

IMPROVING THE PROFESSIONAL TRAINING OF STUDENTS IN HIGHER EDUCATIONAL INSTITUTIONS IN ORGANIC CHEMISTRY ON THE BASIS OF AN INTEGRATIVE APPROACH

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Abstract. The quality of professional training in higher education, particularly in the field of organic chemistry, has become increasingly dependent on the effective integration of theoretical knowledge, practical skills, interdisciplinary awareness, and technological competence. This article explores the methodological and pedagogical aspects of improving the training of students in organic chemistry using an integrative approach. It analyzes the pedagogical tools necessary to merge chemical theory with research practices, digital technologies, professional communication, and ethical responsibility. The integration of chemical knowledge with modern environmental, medical, and technological issues is emphasized as a cornerstone for cultivating globally competent specialists in chemistry-related fields.

Keywords: Organic chemistry, professional training, integrative approach.

Introduction

Organic chemistry stands as a central subject in the curriculum of students studying natural sciences, biotechnology, pharmacy, and chemical engineering. However, traditional approaches to teaching this discipline often prioritize rote memorization of reaction mechanisms over analytical thinking and applied competencies. In light of this, there is an urgent need to reorient the training process towards integrative, student-centered, and research-based learning strategies that connect organic chemistry to real-world applications and interdisciplinary contexts.

The goal of this study is to outline the principles, pedagogical frameworks, and practical methodologies for improving the professional preparation of university students in organic chemistry using integrative approaches. This includes not only the refinement of content delivery but also the redesign of laboratory experiences, the incorporation of technology, and the formation of cognitive, communicative, and reflective competencies.

Materials and methods

Digital technologies play a pivotal role in facilitating integrative learning. Tools such as ChemSketch, Avogadro, PhET simulations, and online

spectroscopy databases enhance visual learning and experimental planning. Furthermore, learning management systems (LMS) like Moodle or Google Classroom help in structuring blended and hybrid learning experiences.

Virtual laboratories and AI-assisted platforms allow students to model complex reactions, analyze spectra, or simulate experimental outcomes in a safe, repeatable digital environment—thus expanding access to sophisticated learning beyond the constraints of physical labs [1].

Results and discussion

Beyond technical proficiency, one of the core goals of professional preparation in organic chemistry is the cultivation of what can be termed chemical thinking — the ability to conceptualize and manipulate abstract molecular behavior in the mind, translate symbolic representations into physical meaning, and make predictions based on reaction mechanisms. An integrative pedagogical model must therefore emphasize the cultivation of these mental models by combining symbolic, macroscopic, and particulate representations during instruction [2].

For example, when teaching electrophilic aromatic substitution reactions, instructors should guide students through the mechanistic logic using animated visuals, analogical reasoning (e.g., comparing electron-rich benzene to a magnet for electrophiles), and interactive simulations. When students learn to mentally simulate the dynamics of a reaction rather than merely memorize outcomes, they are more likely to transfer this competence across different reaction types and chemical contexts — a hallmark of expert-level understanding.

Professional readiness in science is not only about knowing “what” but also understanding “how” and “why.” Reflective practice — the ability to critically evaluate one’s own reasoning, decision-making processes, and learning strategies — is indispensable for fostering independent researchers and responsible professionals.

To this end, integrative instruction should incorporate structured reflection protocols. After each major laboratory session or thematic unit, students can be required to submit “reflection reports” addressing questions such as [3]:

What challenges did I encounter, and how did I respond?

How did my prior knowledge help or hinder my approach to this problem?

What would I do differently in a professional research context?

Such reflection fosters metacognition, reinforces scientific habits of mind, and aligns classroom experience with the iterative and self-critical nature of professional chemical research.

A comprehensive model of professional education must not neglect the ethical dimensions of chemistry as a discipline. Organic chemistry, while responsible for some of humanity's greatest achievements in medicine, agriculture, and industry, is also implicated in environmental degradation, toxic waste, and unsustainable manufacturing practices. Educating future chemists, therefore, means instilling a consciousness of chemical responsibility.

In the 21st century, organic chemistry is increasingly a global enterprise. Whether collaborating on international pharmaceutical research, publishing in multilingual journals, or navigating multinational regulatory frameworks, today's chemists must possess intercultural competence and scientific literacy across disciplines and borders [4].

Conclusion

Integrating theoretical knowledge with practical application, interdisciplinary content, digital tools, and soft skills development provides a comprehensive framework for improving the professional training of students in organic chemistry. An integrative approach transforms the classroom into a dynamic learning environment where students not only learn chemical facts but also apply them in real-world contexts, engage in research, develop critical thinking, and embrace ethical values. As global challenges continue to rise, the need for highly qualified, reflective, and interdisciplinary-minded chemists becomes ever more urgent, and the integrative model of education offers a viable pathway toward that goal.

References:

1. Allen D., Tanner K. Approaches to Biology Teaching and Learning: Infusing Active Learning into the Large-Enrollment Biology Class // CBE—Life Sciences Education. – 2005. – Vol. 4. – P. 262–268.
2. Pienta N.J. Teaching Professional Skills to Chemistry Graduate Students // Journal of Chemical Education. – 2016. – Vol. 93(9). – P. 1506–1510.
3. Wenzel T.J. Using Students' Reflective Writing to Develop Metacognitive Awareness in Chemistry Courses // Journal of Chemical Education. – 2020. – Vol. 97(7). – P. 1817–1823.
4. Eilks I., Hofstein A. Teaching Chemistry – A Studybook: A Practical Guide and Textbook for Student Teachers, Teacher Trainees and Teachers. – Rotterdam: Sense Publishers, 2013. – 336 p.