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EXPLORATION OF AI EMPOWERED EXPERIMENTAL TEACHING REFORM IN COMPUTER SCIENCE

Yu Zhang
Beihai Campus of Guilin University of Electronic Technology, Beihai 536000, Guangxi, China.
Corresponding Email: 76474853@qq.com

Abstract: In the context of rapidly advancing information technology, Artificial Intelligence (AI) has profoundly impacted various industries, presenting new challenges and opportunities for higher education, particularly in computer science experiment teaching. Despite covering fundamental topics such as programming basics and algorithm design, current computer science experiment courses often suffer from a disconnect between content and real-world applications, with outdated materials that fail to keep pace with industry developments. This gap leaves students ill-prepared to navigate rapidly evolving technological landscapes. Additionally, traditional teaching methods and assessment models limit students' opportunities for independent exploration and innovation, while outdated laboratory facilities further hinder the quality of experimental teaching. To address these challenges, this study proposes AI-enabled reforms in experimental teaching. The strategies include establishing a "multi-dimensional, practice-oriented" curriculum system, implementing a "data-driven, precision-guided" teaching model, promoting "self-directed, flexible progression" learning paths, and building a "collaborative innovation and open-sharing" experimental teaching environment. These reforms aim to enhance students' practical skills, increase the practical relevance of courses, and comprehensively improve the quality of experimental teaching, ultimately preparing students to meet the demands of future industry needs.

Keywords: Artificial intelligence; Computer science; Experimental teaching; Multi-dimensional Curriculum System; Personalized teaching

1 INTRODUCTION

In today's rapidly evolving information technology landscape, Artificial Intelligence (AI) is transforming industries at an unprecedented pace, posing both challenges and opportunities for higher education, particularly in the field of computer science[1-3]. As the demand for computer science professionals with advanced skills continues to grow, traditional experimental teaching methods are increasingly proving inadequate in cultivating students' practical abilities, innovative thinking, and adaptability to future technological environments. While computer science experimental courses at universities typically cover fundamental topics such as programming basics, algorithm design, and operating systems, these courses often remain confined to theoretical validation and reinforcement, lacking close integration with rapidly evolving real-world applications. This disconnect is particularly evident in cutting-edge areas such as AI, big data processing, and cloud computing, where the pace of content updates lags behind industry advancements, leaving students ill-prepared to respond effectively to technological changes[4-5].

The prevailing experimental teaching approach largely relies on the traditional "teacher-directed, student-executed" model, which emphasizes standardized procedural steps while neglecting the development of students' abilities for independent exploration and innovative thinking. This rigid teaching model limits students' flexibility in addressing complex problems, and the assessment methods, overly focused on final outcomes, fail to fully capture students' learning processes and cognitive strategies. Moreover, outdated laboratory facilities and limited environmental flexibility further constrain the scope and depth of experimental teaching. The current hardware and software configurations in laboratories are often insufficient to meet the demands of complex contemporary experiments, depriving students of authentic technical experiences during practical exercises[6-7].

Against this backdrop, the need for reform in experimental courses to enhance students' practical skills, increase the applicability of course content, and improve overall teaching quality has become a pressing concern in computer science education. This paper aims to explore how AI-enabled approaches can be leveraged to construct a multi-dimensional experimental curriculum system, optimize data-driven teaching models, design flexible learning pathways, and build a collaborative and innovative experimental teaching environment. These efforts are intended to comprehensively elevate the quality and effectiveness of computer science experimental teaching, ultimately producing high-quality graduates equipped with comprehensive application capabilities and innovative potential.

