"Integrated, Three-Tiered" Digital Empowerment in Teaching Reform and Practice of Engineering Drawing

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Abstract: The current Engineering Drawing course faces challenges such as traditional teaching methods failing to meet students' personalized learning needs and unsatisfactory teaching outcomes. To address these issues, this study introduces advanced digital teaching tools and methods to improve teaching quality and student learning outcomes. A blended teaching model was adopted, integrating virtual reality technology, online learning platforms, and intelligent assessment systems. An "integrated, three-tiered" "theory-practice" project was designed to verify its effectiveness. Results show that digital empowerment in teaching reform significantly increased students' interest and performance, and enhanced their spatial thinking and practical skills.

Keywords: Digital; Empowerment; Engineering Drawing; Teaching Reform

1. Introduction

The rapid advancement of technology has deeply integrated digital tools into various fields, significantly impacting traditional industries. Following the release of the Notice on the Action Plan for Educational Informatization 2.0 [1] and China Education Modernization 2035, [2] there is an urgent need to innovate teaching methods using digital technology to enhance educational quality and effectiveness. This is a crucial issue for future course reforms [3]. Engineering Drawing is a foundational course for engineering students, aimed at cultivating innovation and craftsmanship [4]. Skills in interpreting, drawing, and designing are essential for engineering professionals. The "practical training" component holds a special place in the course, playing a vital role in the balanced development of students' knowledge, skills, thinking, and overall quality [5]. Through practical training, students consolidate their theoretical knowledge of drawing, understand national drawing standards, improve their drawing and interpretation skills, and develop the ability to apply knowledge to solve real-world problems, laying a solid foundation for advanced courses [6-7].

2. Current Teaching Situation of the Course

The teaching system for the Engineering Drawing course in the materials program at Hanshan Normal University was established in early 2016. Although there have been some reforms in recent years, the basic framework remains unchanged. Due to credit limitations, the course offers limited hours, which poses challenges in adapting to the digital age. Traditionally, the course has been divided into 24 hours of theory followed by 24 hours of practical training. This structure ensures that students acquire basic skills in interpreting and drawing, but it also has drawbacks. Theoretical lessons are often monotonous, practical hours are insufficient, and students struggle with retaining basic concepts. With limited time, the focus is primarily on basic software operations, neglecting the development of essential engineering skills like standardized expression. Therefore, we need to reform the content and teaching methods of the "Engineering Drawing Lab" to better suit the characteristics of the materials program and the specific needs of the course.

3. Reform and Practice of "Integrated, Three-Tiered" Digital Empowerment Teaching

3.1 Establishing a Course Teaching System with "Three-Standard Integration and Three-Dimensional Enhancement"

To meet the needs of digital education and the development of new engineering disciplines, as well as the requirements of the materials program, we have revised and improved the Engineering Drawing course. This revision

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draws on the university's strengths in ceramic materials, focuses on student-centered and outcome-oriented teaching, and incorporates educational goals related to ideological and political theories teaching in all courses. Local industry demands for engineering skills have also guided the course content. The new teaching system, called "integrated, three-tiered", moves away from the traditional, rigid approach to course content. It aims to enhance engineering application skills through a structured framework (see Figure 1).

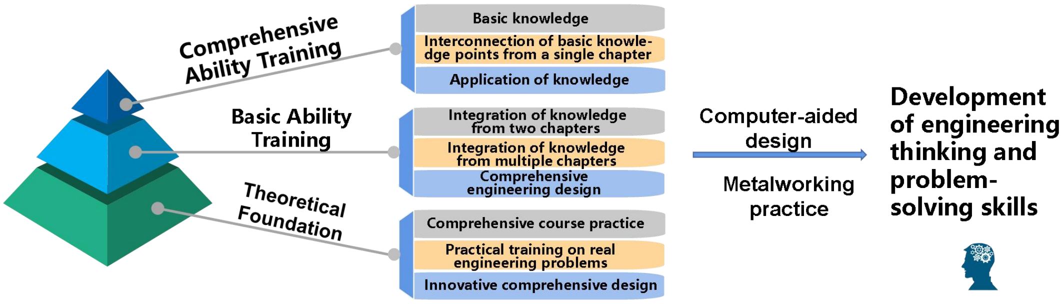

Figure 1. Integrated Three-Tiered Course Reform

3.2 Implementation of the "Integrated, Three-Tiered" Teaching Method

In accordance with the characteristics of the Engineering Drawing course, which aims to cultivate students' engineering application abilities, the teaching process refines theoretical foundations (projections of points, lines, and planes, as well as three-view drawings, 1-24 class hours). This theoretical instruction is synchronized with practical knowledge in the latter half of the course (25-30 class hours), emphasizing verification through practical operations complemented by smaller comprehensive training exercises. This approach not only deepens the understanding of theoretical concepts but also nurtures fundamental experimental skills and applications. In the later stages of the course (31-39 class hours), comprehensive experiments are introduced, reflecting a combination of knowledge points from at least two chapters, thereby consolidating skills and applications while strengthening interdisciplinary connections. Building on the foundational theory and practical skills, the latter part of the course (40-48 class hours) incorporates design-oriented practical training, focusing on real-world projects. Through this design-based training, students develop innovative awareness, a research-oriented mindset, and the ability to identify, analyze, and solve problems. The design training emphasizes personalized educational approaches, encouraging students to leverage their strengths and interests for individualized development. In selecting training content, the aim is to integrate knowledge acquisition, autonomy, applicability, and openness, thereby highlighting a personalized training model.

