ISSN 2522-6398 Vol. 7, Issue 11: 65-71, DOI: 10.25236/FER.2024.071111

Teaching Reform and Practice of the Surveying and Cartography Course under the New Surveying Technologies

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Abstract: *With the rapid advancement of new surveying technologies, particularly the widespread application of unmanned aerial vehicle (UAV) surveying, satellite remote sensing, and geographic information systems (GIS), traditional teaching methods for the Surveying and Cartography course are facing significant challenges. This study aims to explore strategies to enhance teaching quality and student learning outcomes in the Surveying and Cartography course through educational reform in the context of these emerging technologies. First, we analyze the impact of new surveying technologies on the field of surveying and cartography, highlighting the limitations of traditional teaching models and underscoring the necessity for reform. We then propose reform strategies characterized using virtual simulation technology and the integration of competitive activities with education. By constructing a virtual simulation experiment platform, students can practice new surveying techniques in a simulated real-world environment, thereby improving their operational skills and problem-solving abilities. Additionally, by integrating academic competitions with classroom instruction, we can stimulate students' interest in learning, foster innovative thinking, and enhance their teamwork and practical application skills. Finally, based on the practical outcomes of the course reform, we observe significant improvements in students' overall performance and an increase in both participation and awards in competitions. The teaching reform and practical outcomes of the Surveying and Cartography course provide valuable insights for similar reforms at local universities.*

Keywords: *Teaching Reform and Practice; Surveying and Cartography; Virtual simulation; Competition-education integration*

1. Introduction

In the information age of the 21st century, surveying technology is undergoing a revolutionary transformation [1-2]. The adoption of new surveying technologies, such as unmanned aerial vehicle (UAV) surveying, satellite remote sensing, and geographic information systems (GIS), has significantly enhanced the efficiency and accuracy of surveying practices while simultaneously presenting new opportunities and challenges for the education of surveying disciplines [3-4]. As a foundational course in surveying engineering, "Surveying and Cartography" must evolve its content and methodologies to align with advancements in new surveying technologies and the evolving demands of the industry for skilled professionals [5-6].

Traditional instruction in the Surveying and Cartography course often emphasizes fundamental theories and the use of conventional surveying tools, resulting in limited exposure to contemporary surveying technologies [7-8]. This approach restricts students' comprehension and application of modern surveying techniques [9-10]. With the increasing prevalence of new surveying technologies, it is imperative for students to acquire proficiency in advanced tools and methods to meet future workplace expectations [11-12]. Consequently, reforming the "Surveying and Cartography" course to more closely align with these technological advancements has become an urgent priority for educators.

The application of virtual simulation technology, alongside the integration of competition into the educational framework, offers innovative approaches to reforming the "Surveying and Cartography" course [13-14]. Virtual simulation technology can accurately replicate the operational environments of new surveying technologies, enabling students to engage in practical exercises within a safe virtual setting,

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thus enhancing their operational skills and problem-solving capabilities. Simultaneously, the integration of competition with education fosters students' interest in learning and nurtures innovative thinking, while also promoting teamwork and practical application skills [15-16].

This study aims to explore and implement strategies and methods for reforming the teaching of the Surveying and Cartography course in the context of new surveying technologies. We begin by analyzing the impact of these technological advancements on the field of surveying and cartography, highlighting the limitations of traditional teaching models and emphasizing the necessity for reform. We then present teaching reform strategies characterized using virtual simulation technology and the integration of competition with education, detailing specific steps and methodologies for the reform practice. Finally, we showcase the outcomes of these reforms through practical teaching case studies.

2. Necessity of Curriculum Reform

2.1. Requirements of New Surveying Technologies

The rapid advancement of new surveying technologies—such as unmanned aerial vehicle (UAV) surveying, satellite remote sensing, and geographic information systems (GIS)—has fundamentally transformed the surveying and cartography landscape. These technologies not only enhance data collection efficiency and accuracy but also introduce innovative methodologies that challenge conventional educational practices. Given these developments, it is imperative to critically evaluate and update the existing curriculum for the "Surveying and Cartography" course. Traditional teaching methods, which often emphasize foundational theories and the use of conventional tools, may inadequately prepare students for the complexities of modern surveying practices. Therefore, integrating these emerging technologies into the curriculum is essential to equip students with the skills necessary to navigate contemporary challenges and meet industry demands.