2 CURRENT STATE OF COMPUTER SCIENCE EXPERIMENTAL TEACHING

2.1 Lack of Integration with Real-world Applications and Delayed Content Updates

Computer science experimental courses hold a crucial position within university curricula, aiming to help students translate theoretical knowledge into practical skills through hands-on experience. However, there are several notable issues and shortcomings in the current design of these courses[8]. Firstly, in terms of course content, while most universities offer experimental courses covering fundamental topics such as programming basics, algorithm design, computer networks, and operating systems, these courses tend to focus predominantly on the verification and reinforcement of theoretical knowledge. They often lack a close integration with real-world applications, particularly in rapidly evolving fields such as artificial intelligence, big data processing, and cloud computing. The pace of content updates in these areas is often slower than the advancements in the industry, leaving students inadequately prepared to cope with the fast-changing technological environment.

2.2 Monotonous Teaching Methods and Overemphasis on Final Outcomes

In terms of teaching methods, the current experimental courses largely rely on the traditional "teacher-directed, student-executed" model. Most courses emphasize standardized procedural steps, with students typically following the instructions in the laboratory manuals mechanically, without engaging in deep critical thinking or independent exploration[9-10]. This monotonous teaching approach not only limits the development of students' innovative thinking but also weakens their ability to address complex problems. Moreover, the assessment of experimental work often focuses heavily on the final results rather than providing a comprehensive evaluation of students' thought processes and problem-solving strategies. This emphasis on end results further reduces student motivation and engagement in the experimental learning process.

2.3 Outdated Laboratory Equipment and Lack of Flexibility in the Environment

Outdated laboratory facilities also pose a significant constraint on the quality of experimental courses. Many university computer science laboratories are equipped with outdated hardware and software that fail to meet the demands of current complex experiments. For instance, traditional laboratory environments are often incapable of supporting large-scale data processing or the training of sophisticated AI models, which prevents students from gaining authentic technical experience during their practical exercises. Additionally, the lack of flexibility in laboratory environments often makes it difficult to accommodate the specific needs of different experimental courses, further limiting the breadth and depth of the experimental curriculum.

2.4 Insufficient Connection with Industry Frontiers, Lack of Industry Cases and Practical Application Scenarios

The current design of experimental courses often lacks effective alignment with the cutting-edge advancements in the industry. As technology continues to evolve, the industry’s expectations for computer science professionals, particularly in emerging fields such as artificial intelligence, the Internet of Things, and blockchain, are rising. However, the content of university experimental courses frequently lags behind the pace of industrial development, resulting in a disconnect between the knowledge and skills acquired by graduates and the demands of the workforce. Additionally, the availability of industry-related case studies and practical application scenarios within experimental courses is limited, depriving students of opportunities to practice and truly comprehend the application of the latest technologies in industrial settings.

3 STRATEGIES FOR EXPERIMENTAL COURSE TEACHING REFORM

3.1 Reform Objectives

The primary objective of the reform is to enhance students' practical abilities. Experimental teaching reform should focus on cultivating students' hands-on skills and problem-solving abilities by introducing more challenging and practically valuable experimental projects. These projects would enable students to deepen their understanding of theoretical knowledge through practice and learn to flexibly apply what they have learned to real-world scenarios.

Another core objective of the reform is to increase the practical relevance of the courses. The content of experimental courses needs to be closely aligned with current industry trends, particularly in cutting-edge technologies such as artificial intelligence, big data, and the Internet of Things. By incorporating real-world application cases of these technologies, students can not only learn the latest techniques and methods but also understand how these technologies are applied in different industries, thereby enhancing their competitiveness in the job market.

Furthermore, improving the overall quality of teaching is the ultimate goal of the reform. The enhancement of teaching quality is reflected not only in students' academic performance but also in the development of their initiative, creativity, and comprehensive abilities throughout the learning process. By optimizing course structure and content, and employing diverse teaching methods, experimental teaching will evolve from a mere knowledge transmission process to one that stimulates students’ potential and promotes their holistic development.

3.2 Reform Content

3.2.1 Establishing a "Multi-dimensional, Practice-oriented" Experimental Curriculum System

In today’s rapidly evolving technological environment, relying solely on knowledge from a single discipline is insufficient to address complex problems. Therefore, the reform of experimental courses should focus on establishing a "multi-dimensional, practice-oriented" curriculum system. The core of this system lies in integrating multidisciplinary content, organically combining fields such as artificial intelligence, data science, and computer engineering to enable cross-disciplinary application of knowledge. Through this integration, students will not only grasp the fundamental principles of various disciplines but also develop the ability and innovative thinking required to solve real-world problems using cross-disciplinary knowledge.

