Exploration and Practice of Informatization in Organic Chemistry Teaching

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Abstract: Organic chemistry is a fundamental course for chemical engineering students, yet it faces numerous challenges due to limited instructional time, extensive content, and the complexity of its theoretical concepts. These factors often hinder effective teaching and learning. This study explores the integration of modern information technologies in the teaching of organic chemistry, within the context of the digital age. By utilizing tools such as Xuexitong, Rain Classroom, videos, flash animations, comics, images, online resources, QQ, WeChat, and email, a hybrid teaching model combining both online and offline methods is proposed. This approach incorporates various information technologies into an "inquiry-based" teaching methodology. In this model, students are placed at the center of the learning process, with teachers acting as facilitators who guide and organize the learning journey. This approach aims to enhance students' autonomy, creativity, and critical thinking. The teaching process follows an inquiry-based structure of "posing questions, analyzing problems, and solving problems", which nurtures students' curiosity, willingness to explore, and innovative thinking. This method addresses the challenges of traditional teaching models, such as difficulty in learning and the disconnect between theoretical knowledge and practical application.

Keywords: Organic Chemistry; Informatization; Inquiry-Based Teaching

1. Introduction

Organic chemistry is a compulsory course for many engineering disciplines, including Chemical Engineering and Technology, Pharmaceutical Engineering, Materials Science and Engineering, Metallurgical Engineering, and Environmental Science and Engineering. The course primarily focuses on the composition, properties, structure, preparation methods, and interconversion patterns of organic compounds. Its content spans multiple industrial sectors, such as chemical industries, biomedicine, materials manufacturing, and environmental pollution control. Additionally, it is closely integrated with practical laboratory work, making it a vital foundational course [1].

However, with the reform of teaching and curriculum plans, many universities have been reducing the number of hours dedicated to organic chemistry courses. Despite this, organic chemistry remains a challenging subject due to its vast and complex content, abstract theoretical principles that are difficult to grasp, and the varied reaction mechanisms. These factors make it difficult for students to learn effectively. Moreover, traditional teaching methods, which focus heavily on "cramming instruction", often overlook the active role of students in the learning process, posing further challenges for the effective teaching of organic chemistry. In light of these issues, this study draws from the specific context of our institution, the learning abilities of students, and my years of teaching experience. It explores the application of modern information technologies in the context of the digital era. The study suggests reforms to teaching philosophy, models, and methods, offering practical recommendations based on this exploration.

2. Existing Issues and the Necessity of "Inquiry-Based" Teaching

Organic Chemistry is typically scheduled for the second semester of the freshman year or the first semester of the sophomore year. After entering university through the rigorous exam-driven "test-intensive" training, most students approach their studies with a passive, receptive learning style [2]. By the time they reach university, after the adjustment period of their first semester and the relative relaxation of their learning environment and mindset, coupled with the free use of mobile phones, computers, and other information tools, many students become less inclined to engage in steady, methodical study. Instead, they often prefer to quickly complete assignments and prepare for exams [2], leading to a superficial grasp of the material. Most universities still rely on traditional teaching methods, where teachers lecture using multimedia and blackboard notes, while students passively listen and take notes. This approach allows teachers to cover a large amount of organic chemistry content within a limited time frame, and students are able to take notes for later review and reinforcement. However, it lacks the modern "student-centered" teaching philosophy, and the classroom atmosphere tends to be dry, making it difficult to foster students' interest in learning. Furthermore, the limited opportunities for students to think critically about and discuss the course material often result in rote memorization, which hampers the development of their problem-solving and critical thinking skills. Thus, it is imperative to actively engage students' interest and willingness to explore in order to address the issues of passive learning, difficulty in mastering content, and lack of focus in the classroom.

