecology (monitoring, pollution analysis). Such synthesis substantially improves the quality of scientific research.

b) Systems thinking. This method develops a systemic approach that enables master's students to perceive processes holistically, analyze cause-and-effect relationships, and interpret scientific results in a comprehensive manner.

c) Integration of multiple disciplines. Chemical research cannot be complete without the integration of the following disciplines:

- physics (energy systems, optics),

- biology (biopolymers, microorganisms),
- mathematics (statistics, modeling),
- ecology (analysis, monitoring).

This integration fosters the formation of deep and sustainable competence among master’s students.

4. Assessment and monitoring system as a management mechanism for competence development. This method emphasizes that an effective assessment system is essential for identifying the dynamics of master’s students’ development and revealing their strengths and weaknesses.

a) Formative assessment. During the learning process, continuous evaluation of laboratory work quality, experimental results, and stages of scientific research motivates students’ ongoing development.

b) Self-assessment. Through self-assessment, master’s students analyze their own work, identify mistakes, and define their pathways for scientific growth. This process fosters the development of reflective competence.

c) Competence passport. An individual competence passport is developed for each master’s student, indicating the skills acquired, methods mastered, and the scope of laboratory experience. This serves as a modern monitoring tool.

d) Learning Analytics. Through digital systems (HEMIS, Moodle), students’ activity levels, task completion speed, development trajectories, and laboratory results are analyzed. This significantly facilitates data-driven pedagogical decision-making.

The development of research competence among master’s students in chemistry depends not only on personal, pedagogical, and psychological factors, but also directly on the availability and effectiveness of organizational-infrastructural and digital-technological factors. Modern chemistry education and research require a technical, scientific, digital, and industry-integrated environment; therefore, a scientifically grounded analysis of these factors is presented below

1. Organizational and infrastructural factors. Organizational and infrastructural factors play a significant role in preparing master’s students for research activities by providing a practical base, fostering scientific collaboration, creating an appropriate laboratory environment, and ensuring the conditions necessary for conducting research. Modern chemistry education is fundamentally laboratory-based; therefore, a high level of technical infrastructure is required to develop master’s students’ experimental competence. This includes the following:

a) Spectrometric, chromatographic, and electroanalytical instruments. For the identification, analysis, and characterization of chemical systems, the following equipment is of particular importance:

- UV–Vis spectrophotometry,
- Gas chromatography (GC),
- Potentiometry, voltammetry, and conductometry.

These instruments enhance master’s students’ analytical thinking, develop data-processing skills, and increase the reliability of scientific research.

b) Virtual laboratories. Virtual laboratory platforms (Labster, ChemCollective, PhET) enable master’s students to conduct safe, repeatable, and cost-effective experiments, model complex processes, and perform experiments without physical reagents or instruments. They represent an essential technology for addressing limitations in physical laboratory capacity.

c) Safety systems. Chemistry laboratories must be equipped with ventilation and aspiration systems, chemical hazard signage, fire-fighting equipment, personal protective equipment (protective clothing, goggles, gloves), and designated storage areas for hazardous substances. Safety systems are an integral component of modern laboratories and contribute to the formation of professional culture among master’s students.

d) Modern experimental equipment. This includes magnetic stirrers, thermostats and incubators, microscopes (SEM, TEM), electrochemical sensors, automated titrators, and calorimeters. Such equipment enables master’s students to master a wide range of scientific research directions.

2. The level of the university's scientific environment. The presence of a strong scientific environment is crucial for fostering scientific activity, creative inquiry, and the formation of scientific culture among master's students.

a) Scientific schools. The existence of scientific schools within a university contributes to the generation of deep expertise in specific fields, the continuity of traditional research directions, and the availability of strong scientific supervisors. A scientific school serves as a foundational element in shaping a master's student's scientific worldview.

b) Seminars and conferences. Scientific events provide opportunities for the exchange of ideas, presentation of research results, acceptance of analytical criticism, and awareness of global research trends. These activities contribute to the development of communicative and presentation competencies among master's students.

c) Joint research projects. Interdisciplinary projects or projects conducted in collaboration with industrial partners enable master's students to master research methods more deeply, participate in real scientific work, develop teamwork skills, and strengthen innovative thinking.

d) Research internships. Research internships (local or international) immerse master's students in authentic research environments, allowing them to learn new methods, observe modern laboratory technologies, and expand scientific networks.

3. Collaboration with industry. As chemistry is an applied discipline, gaining experience in real industrial environments is of particular importance for master's students.

a) Familiarization with production technologies. Exposure to chemical synthesis processes, technological production lines, safety systems, and quality control laboratories in industrial enterprises connects theoretical knowledge with real-world production practices.

b) Internships in applied chemistry laboratories. These internships provide master's students with practical skills in real analytical analyses, technological process monitoring, and evaluation of raw materials and product quality.

c) Solving real-world problems. Engaging in real industrial challenges—such as waste reduction, development of new catalysts, improvement of energy efficiency, and determination of material composition-shapes master's students into genuine researchers.

Digital and technological factors. In the modern research environment, digital competence has become a leading requirement. Master's students in chemistry are expected to be proficient in digital analytics, modeling, the use of scientific platforms, and virtual experimentation.

1. Access to digital platforms

a) Educational platforms. Platforms such as Moodle, HEMIS, and Google Classroom enable digital submission of assignments, monitoring of learning outcomes, maintenance of electronic portfolios, and access to online consultations. These platforms contribute to the development of master's students' self-regulation and self-management competence.

b) Virtual laboratories. Platforms such as Labster, ChemCollective, and PhET provide opportunities to simulate complex processes, conduct experiments without the use of chemical reagents, create a safe learning environment, and repeat experiments multiple times. These advantages significantly enhance experimental learning.

c) Scientific databases. Resources such as ResearchGate, Scopus, and Web of Science allow users to search for scientific articles, conduct bibliometric analyses (citation analysis), identify relevant sources during the writing process, and explore global research experience in solving scientific problems. Broad access to digital platforms significantly improves the quality of master's students' research activities.

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