In practice, this goal can be advanced by designing experimental projects that encompass multiple disciplines. For example, in AI-related experimental courses, students would not only be required to master the design and implementation of algorithms but also integrate data science knowledge by processing and analyzing large datasets, applying these data to train models. This multidisciplinary approach not only enhances the practical relevance of experimental courses but also helps students better understand and apply their knowledge in complex scenarios, thereby fostering comprehensive abilities to navigate dynamic industrial environments.

Simultaneously, introducing industry project practices is another crucial component of this reform. Based on current industry development needs, representative real-world projects should be selected as experimental case studies through collaboration with enterprises. By solving these real-world problems, students can gain a profound understanding of the application scenarios of AI technologies. For instance, in an experimental project within the field of intelligent manufacturing, students would engage in the entire process, from requirements analysis and algorithm design to system implementation. Such industry-connected experimental courses not only expose students to the latest technologies and practices during their academic studies but also lay a solid foundation for their future careers.

3.2.2 Implementing a "Data-supported, Precision-guided" Teaching Model

To enhance the targeting and effectiveness of experimental teaching, the reform should implement a "data-supported, precision-guided" teaching model. This model leverages intelligent learning assessment systems that use big data analysis and AI technologies to conduct real-time evaluations of students' learning progress and experimental outcomes, thereby providing personalized learning suggestions for each student.

Specifically, an intelligent learning assessment system can comprehensively analyze students' operational data, learning behaviors, and experimental results to identify potential difficulties and issues encountered during the learning process. For example, the system might detect that a student frequently makes errors in a particular experimental step, prompting it to automatically recommend relevant supplementary resources or provide further guidance. This data-driven precision guidance not only helps students promptly correct their learning deficiencies but also significantly enhances their learning outcomes.

By deeply analyzing students' learning data, instructors can quickly identify shortcomings in their teaching, dynamically adjusting the content and difficulty of experimental courses to better meet the diverse learning needs of students. For instance, based on students' overall performance and feedback, instructors may increase or decrease the difficulty of certain experimental tasks or rearrange the sequence of experiments to improve the coherence of the course and the efficiency of students' learning. This dynamic adjustment mechanism ensures that experimental courses maintain high standards while also being flexible enough to accommodate the personalized needs of students.

3.2.3 Promoting a "Self-directed, Flexible Progression" Learning Pathway

The core of this strategy lies in the modular design of experimental courses, where the curriculum is divided into multiple independent modules, each focusing on a specific area of knowledge or skill. Students can independently select and combine different modules based on their interests and career plans, thereby achieving personalized learning objectives. Figure 1 illustrates three experimental module groups, with arrows indicating overlapping areas. For example, a student interested in AI algorithm development might choose experimental modules that include algorithm design and model optimization. This self-directed learning pathway not only allows students to explore their areas of interest in greater depth but also better prepares them for their future careers.