To effectively implement this reform, educational institutions must adopt a structured framework that encompasses comprehensive curriculum updates and hands-on training opportunities. This framework should prioritize practical experience with UAVs and GIS tools, enabling students to engage directly with the technologies shaping their field. Additionally, fostering collaborative learning through project-based assignments can simulate real-world scenarios, encouraging teamwork and problem-solving skills. By aligning educational practices with advancements in surveying technologies, institutions can better prepare students for the workforce, enhancing their employability and ensuring they can contribute effectively to the evolving landscape of surveying and cartography.

2.2. Internal Challenges of the Curriculum

The current curriculum for "Surveying and Cartography" increasingly misaligns with rapid advancements in the industry, leading to a degree of obsolescence. Existing teaching materials inadequately address modern surveying technologies, such as the Beidou navigation system, unmanned boats, and surveying robots, which are now widely utilized in practice. Instead, textbooks primarily focus on traditional methods and conventional applications, providing minimal exposure to these cutting-edge technologies. Furthermore, some instructors rely heavily on traditional lectures, resulting in limited interaction and hands-on practice, which fails to engage students and stimulate their initiative. While the current teaching model effectively conveys foundational knowledge, it lacks the practical and interactive elements crucial for a skill-oriented course like "Surveying and Cartography".

Additionally, many students in the geography program at Hubei University of Arts and Science come from arts and humanities backgrounds, often lacking a solid foundation in mathematics and science. Consequently, their interest and enthusiasm for a course like "Surveying and Cartography," which requires mathematical proficiency and practical skills, tend to be low. Moreover, with over 70% of the students being female, there is often limited interest in more technical or engineering-focused courses, resulting in low classroom participation. This not only hampers their understanding and mastery of the course content but also diminishes their willingness to engage in hands-on surveying and cartography activities. Compounding this issue, the current assessment system is overly focused on theoretical testing, with insufficient emphasis on practical skills. This imbalance in evaluation leads students to undervalue practical operations, ultimately undermining their hands-on capabilities and innovative potential.

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3. Strategies for Teaching Reform

3.1. Introduction of Virtual Simulation Software in Surveying

In today's rapidly evolving technological landscape, virtual simulation technology plays an increasingly pivotal role in education, particularly in the field of surveying. Virtual simulation software creates a safe, cost-effective, and efficient learning platform by simulating real-world surveying environments and operational processes. The software introduced in the "Surveying and Cartography" course (as illustrated in Figure 1) comprises two key components: video explanations and a virtual simulator. The video segments provide students with intuitive visual materials that demonstrate the structure and operational processes of various surveying instruments, while the virtual simulator replicates the operating environments of total stations, leveling instruments, and surveying drones through advanced computer simulation technology. Within this virtual environment, students can practice operations such as second-order leveling, satellite positioning navigation, and UAV surveying. This approach not only enhances students' engagement but also significantly improves their operational skills and problem-solving abilities.

The advantages of virtual simulation software in surveying education are substantial. It transcends the constraints of time and space, allowing students to learn anytime and anywhere, thereby significantly increasing teaching flexibility. Furthermore, the software can simulate a wide range of complex surveying environments, providing students with ample practical opportunities that foster their practical skills and innovative thinking. Additionally, it effectively reduces teaching costs and minimizes risks associated with hands-on operations, ensuring a safer educational experience. As virtual simulation technology continues to advance, its application in surveying education is expected to expand, positively influencing the quality and effectiveness of teaching.

