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THE ROLE OF THE PRINCIPLE OF SCIENTIFIC RIGOR IN IMPROVING THE METHODOLOGY FOR DEVELOPING RESEARCH COMPETENCE AMONG MASTE'S STUDENTS IN CHEMISTRY

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Abstract
In this article, the theoretical and methodological approaches to developing and enhancing the research competence of master's students specializing in chemistry within the higher education system are reconsidered through the lens of the principle of scientific rigor. During the study, the essence of research competence, its structural components, and the mechanisms of its formation were thoroughly analyzed. Based on the findings obtained, effective methodological recommendations and improved pedagogical solutions aimed at further strengthening research competence among master's students were developed.

Keywords: Scientific competence, research competence, creativity, research activity, principle of scientific rigor, program.

Introduction

In the global educational policies of international organizations and developed countries, particular emphasis is placed on the role of education in ensuring the sustainable development of society. In particular, the Incheon Declaration and the international education development agenda "Education 2030" identify as a key objective "Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all"1.

This concept interprets the education system not merely as a means of knowledge transmission, but as a fundamental factor in developing the intellectual potential of nations, their scientific and technological capacities, and innovative thinking. At present, the education sector faces a number of pressing and complex challenges.

From this perspective, the formation of research competence in the modern higher education system is regarded as a complex, multifactorial, and systemic process. This process is based on the integration of a master's student's knowledge, skills, values, and reflective activities. Its effectiveness primarily depends on the correct selection and consistent implementation of

11 Incheon declaration/ Education 2030: Towards inclusive and equitable quality education and lifelong learning for all (Word Education Forum, 19-22 may 2015, Incheon, Republic of Korea). - 48 p.

methodological principles. An analysis of scientific literature indicates that the principle of scientific rigor plays a crucial role in improving the research competence of master's students specializing in chemistry.

The principle of scientific rigor is a fundamental didactic principle that requires the training of chemistry master's students to be based on scientifically grounded sources, experimental and observational results, objective facts, and laws that connect theory with practice.

The scientific reliability of knowledge implies that all information provided to master's students must rely on modern chemical theories, experimentally validated evidence, scientific results published in internationally indexed journals, and recognized scientific schools and methodologies. In chemistry, theory is confirmed through practical experimentation; therefore, the principle of scientific rigor is closely linked with laboratory classes, experimental verification, scientific modeling, and analytical analysis.

The application of the principle of scientific rigor requires master's students to develop skills in formulating scientific problems, generating hypotheses, selecting appropriate research methods, conducting experiments, statistically processing results, and drawing scientifically grounded conclusions. Chemical experiments must be reproducible, controllable, account for possible errors, and undergo validation, which constitutes one of the most important requirements of this principle.

A high level of mastery of fundamental areas such as chemical kinetics, thermodynamics, analytical methods, instrumental analysis, chemical equilibrium, and spectral methods is ensured through the implementation of the principle of scientific rigor. As a result, master's students acquire competencies in precise experimental planning, correct selection of measurement methods, working with instruments, соблюдение safety requirements, and minimizing experimental errors.

Level of Prior Research on the Topic

O. U. Hasanboeva(2015) examined research competence in the scientific activity of master's students through several interrelated components. In particular, the cognitive component includes the formulation of a scientific problem, research topic, objectives and tasks, hypothesis development, and work with scientific literature. The operational–practical component encompasses experimentation, observation, modeling, and experimental design. The reflective component involves the analysis of one's own activities, identification of errors, and evaluation of the reliability of results. The communicative component is reflected in skills related to scientific writing, presentations, seminars, and thesis defense, through which scientific ideas are articulated and justified2.

In the works of J.G.Yo'ldoshev, the concept of "research competence" is not presented as an independent, explicitly defined section. However, his studies provide valuable insights into scientific research activity, creative competence, analytical skills, and reflection, which are significant for understanding the formation of research competence3.