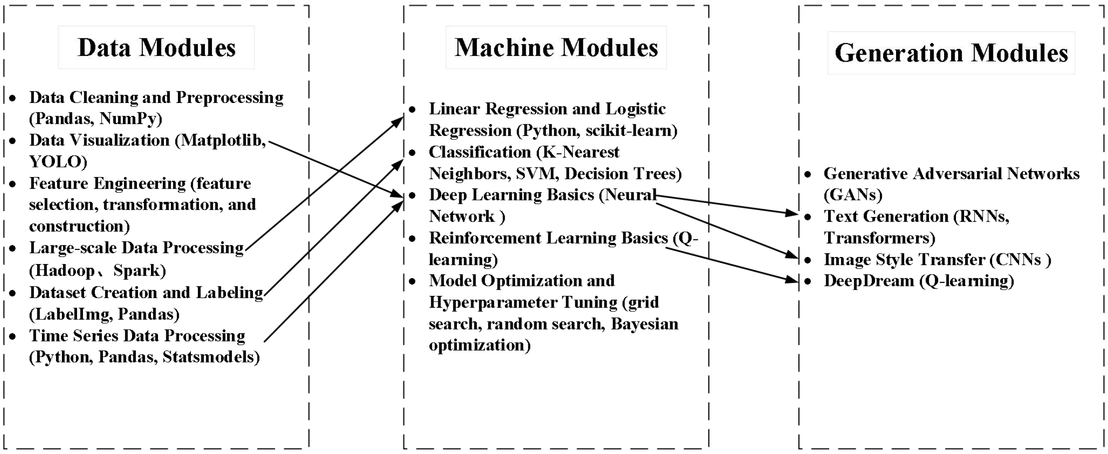

Figure 1 The Classification and Intersection of Experimental Module Groups

Supporting flexible scheduling of experiments is also a key component of this strategy. By introducing online experimental platforms and remote virtual lab environments, students can conduct experiments outside of regular class hours and manage their progress more flexibly. For example, students may continue working on experiments beyond the lab's scheduled hours or revisit experiments after completion to reinforce their understanding. This flexibility not only enhances learning efficiency but also accommodates different learning paces, ensuring that each student can fully grasp the material. By offering flexible learning pathways and schedules, the reform effectively meets students' individual needs and promotes their overall development.

3.2.4 Building a "Collaborative Innovation and Open-sharing" Experimental Teaching Environment

To cultivate students' innovation capabilities and teamwork skills, the reform of experimental teaching should also focus on building a "collaborative innovation and open-sharing" teaching environment. The core of this environment is fostering teacher-student co-innovation through a project-driven teaching model, which encourages both teachers and students to collaborate in designing and implementing experimental projects. This collaboration not only stimulates students' creativity but also develops their ability to work collaboratively in solving problems.

In this model, teachers are no longer mere transmitters of knowledge but become collaborators with students. Together, teachers and students can determine the themes of experimental projects, design the experimental framework, and work closely throughout the execution process. This cooperative teaching approach not only engages students more actively in the experimental process but also helps them cultivate critical thinking and innovative skills in practice. For example, in an open-ended experimental project, teachers and students might jointly research a new algorithm, explore its applications in specific fields, and continuously refine it based on experimental results.

Strengthening university-industry collaboration is another critical element in building an open-sharing experimental teaching environment. By integrating industry experts and resources into the design and implementation of experimental courses, the curriculum can be more closely aligned with industry needs, ensuring that the content remains cutting-edge and practically relevant. University-industry collaboration not only provides students with more internship and employment opportunities but also offers new perspectives and resources for teachers' research and teaching. For instance, industry experts might be invited to participate in course design or organize student visits to corporate R&D departments to learn about the latest technologies and industry trends. This model of university-industry cooperation not only enhances students' practical skills but also boosts their competitiveness in the future job market.

4 CONCLUSION

Through the exploration of AI-enabled reforms in computer science experimental teaching, this study has proposed a series of specific strategies aimed at enhancing the quality of experimental teaching and improving its alignment with modern industry demands. Establishing a multi-dimensional, practice-oriented experimental curriculum system can cultivate students' comprehensive application skills and innovative thinking. The implementation of a data-supported, precision-guided teaching model makes the teaching process more personalized and efficient. Meanwhile, promoting self-directed, flexible progression learning pathways provides students with greater freedom in their studies, and building a collaborative innovation and open-sharing experimental teaching environment further stimulates students' creativity and teamwork abilities.

Overall, this study not only provides a theoretical foundation and practical guidance for current reforms in computer science experimental teaching but also points to future directions for educational reform. As AI technology continues to advance, the reform of experimental teaching must also progress to ensure that education and technology develop in tandem, ultimately producing more outstanding talents capable of leading future technological innovation.

COMPETING INTERESTS

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