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LASER POINT CLOUD TECHNOLOGY ENABLING THE TEACHING OF HUIZHOU VERNACULAR DWELLING MAPPING COURSES IN HIGHER EDUCATION

Lei Zhang[1], Xin Huang[2*], XiYue Zeng[1]
[1]*Department of Architecture, Anhui Jianzhu University, Hefei 230601, Anhui, China.*
[2]*Department of Architecture, Tongji Zhejiang College, Jiaxing 314051, Zhejiang, China.*
Corresponding Author: Xin Huang, Email: huangxin@tjzj.edu.cn

Abstract: This paper explores the application of laser point cloud technology in reforming the teaching of Huizhou vernacular dwelling mapping courses in architectural education. By reviewing existing literature and conducting empirical research, this study aims to propose an innovative teaching model that integrates laser point cloud technology into traditional surveying and mapping methods. The proposed model addresses the challenges faced in teaching ancient architectural mapping and aims to enhance students' skills in utilizing digital technologies while preserving the cultural heritage of Huizhou vernacular dwellings. The paper concludes with a discussion on the effectiveness of the proposed model and suggests future directions for research and teaching practices.
Keywords: Higher education; Teaching; Laser point cloud technology; Huizhou vernacular dwelling

1 INTRODUCTION

Huizhou vernacular dwellings, renowned for their unique architectural style and historical significance, are important subjects in architectural education. However, traditional teaching methods in architectural mapping courses often struggle to adequately capture the intricate details and spatial characteristics of these ancient structures. The advent of laser point cloud technology presents new opportunities for teaching reform, enabling more accurate and efficient mapping of complex architectural features. This study aims to explore how laser point cloud technology can be integrated into the teaching of Huizhou vernacular dwelling mapping courses to enhance students' learning experiences and skill sets.

Recent research has highlighted the importance of reforming architectural mapping courses to adapt to the evolving demands of the profession. Min Zhou and Haihui Yang (2021) provide a multidimensional perspective on the reform of ancient architectural mapping courses. They emphasize the significance of these courses in architectural education and propose a series of reform methods, including the compilation of internship guidebooks, setting teaching objectives, adjusting teaching organization, and implementing diversified teaching assessments. These methods aim to clarify professional characteristics and expand the scope of mapping to align with the three-dimensional digitization trend in architectural education. Haiyan Gu et al. (2020) further emphasize the necessity of teaching reform in architectural mapping courses at local universities in the context of informationization and digitization. They argue that teaching reform should adopt an interdisciplinary approach, integrating local characteristics to cultivate architectural mapping talents who can adapt to the development of the times. Hongyu Zhu (2019) specifically discusses the mapping method that combines digital technology with traditional means. Through the mapping practice of three churches in Macao's historic urban area, he proposes a set of mapping teaching methods suitable for undergraduates, which effectively solve some technical problems in traditional mapping. Zheng Sun and Huayu Guo (2019) present the reform practices in the ancient architectural mapping course at Nanjing Tech University from the perspective of teaching reform. They stress the importance of the rationality of mapping techniques and propose a teaching mode that combines laser scanning, photogrammetry, and other optical measurement technologies to improve students' mapping skills and graphic expression abilities. Zhimin Zhang (2015) focuses on the application of three-dimensional scanning technology in the teaching of ancient architectural mapping. He explores how to combine this emerging technology with traditional mapping techniques to enable students to meet the basic requirements of ancient architectural mapping internships while mastering the basic principles and skills of digital technology. Yue Zou et al. (2009) provide ideas for constructing a teaching platform for architectural digital design. They propose that by relying on Building Information Modeling (BIM), adjusting teaching content and curriculum systems can play a greater role in students' design practice. [1-13]

