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Research Article

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Assessment of Innovation-driven Teaching Methods for Undergraduate Engineering Students

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Abstract The purpose of this study is to evaluate the use of new teaching methods in undergraduate engineering education and its prospects for development. New teaching methods such as flipped classroom, blended learning, online education, and simulation experiments have been applied in the teaching of undergraduate engineering students. Through questionnaires, interviews, and classroom observations, this new teaching mode was systematically evaluated. It was found that the new teaching methods showed significant advantages in enhancing students' academic performance, learning interest and practical skills. However, it also faced challenges such as insufficient technical support, increased course preparation time, and students' poor adaptability in the implementation process. Based on these findings, it is recommended that teachers make personalized adjustments and designs of teaching methods according to the characteristics of the curriculum. The study focuses on the application and long-term impact of the new teaching models in different engineering fields. Future research needs to further explore the application of teaching method in different types of educational backgrounds and develop new assessment tools to promote the continuous progress of engineering education.

Keywords New teaching method, Engineering undergraduate education, Flipped classroom, Blended learning

1. Introduction

Undergraduate engineering education is facing increasingly severe challenges, and the traditional lecture-based teaching mode has been difficult to meet the requirements of modern engineering education for students' comprehensive ability. In addition to solid theoretical knowledge, students also need to have the ability to solve complex problems, innovative thinking and teamwork. However, the traditional teaching mode neglects the cultivation of students' independent learning and practical operation, resulting in a significant disconnect between the comprehensive quality of engineering undergraduates and the needs of the industry. This limitation has become increasingly prominent in practical teaching, making engineering education in dire need of new teaching methods to adapt to the rapidly changing engineering environment and needs.

In this context, engineering education has gradually introduced new teaching methods such as didactics, flipped classroom, and project-driven learning. Utilizing modern technologies, these methods attempt to break through the limitations of traditional teaching and provide more flexible and diverse learning methods to help students better cope with the complex challenges in the engineering field. Therefore, systematically evaluating the actual effects and potential impacts of new teaching methods has become the focus of current research. This study aims to evaluate the practical effects of these new teaching methods and explore their impact on the learning and comprehensive quality of engineering undergraduates, so as to provide a scientific basis for educational practice and promote the continuous improvement of engineering education.

2. Literature Review

The traditional way of engineering education mainly consists of lectures, experiments and subject research [1]. Although traditional lectures are systematic and efficient in information transmission, they have low participation and little interaction, making it difficult to effectively improve students' practical abilities and critical thinking. Although experimental teaching can improve students' hands-on ability through hands-on, it is difficult to truly reflect complex engineering problems due to the constraints of the experimental environment, resources and other factors [2]. Although project-oriented teaching can improve students' problem solving ability through real-life cases, there is significant uncertainty in its practical application, which affects students' learning effects.

At present, many new teaching methods such as flipped classroom, blended learning, online education, simulation experiments and so on are being vigorously promoted [3]. Flipped classroom is a kind of teaching activity that takes students' self-learning and classroom interaction outside the classroom as the main means, and its effectiveness depends on teachers' preparation level and students' self-learning ability [4]. The blended learning model that integrates “online” and “offline” is conducive to improving students' independent learning and practical ability but needs to take into account the curriculum design and technical support. Research has shown that new teaching methods can significantly improve the learning effect of engineering undergraduates. For example, flipped classroom improves learning performance and satisfaction [5], and blended learning increases learning participation and achievement. Online education and simulation experiments have shown outstanding performance in compensating for the shortcomings of traditional teaching methods, enhancing practical ability and innovative thinking [6].

3. Materials and Methods

This study utilizes a mixed research methodology that combines qualitative and quantitative research to comprehensively assess the effectiveness of novel teaching methods in engineering undergraduate education.