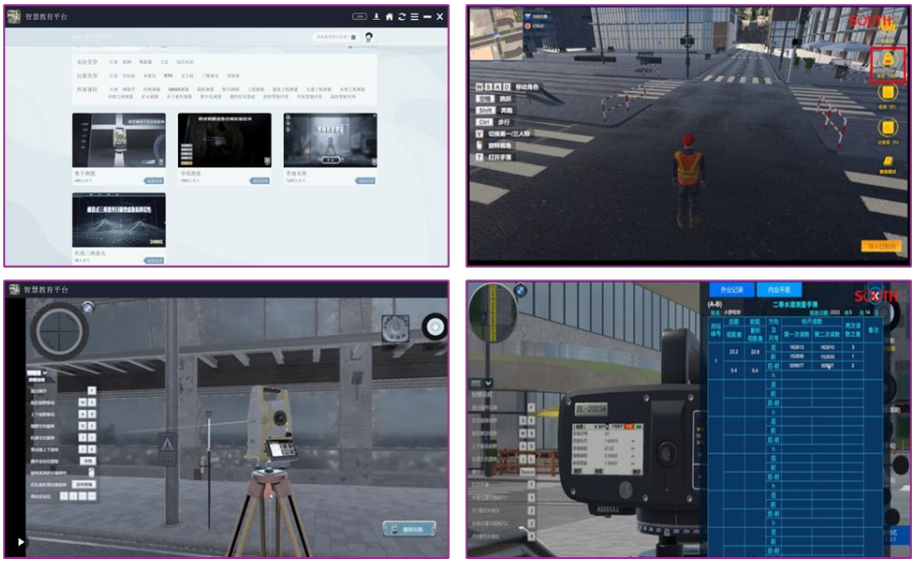

Figure 1: Virtual Simulation Platform in Surveying.

3.2. Integration of Competition and Education

In the contemporary educational landscape, integrating theory with practice to cultivate students' innovative abilities and practical skills has become a crucial objective in higher education. As a core course within the Surveying Engineering program (see figure 2), the "Surveying and Cartography" course requires significant reform. By incorporating the National College Students' Surveying Innovation and Entrepreneurship Intelligent Competition (hereinafter referred to as the "Competition"), the course achieves a profound integration of theory and practice, enhancing students' overall competencies. The curriculum covers modern surveying instruments such as total stations, drones, leveling instruments, and theodolites, along with practical measurement skills in elevation measurement, leveling, length measurement, and coordinate acquisition. Additionally, it encompasses map-making skills such as topographic mapping, thematic mapping, and drone aerial photography. These components not only provide students with a solid foundation in surveying knowledge but also prepare them effectively for participation in the Competition.

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The Competition includes various events, such as airborne LiDAR virtual simulation contests, UAV surveying virtual simulations, virtual simulation digital mapping competitions, and surveying program design contests. These events require students to apply the theoretical knowledge acquired in the classroom to practical operations, enhancing their practical capabilities and innovative thinking through problem-solving. The integration of the course with the Competition allows students to reinforce and deepen their theoretical understanding while developing teamwork and problem-solving skills in real-world scenarios.

During the course implementation, we adopted several strategies: First, aligning the course content with the Competition projects ensures that the theoretical knowledge learned in class can be practically applied in the contests. Second, practical teaching is combined with competition training, allowing students to complete tasks such as elevation measurement and leveling under teacher guidance in simulated measurement environments, thereby laying a strong foundation for participation in the airborne LiDAR and UAV surveying virtual simulation competitions. Finally, course evaluation is linked to competition performance, assessing students not only on their grasp of theoretical knowledge but also on their achievements in the contests.

Through this integrated teaching model, students have significantly improved both their theoretical knowledge and practical skills. In the Competition, student teams demonstrated exceptional surveying skills and innovative capabilities, winning several awards. These accomplishments not only validate the effectiveness of the integrated model but also boost students' confidence and professional competence, establishing a solid foundation for their future careers. The integration of competition and teaching provides an innovative platform for the "Surveying and Cartography" course, closely linking course content with practical applications and enhancing students' operational abilities and innovative thinking. By participating in the National College Students' Surveying Innovation and Entrepreneurship Intelligent Competition, students can apply classroom knowledge to real-world challenges while developing teamwork and resilience. This teaching model offers new insights and practical examples for educational reform in the surveying discipline.