2 Hasanboeva, O. U. (2015). Oliy ta'limda magistrlarning ilmiy-tadqiqot kompetensiyasini shakllantirish texnologiyasi. pp 24-39

3 Yo'ldoshev, J. G., & Ishmuxamedov, R. (2008). *Pedagogik texnologiya asoslari.*Toshkent: TDPU.-164 bet.

S.T.Teshabaev (2019) emphasizes that in chemistry education, scientific inquiry, its structure and stages require high-level analytical thinking from master's students, as well as independence in conducting experiments and interpreting results. According to the author, theability to formulate a scientific problem, define a research topic and objectives constitutes the cognitive component of research competence4.

However, an analysis of existing literature indicates that the issue of pedagogical preparation of chemistry master's students specifically for the development of research competence has not yet been sufficiently and comprehensively studied. In particular, problems related to the integration of pedagogical technologies designed for chemistry master's students into educational practice, the enhancement of their activity-oriented professional preparation, and alignment with international standards remain highly relevant. Therefore, this article aims to provide a deeper exploration of the topic and to improve strategic methodological principles by integrating existing scientific and practical approaches in a coherent manner.

Statistical Analysis and Results

The principle of scientific rigor requires master's students to possess skills in statistical analysis, the use of graphical representations and modeling, the reliable presentation of scientific evidence, and working with objective results rather than subjective opinions.

An integral component of the principle of scientific rigor is the culture of working with scientific information. Scientific data used in this study were obtained from the following sources:

-Scopus, Web of Science, PubChem, ScienceDirect;

-scientific articles, patents, and research reports;

-modern research directions in chemistry.

Working with Scopus, Web of Science, PubChem, and ScienceDirect

Scopus is known as one of the largest bibliographic databases in the world and provides chemistry master's students with extensive research opportunities. Through Scopus, master's students are able to identify the most relevant scientific topics by reviewing publications from the last 5–10 years, analyzing highly cited works, and determining which research areas are most actively investigated. In addition, Scopus enables the identification of leading scientists and scientific schools in the field of chemistry.

For example, in conducting a dissertation entitled "Nitric Acid Production", a chemistry master's student was able to determine:

-which authors have published the highest number of articles in this area;

-which universities are leading research centers;

-which laboratories are most actively involved in this field.

Citation analysis was also conducted. Citation analysis refers to the process of evaluating the scientific impact, relevance, significance, and authority of a scientific article, researcher, or scientific school based on the number of citations received from other researchers. This

4 Teshabaev, S. T. (2019). Innovatsion ta'lim texnologiyalari va kimyo fanini o'qitish metodlari.Toshkent: Universite pp. 87–94

approach allowed the master's student to identify the most influential articles, fundamental studies, and impactful research contributions.

Bibliographic data obtained for literature analysis served as a key source for preparing the literature review section of the research. Scopus significantly enhanced the master's student's scientific outlook, logical thinking, and the quality of research topic selection.

Web of Science (WoS) indexes journals with the highest quality standards. Using reliable and rigorously validated scientific sources, the master's student selected only high-impact journal articles relevant to the research topic. Through WoS, the relevance of the scientific problem, existing research gaps, and unresolved aspects of the problem were substantiated with solid evidence. Furthermore, WoS enabled the comparison and selection of research methodologies. For instance, WoS was used to identify the most reliable methods related to:

- HPLC techniques;
- UV–Vis spectrophotometric and titrimetric methods;
- methods for studying catalytic processes.

Thus, Web of Science served as a powerful platform for method selection, problem justification, and ensuring the overall quality of research.

Use of PubChem in Chemical Research

For chemists, PubChem represents a fundamental platform for information on chemical structures, properties, and reactions. Developed by the National Institutes of Health (NIH), PubChem is the largest chemical information database and is of exceptional value for chemistry master's students.

PubChem provides chemical structures in multiple formats, including Molfile, SMILES, InChI, and 2D/3D representations. It also offers essential physicochemical properties such as molar mass, boiling point, melting point, density, pKa, logP, and solubility. In addition, master's students can obtain information on reaction pathways, catalysts, and reaction conditions. This platform is particularly important for research in environmental chemistry and pharmaceutical chemistry. PubChem serves as a key resource for experimental design, reagent selection, and ensuring laboratory safety.

