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ADDRESSING COMMON CHALLENGES IN CHEMISTRY COURSES FOR MEDICAL STUDENTS AND ENSURING ACTIVE STUDENT PARTICIPATION

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Annotation. This article analyzes the main difficulties encountered by medical students in learning chemistry and ways to overcome them. The research proposes innovative methods to ensure active student participation in chemistry education, including problem-based learning, collaborative learning strategies, digital technologies, and enhancing learning through establishing clinical connections. The article provides practical recommendations and promising approaches for designing and teaching chemistry courses in medical educational institutions.

Keywords: medical education, chemistry teaching, student difficulties, active learning, engagement strategies, problem-based learning, motivation, clinical connections.

Introduction

In medical education, chemical sciences are considered one of the fundamental sciences, as they create the necessary foundation for future doctors to master clinical sciences, understand disease mechanisms, and study pharmacotherapy principles. However, for many medical students, mastering chemistry subjects such as biochemistry, organic chemistry, general chemistry, and pharmaceutical chemistry presents serious challenges. These challenges are related to various factors, including the complexity of chemical concepts, abundance of abstract notions, mathematical calculations, and difficulties in understanding the connection between chemistry and medicine.

The ability of medical students to effectively master chemistry is important not only for academic success but also for future clinical practice. Modern medicine relies more than ever on understanding chemical processes - from drug action mechanisms to metabolic disorders. Therefore, in medical education, it is crucial to address students' difficulties in learning chemistry and ensure their active participation.

This article aims to identify the main challenges medical students face in studying chemistry, propose strategies to overcome them, and recommend innovative approaches to ensure active student engagement. The research is based on modern pedagogical methods, digital technologies, and best practices in medical education.

1. Common challenges faced by medical students in chemistry courses

1.1. Complexity of chemical concepts

One of the biggest challenges in chemistry for medical students is understanding complex chemical concepts and grasping the relationships between them. Topics such as chemical reaction mechanisms in organic chemistry and biochemistry, stereochemistry, and acid-base balance are particularly challenging for students.

1.2. The problem of visualizing abstract concepts

Visualizing abstract concepts such as molecular structures and the spatial arrangement of atoms and molecules is difficult for most students. Explaining three-dimensional molecular structures by depicting them on two-dimensional paper often fails to form a complete understanding in students.

1.3. Difficulties associated with mathematical calculations

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Mathematical problems, such as stoichiometric calculations of chemical reactions, determining concentrations, and calculating pH, are difficult for many students, especially those with insufficient basic training in mathematics.

1.4. Problems in understanding the connection with medicine

Many medical students ask, "Why do I need this?" when studying chemistry. The inability to see the connection between chemical concepts and clinical practice leads to decreased motivation and difficulties in mastering the material.

1.5. Terminological and linguistic complexities

The science of chemistry has its own special terminology, system of symbols, and "language." Mastering this "language" creates additional difficulties for medical students, especially if education is not conducted in their native language.

1.6. Lack of motivation

Most medical students perceive chemistry as a "mandatory" subject and show more interest in clinical sciences. This leads to a lack of motivation and superficial assimilation of educational material.

1.7. Time constraints and workload

Medical education programs usually include numerous subjects, and students cannot allocate enough time for in-depth study of chemistry due to time limitations and heavy workloads.

2. Strategies for overcoming difficulties

2.1. Improvement of teaching methodology

2.1.1. Gradual explanation of complex concepts

Clear and sequential explanation of chemical concepts from simple to complex helps students better grasp the material. Each new concept should be presented in connection with previously studied topics.

Practical recommendations:

• Dividing chemical concepts into components and explaining each part separately
• Explaining concepts through visual aids (diagrams, schemas)
• Connecting each concept with real-life examples

2.1.2. Use of visualization tools

The use of 3D models, animations, videos, and interactive simulations in explaining abstract chemical concepts allows students to visualize the material and better understand the concepts.

Practical recommendations:

• Using 3D models in the study of molecular structures
• Demonstrating chemical reactions through animations
• Visualizing processes at the molecular level using AR/VR technologies

2.1.3. Development of mathematical skills

Organizing additional classes for students struggling with mathematical calculations in chemistry, increasing the number of practical sessions, and using a step-by-step explanation methodology.

Practical recommendations:

• Organization of integrated lessons in cooperation with chemistry and clinical sciences teachers
• Analysis of problem situations based on clinical cases
• Explain the clinical outcomes of chemical processes

2.2. Connection with the clinical context

2.2.1. Integration of medical examples

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The use of clinical examples and medical cases in teaching chemical concepts helps students understand the connection between chemistry and medicine.

Practical recommendations:

• Connect each topic with medical examples.
• Chemical analysis of disease cases
• Study of the chemical structure and mechanisms of action of drugs

2.2.2. Creation of integrated courses

Teaching chemistry and clinical sciences in an integrated manner, such as biochemistry and pathophysiology, pharmaceutical chemistry and pharmacology, helps students see interdisciplinary connections.

Practical recommendations:

• Organization of integrated lessons in cooperation with chemistry and clinical sciences teachers
• Analysis of problem situations based on clinical cases
• Explain the clinical outcomes of chemical processes

2.3. Implementation of active learning methods

2.3.1. Problem-based learning

The problem-based teaching methodology allows students to study chemical concepts by solving real clinical problems.