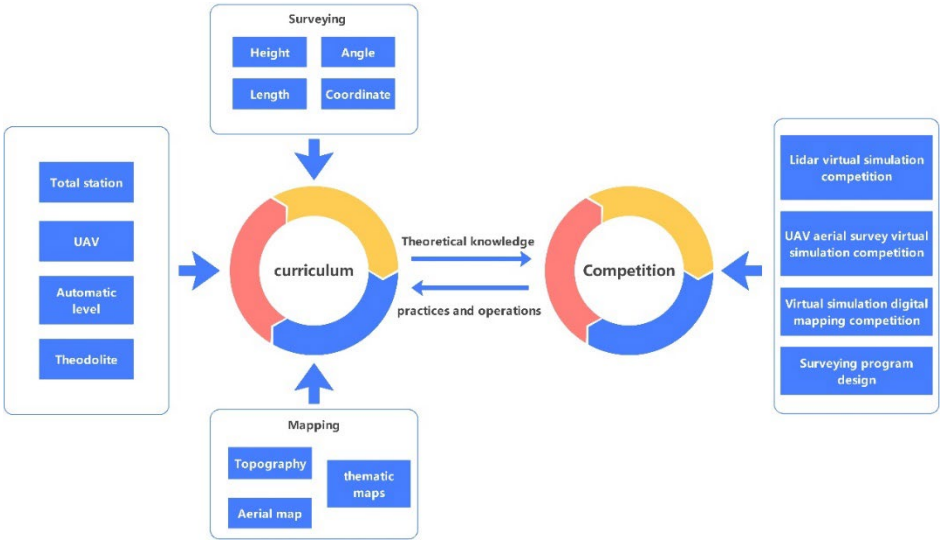

Figure 2: Flowchart of Competition-Education Integration.

4. Effects of Curriculum Reform

4.1. Improvements in Comprehensive Scores

Figure 3 illustrates the distribution of comprehensive scores across four grade categories (Fail: 0-69, Pass: 70-79, Medium: 80-89, Excellent: 90-100) for students from the 2022, 2023, and 2024 cohorts. In 2022, the percentage of students scoring in the Fail range exceeded 14%, with 8 students failing and only 50% achieving a Pass. Approximately 36% and 2% of students earned scores in the Medium and Excellent categories, respectively. In contrast, the 2023 cohort saw a decrease in the percentage of failing students to 10%, while those in the Pass category dropped to 39%. The proportion of students scoring in the Medium category increased to 47%, and the Excellent category rose to 5%. By 2024, only 3 students failed the exam, while 9% achieved Excellent scores. The reduction in failures and the increase in

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Excellent scores indicate the initial success of the curriculum reform.

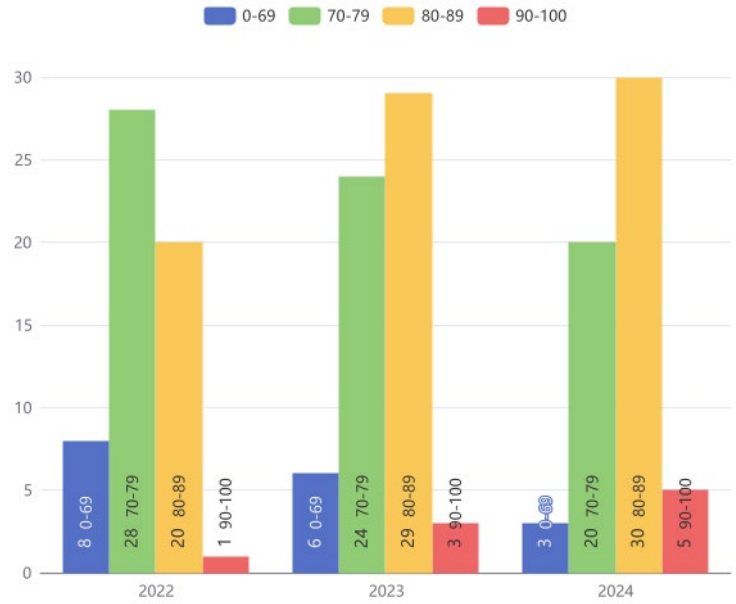

Figure 3: Distribution of Curriculum Grades from 2022 to 2024.