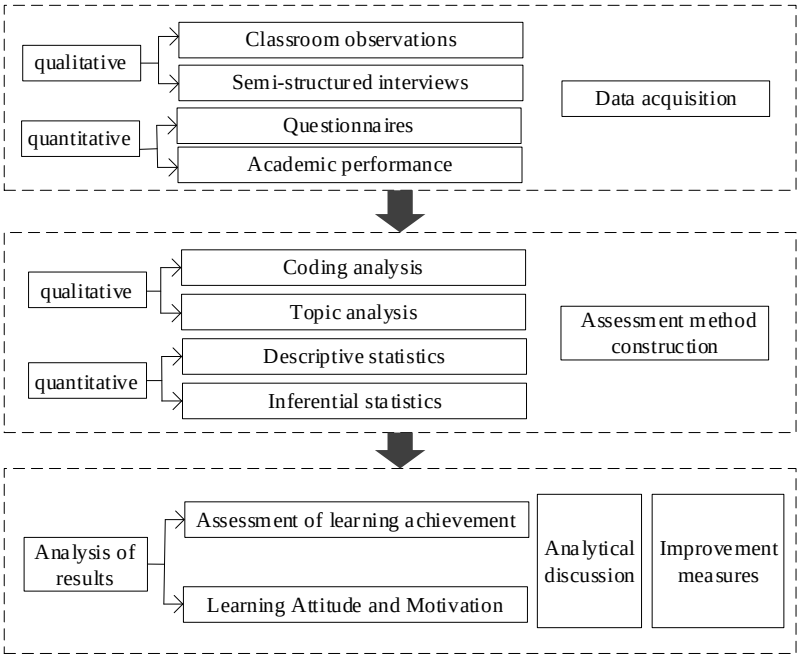

Figure 1: Technology roadmap

Different tools and methods will be used to ensure the completeness and accuracy of the data. Firstly, a questionnaire containing the effectiveness of teaching methods, student satisfaction, and learning motivation was developed and administered to engineering students to obtain quantitative information. The main contents of the questionnaire were: students' feelings about various teaching methods, self-assessment, and overall satisfaction with the teaching methods during the learning process. Semi-structured interviews will be used to provide detailed feedback on the application of the new teaching methods in practice, challenges and successes, as well as suggestions for improvement. The technology roadmap is shown in Figure 1.

Quantitative methods were used to analyze survey data. Statistical software such as SPSS or R were employed to comprehensively process questionnaire survey data, including descriptive statistical analysis (e.g., mean and standard deviation) and inferential statistical analysis methods (e.g., t-test and ANOVA). The analyses were designed to assess the impact of the new pedagogies on student learning outcomes and to compare the differences between the different pedagogies. Figure 2 shows the mean ratings (out of 10) of the four teaching methods. The results show that the innovative teaching method has the highest mean rating and the lowest standard deviation, indicating that the method has a higher level of acceptance and greater consistency of evaluation among students. In contrast, the traditional teaching method has the lowest average rating and a larger standard deviation, reflecting its relatively poor effectiveness and large differences in student evaluations.