Implementing "inquiry-based" teaching in Organic Chemistry not only places the student at the center of the learning process, but also transforms the teacher into the organizer and guide of the learning journey, fostering students' autonomy, creativity, and engagement. The entire teaching process follows the "posing questions - analyzing problems - solving problems" structure. For example, a question could be posed: "Why does structure determine properties?" [3] Students can then analyze this by citing examples, such as the sp2 hybridization of alkenes, which leads to electron-rich double bonds, thereby making alkenes prone to electrophilic addition reactions. This teaching model not only diminishes the teacher's absolute control over the course, but also emphasizes active, frequent student involvement in critical thinking, which is essential for developing their intellectual abilities. This approach nurtures students' curiosity, desire to explore, and innovative spirit, addressing the issues in traditional teaching methods such as difficulty in learning and the abstract, dry nature of theoretical knowledge.

3. Leveraging Modern Information Technology Tools to Enhance Teaching

In the context of the modern digital era, it is essential to integrate the internet and diverse teaching methods in a way that allows students to transform digital tools from entertainment devices into valuable learning aids. By effectively harnessing the potential of these tools, such as smartphones and computers, students can be encouraged to use them for educational purposes rather than purely recreational ones.

The first step in this integration is the implementation of a blended online-offline teaching model. This model not only optimizes the design of online teaching resources but also caters to the demands of both digital and traditional learning environments. Teaching materials should be adapted into formats suitable for online presentation, ensuring digitalization and interactivity. In addition to recording MOOC videos, educators should create or collect various multimedia materials from the internet to enhance the learning experience. Platforms such as Xuexitong or New Cloud Classroom can be used to develop custom interactive online animations, which increase student engagement and immersion in the learning process. By utilizing the data analysis features of these platforms, teachers can offer personalized learning paths and resource recommendations, tailored to the diverse needs and backgrounds of their students. Furthermore, diverse teaching methods compatible with the blended model—such as flipped classrooms, peer learning, and online discussions—can be introduced to encourage active learning and foster critical thinking. These methods promote student interaction and collaboration, which helps create a more dynamic and engaging learning environment [4,5].

In addition to online platforms, students can be directed to high-quality educational resources from well-known academic platforms. For instance, online courses curated by esteemed professors like Professor Li Yanmei from Tsinghua University or Professor Luo Yiming from Central South University can broaden students' knowledge base. By guiding students to utilize these platforms for information retrieval, they can independently search for and access the resources that best support their learning needs [6]. Before class, students can benefit from micro-lecture videos provided by online platforms to focus on key concepts. During class, various digital tools—such as Rain Classroom, videos, animations, comics, images, and PowerPoint presentations—can be used to enrich both the content and delivery of lessons. These resources, combined with group discussions and collaborative inquiries, enable teachers to facilitate student-centered learning, where students take the lead in their educational journey. After class, interactive platforms like Xuexitong, QQ, WeChat, and email can serve as channels for continued teacher-student communication, offering post-class support and clarification.

4. Integration of Theoretical Knowledge and Practical Application

Traditionally, the teaching of Organic Chemistry has focused primarily on theoretical aspects, often disconnected from real-world applications and the advancements of contemporary society and technology. However, Organic Chemistry is intrinsically practical and highly relevant to everyday life. Common substances such as acetic acid and ethanol are organic compounds, and understanding their structures, properties, synthesis, and applications are fundamental to the study of Organic Chemistry. Therefore, teaching Organic Chemistry should not be divorced from practical life and societal developments. Furthermore, organic chemistry laboratory courses are foundational, hands-on classes where experimental principles derive from theoretical teachings in organic chemistry. Incorporating experimental content, including lab videos, into the organic chemistry curriculum can significantly aid students in grasping complex concepts more effectively. Issues encountered or uncovered during lab sessions can be addressed in the theoretical classroom through an "inquiry-based teaching model", where students are encouraged to analyze and resolve problems using their theoretical knowledge. This approach achieves a seamless fusion of theory and practice, facilitating a deeper understanding and mastery of key concepts.

Thus, a teaching model that integrates theoretical lectures with laboratory sessions not only complements both teaching methods but also stimulates student engagement and initiative. This approach enhances the solid grasp of theoretical knowledge while fostering self-learning abilities. A teaching model that tightly interweaves theoretical knowledge with experimental operations tends to develop students' problem-solving skills, guiding them in learning experimental design and methodology, which is pivotal in cultivating practical skills [7].