ScienceDirect as a Full-Text Scientific Resource

ScienceDirect is a full-text scientific database and one of Elsevier's largest academic platforms, providing chemistry master's students with the following opportunities:

1. Access to full-text scientific articles, whereas Scopus and WoS mainly provide bibliographic information;
2. Study of experimental methodologies, including analytical techniques, synthesis pathways, measurement methods, and laboratory protocols;
3. Deepening theoretical knowledge through access to leading textbooks and monographs;
4. Preparation of the literature review section using high-quality, peer-reviewed sources.

ScienceDirect is therefore a primary platform for mastering scientific texts, methodologies, and academic writing.

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webofjournals.com/index.php/1

Scientific Articles, Patents, and Research Reports

The research competence of chemistry master's students is largely based on their culture of working with information, namely the ability to search for, analyze, compare, evaluate, synthesize, and correctly use scientific sources. Scientific articles, patents, and research reports served as the primary sources in this process.

Scientific articles are the main source of fundamental and up-to-date knowledge and represent the most frequently used and reliable resources in the research activities of master's students. Articles were used to select and justify research topics. Through article analysis, master's students were able to determine:

- the relevance of the research topic;
- which issues have already been addressed;
- which aspects remain unexplored;
- how international researchers approach the topic.

Thus, scientific articles enabled the scientific justification of the chosen research topic.

In preparing the literature review, articles provided experimental, theoretical, and methodological foundations. Master's students compared methods, synthesized key ideas, and identified research gaps. In forming the research methodology, articles were used to analyze reagents, analytical methods, optimal conditions, and measurement procedures.

Experimental results such as IR spectra, UV–Vis absorption data, chromatographic peaks, reaction rates, and physicochemical parameters were compared with results reported in the literature.

Patents serve as sources of innovation, technology, and applied developments. In chemistry, patents are particularly important for technological processes, chemical synthesis, catalytic reactions, and the development of new materials. Master's students used patents to identify scientific novelty, study new synthesis routes, catalysts, efficient methods, and technological processes. Patent-based technologies also provided real data on economic efficiency, safety, industrial applicability, and production processes.

During research project development, master's students were able to formulate new hypotheses, enrich methodologies, and design improved technological schemes based on patented technical solutions. In addition, working with patents fostered respect for intellectual property, understanding of patent requirements, and criteria of novelty, thereby strengthening creative and innovative thinking.

Scientific reports (laboratory reports, grant reports, and final reports of state-funded projects) played an important practical role in research activities. From these reports, master's students learned experimental procedures, including sequences of experiments, reagent quantities, laboratory conditions, equipment parameters, potential errors, and safety measures. Reports also provided reference data such as IR spectra, chromatograms, titration results, and process graphs, which helped master's students accurately interpret their own experimental results.

Moreover, reports contained discussions of methodological improvements, limitations, and recommendations, enabling more precise experimental planning, error reduction, and optimal method selection. Information on technological efficiency, such as NO_2 formation, energy savings, and catalyst performance, was also included.

Modern Research Directions in Chemistry

The term "modern research directions in chemistry" refers to fields that are currently the most actively studied, highly significant scientifically, frequently represented in international literature, and capable of generating novel scientific results. Master's students use these directions as sources of scientific information, methodological foundations, and tools for substantiating the relevance of their research.

Modern research directions guide master's students in selecting research topics and include areas such as:

- nanochemistry;
- catalysis and green chemistry;
- bioorganic chemistry;
- energy chemistry (batteries and hydrogen technologies);
- computational chemistry and modeling;
- materials chemistry (polymers, semiconductors, composites);
- advanced analytical methods (HPLC, ICP-MS, biosensors);
- environmental chemistry and environmental monitoring.

By relying on these directions, master's students select relevant research topics, justify their international significance, and enhance the modernity of their work. Engagement with contemporary scientific trends enables alignment of research with global developments.