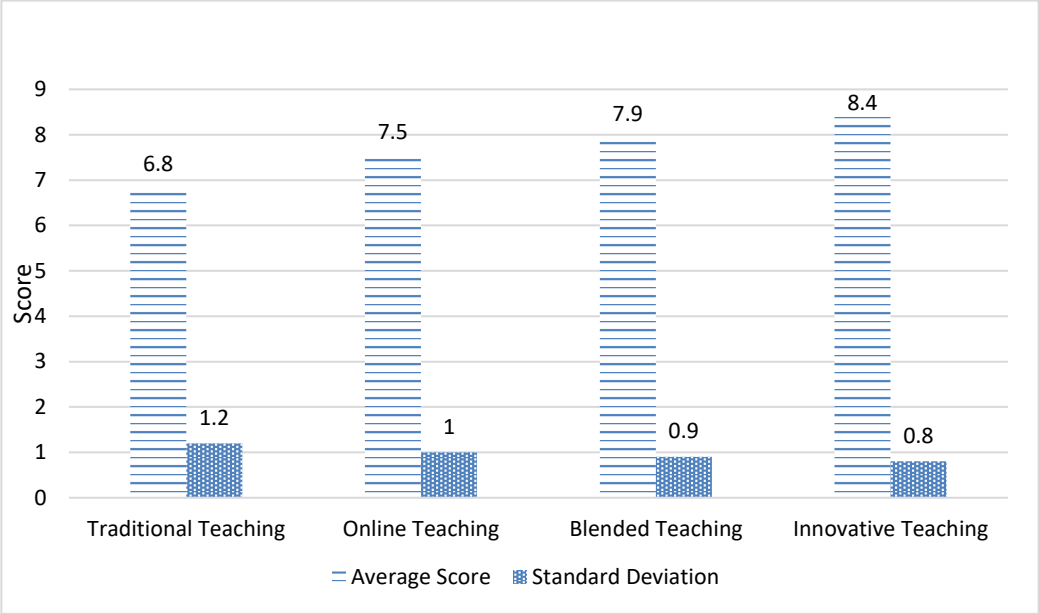

Figure 2: Comparison of Average Scores and Variability Across Teaching Methods

In terms of qualitative data analysis, this study used coding and thematic analysis methods to conduct in-depth analysis of interview records and classroom observation data. Firstly, the interview transcripts and observation notes were coded to classify the data into different thematic categories; Subsequently, the main ideas and patterns were distilled through inductive summarization. This process would help to reveal the specific details of the implementation of the new teaching methods and their impact on students' learning experiences. By synthesizing the qualitative and quantitative data, four different teaching methods were investigated and the average rating (out of 10) for each method was calculated. This is shown in the Figure 3. This study aims to comprehensively understand the application effects of new teaching methods and provide empirical evidence and improvement suggestions for further reform of engineering education.

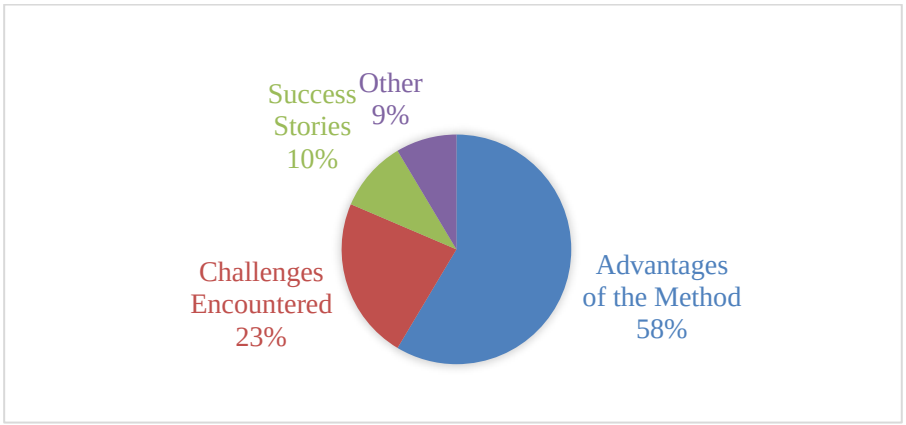

Figure 3: Distribution of feedback themes on the implementation of new teaching methods

4. Results & Discussion

This study assessed the effectiveness of new teaching methods with 500 undergraduate engineering students and 40 faculty members from the university as survey respondents. The participating courses included basic engineering courses, specialized core courses and laboratory courses, all of which used new teaching methods such as flipped classroom, blended learning, online education platform and virtual simulation technology. In the flipped classroom, students learn the basics through videos before class and engage in project discussions and practical operations in class. Blended learning combines online resources with offline interaction. The online education platform provides anytime, anywhere learning opportunities; virtual simulation technology provides an effective alternative for courses that lack laboratory equipment.

The results showed that these new teaching methods significantly improve students' academic performance and motivation. In particular, the flipped classroom and blended learning model improved student performance in labs and exams by 10% to 15%. In addition, students showed significant improvements in learning satisfaction, autonomy, and classroom engagement. However, faculty faced challenges in course preparation and technical support during implementation and noted that students' self-management skills were critical to the successful implementation of the new teaching methods. Nonetheless, this new teaching model has achieved significant results in engineering education, especially in terms of improving students' academic performance and motivation. However, further technical and adaptive issues need to be addressed to realize its full potential.

5. Conclusion

In this study, empirical research was conducted on undergraduate engineering students. It has been found that new educational methods such as flipped classroom, blended learning, online education, and simulation experiments have a significant promoting effect on students' academic performance, learning attitude, and motivation. The teaching method system can effectively improve students' learning ability, practical ability, and creative thinking, especially in solving complex engineering problems and enhancing their teamwork ability. Flipped classroom and blended teaching can significantly improve students' classroom participation and satisfaction. The study found that the existing teaching modes have problems such as insufficient technical support, long course preparation time, and low adaptability of students in the implementation process.

Therefore, when implementing new teaching models, teachers should combine the characteristics of the curriculum and the needs of students, use modern information technology as an aid, and adopt personalized teaching methods to maximize teaching effectiveness. Under the new teaching mode, the curriculum should be flexible. On this basis, this project will continue to delve into the role of new educational models in engineering practice and explore their long-term development prospects. The study will also systematically evaluate the adaptability of new teaching methods in diverse teaching environments and develop new assessment tools to better understand their feasibility for application in diverse teaching environments. In this way, the sustainable development and innovation of engineering education can be better promoted.

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