For example, consider the incorporation of amusing and illustrative methods into classroom instruction for optimal learning. When introducing the acidity of "carboxylic acids", one might use a comic strip or flash animation to narrate a story: "Mom says, ‘The kettle has limescale, it's so dirty!’ Dad replies, ‘Let's clean it with acetic acid!’ After a while, Mom exclaims, ‘Wow! The acetic acid made the kettle so clean!’" This simple narrative effortlessly introduces the acidic properties of carboxylic acids. Following the story, a question can be posed based on the previously covered material: "Students, please design an experiment to investigate the relative acidity of acetic acid, carbonic acid, and phenol." Students would then be guided to propose an experiment, using the property that a strong acid can generate a weak acid, to figure out a simple and effective method for comparing their acid strengths. Students present their experimental plans, and the teacher engages them in discussion, ultimately presenting the optimal solution, as illustrated in Figure 1. This method helps students thoroughly understand the concept of carboxylic acid acidity and their relative strengths. The incorporation of engaging stories and experimental demonstrations makes the explanation of carboxylic acids' structure, chemical properties, and reaction mechanisms easier and more relatable, significantly boosting student enthusiasm for learning. In conclusion, combining "inquiry-based" teaching models, various digital tools, and the integration of theoretical and practical approaches transforms the otherwise dry and monotonous subject of organic chemistry into a vivid and engaging discipline. This combination makes the material more accessible and comprehensible to students, resulting in more effective teaching outcomes.

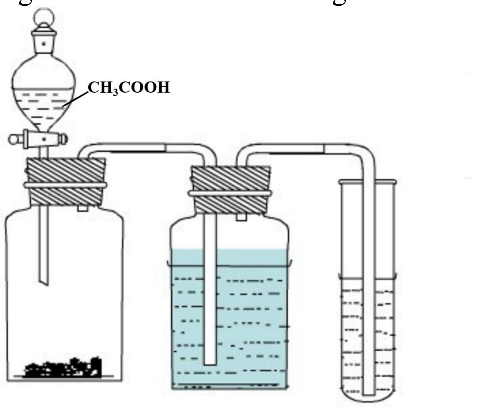

Figure 1. Experimental Design to Compare the Relative Acidity of Acetic Acid, Carbonic Acid, and Phenol

5. Teaching Recommendations

Organic Chemistry is a fundamental course in chemical engineering; however, as highlighted earlier, several issues persist in its teaching. This study, considering the context of the modern information age, proposes the use of various modern information technologies such as Xuexitong, Rain Classroom, videos, flash animations, comics, images, online course resources, and communication tools like QQ, WeChat, and email, to implement blended learning (a combination of online and offline instruction). By integrating these technological tools, an "inquiry-based" teaching approach can be adopted. The focus of this approach is on student-centered learning, where the teacher acts as the organizer and guide of the entire learning process, effectively promoting students' autonomy, initiative, and creativity. The teaching process follows a central inquiry framework of "posing questions – analyzing problems – solving problems", fostering an environment where students develop a mindset that encourages questioning, exploration, curiosity, and innovation. This approach addresses common challenges in traditional teaching, such as the difficulty of learning and the disconnect between theoretical knowledge and practical reality. Moreover, it is recommended to integrate theoretical knowledge with experimental practice in Organic Chemistry. Analyzing theoretical concepts can help students understand the basic principles and objectives of laboratory experiments. Additionally, guiding students to reflect on related theoretical knowledge during experimental operations can enrich the theoretical content of the classroom and reinforce students' mastery of key concepts.

Furthermore, the course content should evolve in tandem with advancements in the field of chemistry, embedding modern chemical theories throughout the organic chemistry curriculum. For example, topics such as electronic effects, stereoelectronic effects, and the relationship between structure and properties should be incorporated. This approach will enhance the depth and complexity of the course. Additionally, introducing cutting-edge research in organic synthesis, such as new reactions, reagents, methods, and research progress related to the core concepts, will broaden students' understanding and keep them engaged with current developments in the field [8].

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