Practical recommendations:

• Creating problem situations based on clinical scenarios
• Working in small groups and analyzing the problem
• Encourage students to conduct independent research

2.3.2. Collaborative learning

Methods of working in groups, learning in pairs, and peer-to-peer learning strengthen students' interaction and contribute to a deeper understanding of the material.

Practical recommendations:

• Implementation of cooperative projects
• Organization of peer learning sessions
• Encourage group discussions

2.3.3. Project-based learning

Providing students with the opportunity to implement projects at the intersection of chemistry and medicine develops their independent learning skills and increases their motivation.

Practical recommendations:

• Proposing clinical and chemical research projects
• Projects for the study of the mechanisms of action of drugs
• Study of the impact of environmental problems on human health

2.4. Use of digital technologies

2.4.1. Online resources and virtual laboratories

Online platforms, video lessons, interactive exercises, and virtual laboratories allow students to further study chemistry.

Practical recommendations:

• Use of distance learning platforms (Coursera, EdX)
• Apply virtual laboratory simulations
• Use interactive textbooks and apps

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2.4.2. Adaptive training systems

Adaptive learning systems based on artificial intelligence provide material tailored to the individual needs of each student and personalize the learning process.

Practical recommendations:

• Use of adaptive training programs
• Automatic assessment of student progress
• Identify weaknesses and recommend additional materials

2.4.3. Mobile applications and additional tools

Mobile applications designed for studying chemistry allow students to review the material at any time and in any place.

Practical recommendations:

• Use applications that visualize molecular structures
• Flashcards for studying chemical formulas and reactions
• Interactive tests and exercises

3. Strategies for ensuring active student participation

3.1. Increasing motivation

3.1.1. Confirmation of clinical significance

Constantly emphasizing the importance of chemistry in clinical practice, showing how it is used in medical practice, increases students' motivation.

Practical recommendations:

• Regularly cite clinical cases and examples
• Organize seminars explaining the role of chemistry in medicine
• Invite practicing physicians to the lesson process

3.1.2. Establishing a personal connection

Explain how chemical processes affect students' personal lives, health, and future professional activities.

Practical recommendations:

• Give examples from everyday life
• Identify students' personal interests and provide adapted examples
• Share stories from professional experiences

3.1.3. Demonstrating successful examples

Provide information about former students who have achieved good results in chemistry and their professional achievements, invite them.

Practical recommendations:

• Organize meetings with former students
• Share success stories
• Create Mentor Programs

3.2. Interactive teaching methods

3.2.1. Flipped classroom method

Independent study of theoretical material at home, and dedicate class time to discussions, problem-solving, and practical exercises.

Practical recommendations:

• Organization of integrated lessons in cooperation with chemistry and clinical sciences teachers
• Analysis of problem situations based on clinical cases

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• Explain the clinical outcomes of chemical processes

3.2.2. Application of game elements (gamification)

Include game elements in the learning process, such as rating systems, awards, contests, etc.

Practical recommendations:

• Creation of chemical "escape rooms"

• Conducting online quizzes and competitions

• Implementation of a system of digital badges and awards

3.2.3. Increase the number of practical classes

Increasing the possibilities of applying theoretical knowledge in practice, allocating more time for laboratory work, clinical simulations, and other practical exercises.

Practical recommendations:

• Organization of interactive laboratory classes

• Creation of opportunities for observing chemical processes in the clinical environment

• Participation in real laboratory tests and examinations

3.3. Improvement of the assessment system

3.3.1. The role of formative assessment

Regular use of formative assessment methods allows students to identify and timely fill gaps in their knowledge.

Practical recommendations:

• Conducting short quizzes and tests

• Providing self-assessment tools

• Constructive feedback

Regular use of formative assessment methods allows students to identify and timely fill gaps in their knowledge.

Practical recommendations:

• Conducting short quizzes and tests

• Providing self-assessment tools

• Provide constructive feedback

3.3.2. Alternative assessment methods

Expansion of the assessment system through projects, portfolios, presentations, and not limited to written exams.

Practical recommendations:

• Assessment based on clinical conditions

• Creation of project portfolios

• Assessment of practical skills

3.3.3. Strengthening feedback mechanisms

Providing students with regular and constructive feedback, monitoring and supporting their progress.

Practical recommendations:

• Conducting individual consultations

• Provide detailed reviews of written works

• Monitoring student development dynamics

3.4. Creation of support systems

3.4.1. Additional assistance resources

Organization of additional classes, tutoring classes, and consultations for struggling students.

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Practical recommendations:

• Organization of additional classes

• Provide online consultations

• Preparation of auxiliary educational materials

3.4.2. Peer learning system

Engaging senior students or students with good academic performance as tutors.

Practical recommendations:

• Create a peer-to-peer learning program

• Organization of training groups

• Training and support of tutors

3.4.3. Psychological Support

Reduce students' anxiety and stress related to chemistry, increase their self-confidence.

Practical recommendations:

• Training in anxiety reduction techniques

• Consulting on learning skills development

• Offering psychological support services

4. Innovative approaches and future prospects

4.1. Personalization and adaptive learning

Modern technologies and pedagogical methods create personalized learning opportunities, adapted to the individual needs of students.

Promising directions:

• Adaptive learning systems based on artificial intelligence

• Opportunities to create your own learning path

• Materials tailored to students' learning styles

4.2. Multidisciplinary approach

The teaching of chemistry in integration with other medical disciplines is forming as a future trend.

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