4.2. Increased Participation and Awards in Competitions

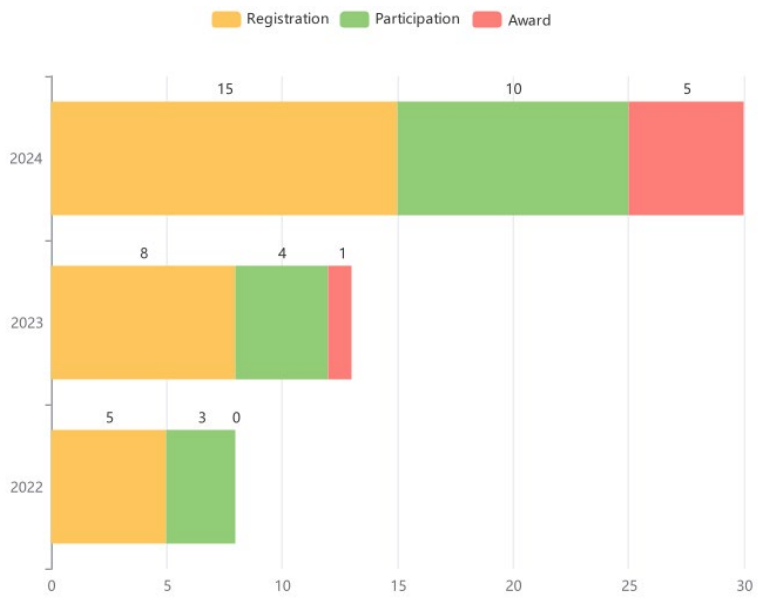

Figure 4: Registration, Participation, and Award Rates in Competitions from 2022 to 2024.

Figure 4 presents data on registration, participation, and award rates in surveying competitions from 2022 to 2024. In 2022 and 2023, the number of students registering for surveying competitions was only 5 and 8, respectively, with 3 and 4 participating. During this period, only one student received an award. However, in 2024, the number of registered students increased to 15, with 10 participating in competitions. This surge in participation can be attributed to the inclusion of the 2023 National Surveying Discipline Innovation and Entrepreneurship Competition in the Ministry of Education's National List of College Student Competitions, which represents the highest level of competition in surveying science. This change has heightened the event's difficulty. Despite the increased challenge, the award rate improved, with 5 students receiving awards. This reflects a growing enthusiasm among students for participating in these competitions and suggests an increased interest in the Surveying and Cartography course, further underscoring the positive outcomes of the curriculum reform.

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5. Conclusions

This study highlights the necessity and effectiveness of reforming the "Surveying and Cartography" course in response to the rapid advancements in surveying technologies such as UAV surveying, satellite remote sensing, and GIS. The integration of virtual simulation technology and competition-based learning has proven to be a pivotal strategy in enhancing educational outcomes. By creating a safe and engaging virtual environment for practical skills development, students have shown significant improvements in their operational competencies and problem-solving abilities. The curriculum reform has led to a notable increase in students' comprehensive scores, with a marked reduction in failures and a rise in the proportion of students achieving excellent grades. Furthermore, participation in surveying competitions has surged, reflecting an elevated enthusiasm for the course and a stronger connection between theoretical knowledge and practical application. The integration of competition and education not only fosters teamwork and innovative thinking but also better prepares students for the demands of the modern workforce. Overall, the findings of this research underscore the importance of aligning educational practices with technological advancements in the surveying field. The successful implementation of these reforms offers valuable insights for similar initiatives at other educational institutions, contributing to the continuous improvement of surveying and cartography education.

Acknowledgements

The work is supported by Innovation and Entrepreneurship Education of Hubei University of Arts and Sciences (No.CX202408); Natural Science Foundation of Hubei Province (No.2024AFB108), Science and Technology Research Project of Education Department of Hubei Province (No. Q20232607), and Innovation and Development Joint Fund of Natural Science Foundation of Hubei Province (No.2023AFD060).

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