3.3 Development of Online Teaching Resources and Introduction of an Open Teaching Model

Throughout the teaching process, a digital teaching approach is employed, leveraging online teaching resources to assist students in pre-class preparation, in-class learning, and post-class review. By engaging with online resources prior to classes, students can familiarize themselves with course content, enhancing their comprehension during lectures. During class, questioning techniques are utilized to encourage active thinking and exploration, enabling students to construct their own knowledge frameworks. In this interactive process, the instructor provides feedback and guidance based on students' responses, aiding their understanding of the material.

In the foundational theory segment, a diverse array of teaching methods is employed to stimulate students' interest and engagement. By prompting students with questions, and facilitating discussions based on prior knowledge, their cognitive sparks are ignited, allowing them to build new knowledge upon existing concepts. This approach not only deepens students' grasp of theoretical content but also cultivates their critical thinking and innovative abilities. In the practical training component, a blended learning model combining online and offline methodologies is implemented. This maximizes the use of online resources, supplemented by multimedia presentations and practical operation videos for virtual instruction. A virtual online laboratory has been established, providing various experimental equipment and environments, enabling students to conduct experiments from home. This method enhances their mastery of experimental skills and application of knowledge, while also fostering their autonomous learning and problem-solving capabilities. In the later stages of the course, a comprehensive training project is introduced, where students work in groups to apply the knowledge acquired throughout the course to complete an innovative training project. The project task is announced one month in advance, allowing ample time for preparation and reflection. During the implementation phase, necessary guidance and support are provided to ensure the project progresses smoothly. Through this method, students are better equipped to apply their learning to real-world projects, thereby developing their teamwork and innovative thinking skills.

4. The Effectiveness of Course Reform Empowered by Digitalization

The integrated, three-tiered teaching reform empowered by digitalization has yielded remarkable results in enhancing students' interest in learning, academic performance, spatial reasoning abilities, and practical skills. Firstly, after engaging with virtual reality technologies and online learning platforms, students exhibit significantly higher levels of interest and participation, contrasting sharply with traditional teaching methods. The hands-on experience gained through comprehensive innovation projects allows students to intuitively grasp complex engineering design tasks, thereby boosting their initiative and enthusiasm for learning.

In terms of academic performance, students' results post-reform show a substantial improvement compared to their pre-reform scores, particularly regarding the completeness and accuracy of complex engineering design tasks. This demonstrates that the digitally empowered teaching methods significantly enhance students' mastery and application of knowledge. Utilizing virtual reality technologies and computer-aided design software, students can practice in a virtual environment, thereby better acquiring the core skills of engineering drawing.

Moreover, the enhancement of students' spatial reasoning capabilities stands out as a crucial achievement of the digital teaching reform. Through integrated engineering design training, students gain a deeper understanding of spatial relationships and structural characteristics, which are essential for mastering the engineering drawing course. The post-reform assessments reveal that students perform significantly better in spatial reasoning tests than they did before, further validating the effectiveness of digital teaching tools in fostering students' spatial thinking skills.

5. Application Scenarios and Limitations of Research Findings

The practical application and impact of the research findings in educational settings are manifested in several key areas. Firstly, the implementation of digitally empowered teaching methods in engineering drawing courses has significantly enhanced students' interest and engagement, fostering greater interactivity and practical application in teaching. This approach is not limited to engineering drawing; it can also be extended to other engineering disciplines, such as mechanical design, utilizing digital and multimedia resources to facilitate students' understanding and mastery of complex engineering concepts and skills. Furthermore, the online teaching resources developed in this course compile and share high-quality digital teaching materials, providing convenience for numerous institutions and educators.

However, while the research has yielded certain achievements, it also has limitations. The relatively few iterations of the reformed teaching process may affect the generalizability and representativeness of the results. Additionally, the study primarily relies on post-class surveys and comparisons of grades before and after the reform, which may introduce subjective biases and limitations in the analysis. Future research should broaden its scope, employing diverse data collection methods to enhance the reliability and validity of the findings. Moreover, it should further explore the effectiveness of digital empowerment across different stages of the course, conducting in-depth analyses of its long-term impacts and potential challenges in practical teaching. Continuous improvements and optimizations will be essential to advance the digital transformation and innovative reform of the course.

6. Conclusion

With the rapid advancement of digital technology, the adoption of digitally empowered

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teaching models has become an inevitable trend in the future of educational reform. Through an integrated, three-tiered approach to digital empowerment, we have not only enhanced the quality of instruction in the Engineering Drawing course and improved students' learning outcomes, but we have also significantly developed their spatial reasoning and innovative thinking skills. This highlights the critical role that digital empowerment plays in fostering the comprehensive capabilities of students. In the ongoing process of educational reform, we must continue to explore and implement digitally empowered teaching models, thereby contributing to the cultivation of a greater number of highly skilled engineering professionals.

Acknowledgments

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