Modern research directions also assist in justifying research problems and addressing questions such as:

- Is the problem globally relevant?
- In which areas do research gaps exist?
- Who are the key contributors to this field?
- Which methods are the most effective?

For example, when studying new catalytic methods for nitric acid production, master's students rely on modern approaches such as nanocatalysts, heterogeneous catalysis, energy-efficient technologies, and environmental impact reduction. This process significantly contributes to the development of the competence to scientifically and convincingly justify research problems.

Discussion

Modern research directions assisted master's students in selecting advanced methods and designing their research frameworks. In particular, the following contemporary methods were applied:

Spectral methods:

- IR, UV–Vis, NMR
- Mass spectrometry

Chromatographic methods:

- HPLC, GC, GC–MS

Computational modeling:
- Density Functional Theory (DFT)
- Molecular dynamics
- Gaussian, Schrödinger, and related software packages

Nanoanalytics:
- SEM, TEM
- XRD

By employing these methods, master's students enhance the reliability of their research, construct experimental designs at a modern scientific level, and correctly interpret scientific results. This significantly strengthens their methodological competence and increases the effectiveness of working with scientific literature. Modern research directions enable master's students to identify the latest publications, relevant topics, innovative technologies, and materials from international conferences through databases such as Scopus, Web of Science, and ScienceDirect. As a result, master's students deepen their literature analysis, prepare comprehensive scientific reviews, and enrich the theoretical and empirical basis of their dissertations.

Modern research directions also provide a solid theoretical foundation for interpreting experimental results. For example:
- analyzing peaks in spectral data;
- explaining separation mechanisms in chromatograms;
- interpreting energy profiles in catalytic processes;
- explaining changes in the properties of nanoparticles.

All of these interpretations are grounded in modern chemical theories, thereby fostering the development of analytical and interpretative competence among master's students.

Furthermore, contemporary directions in chemistry promote the formation of innovative scientific thinking by creating opportunities to propose new ideas, develop novel methods, and modernize existing processes. This transforms the master's student into a creative, innovative individual with well-developed scientific thinking.

Engagement with modern research directions broadens the scientific worldview of master's students by enabling them to stay informed about global scientific processes, master international research standards, understand current trends in the development of chemistry, and view their research topics within a global context. This, in turn, facilitates their integration into the international scientific community.

The principle of scientific rigor serves as the foundation for developing the research competence of master's students specializing in chemistry. This principle fosters scientific thinking, experimental culture, statistical analysis skills, theoretical depth, objectivity, reflection, and evidence-based reasoning, thereby cultivating master's students as independent researchers.

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REFERENCES

1. Incheon Declaration and Framework for Action for the Implementation of Sustainable Development Goal 4.Education 2030: Towards Inclusive and Equitable Quality Education and Lifelong Learning for All.World Education Forum, 19-22 May 2015, Incheon, Republic of Korea. - 48 p.
2. Hasanboeva, O. U. (2015). Oliy ta'limda magistrlarning ilmiy-tadqiqot kompetensiyasini shakllantirish texnologiyasi. Toshkent. B. 24-39.
3. Yo'ldoshev, J. G.,&Ishmuxamedov, R. (2008).Pedagogik texnologiya asoslari.Toshkent: TDPU. - 164 b.
4. Teshabaev, S. T. (2019). Innovatsion ta'lim texnologiyalari va kimyo fanini o'qitish metodlari.Toshkent: Universitet. B. 87-94.
5. Хуторской, А. В.(2003). Ключевые компетенции как компонент личностно-ориентированной парадигмы образования.Москва.
6.Тешабаев, С.Т, Қулматов, Р.А(2019). Табиий фанларни ўқитишда инновацион методлар.Тошкент: Университет.
7. Колмогоров, А. Н.(1988).О науке и научном методе.Москва: Наука.
8. Creswell, J. W.(2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (4th ed.).Thousand Oaks, CA: SAGE Publications.

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