In addition, Zhong and Xu (2024) explore the application of digital technology in the protection of traditional Huizhou architecture, taking the wooden carved buildings in Lu Village, Yixian County, as an example. Through three-dimensional information mapping and field investigation, they construct a three-dimensional information model of the wooden carved buildings, providing basic data and technical support for their protection and restoration. Jiaqi Zhang 's (2023) doctoral thesis discusses the method of constructing volume roaming of traditional villages in Jilin Province based on point cloud big data. He proposes a new way to protect and display traditional villages using three-dimensional laser point cloud technology and virtual reality technology. Wenhua Zhou (2022) focuses on the virtual reconstruction of buildings in traditional villages in Jilin Province under laser point cloud big data. He uses BIM technology software to conduct virtual reconstruction and drawing of traditional village buildings, summarizes the characteristics of different ethnic buildings, and completes the architectural digital archives of traditional villages in Jilin Province. Jinhu Li et al. (2021) explore the method of establishing digital archives of traditional villages using non-contact mapping technology. They argue that by establishing a complete three-dimensional model of traditional villages, a complete electronic archive can be formed, providing accurate scientific basis for the research, restoration, reconstruction, and cultural and creative product development of traditional villages. [4-16]

2 METHODOLOGY

The development of the proposed teaching model was a multifaceted process, involving a combination of literature review, case studies, and empirical research. The literature review provided valuable insights into existing teaching methods and challenges in architectural mapping courses. It examined various approaches to teaching architectural mapping, including traditional methods such as manual measurement and drafting, as well as more recent incorporations of digital technologies. [1] The review highlighted the need for a comprehensive teaching model that not only emphasizes technical skills but also cultural sensitivity and preservation ethics.

Case studies were conducted to analyze successful applications of laser point cloud technology in architectural mapping. These studies focused on projects where laser scanning had been used to create accurate digital representations of historical buildings and sites. [2] By examining these cases, the research team identified key factors contributing to the success of laser point cloud technology in architectural mapping, including equipment selection, data processing techniques, and integration with other digital tools.

Empirical research involved implementing the proposed teaching model in an actual architectural mapping course and collecting data on students' learning experiences and outcomes. The course was designed to accommodate a diverse group of students, including those with prior experience in architectural mapping and those who were new to the field. Data collection methods included surveys, interviews, and assessments of students' projects, providing a comprehensive understanding of the effectiveness of the teaching model. [3]

3 TEACHING MODEL

The proposed teaching model consists of four main components: theoretical instruction, practical training, project-based learning, and technology integration. Each component is designed to build upon the previous one, providing students with a well-rounded educational experience in architectural mapping using laser point cloud technology.

3.1 Theoretical Instruction

Students are provided with a solid foundation in traditional architectural mapping techniques and principles. This includes instruction on manual measurement methods, drafting techniques, and the historical context of architectural mapping. Students are also introduced to the basics of laser point cloud technology and its applications in architectural mapping. The theoretical instruction component emphasizes the importance of understanding the underlying principles of both traditional and digital mapping techniques, enabling students to make informed decisions when selecting and applying technologies in their projects. [4]

The theoretical instruction component of the teaching model is designed to provide students with a strong foundation in both traditional architectural mapping techniques and the principles of laser point cloud technology. The curriculum begins with an overview of the historical context of architectural mapping, tracing its evolution from manual methods to digital technologies. [5] Students learn about the various tools and techniques used in traditional architectural mapping, such as tape measures, theodolites, and drafting instruments. They also study the theoretical underpinnings of architectural mapping, including the principles of perspective, proportion, and scale.

In addition to traditional mapping techniques, students are introduced to the basics of laser point cloud technology. They learn about the principles of laser scanning, including how the technology works, its advantages and limitations, and its applications in various fields, such as architecture, engineering, and cultural heritage preservation. Students also study the different types of laser scanning equipment available, considering factors such as accuracy, range, and portability when selecting equipment for specific projects[6].

To complement the theoretical instruction, students participate in discussions and debates about the ethical considerations involved in architectural mapping and cultural heritage preservation. They explore topics such as the importance of cultural sensitivity, the role of architects and conservationists in preserving historical buildings, and the potential impacts of digital technologies on cultural heritage sites. These discussions are designed to foster critical thinking and encourage students to consider the social and cultural implications of their work as architects.

3.2 Practical Training

Following the theoretical instruction, students engage in hands-on training sessions where they learn how to operate laser point cloud scanning equipment and software. These sessions are designed to be interactive and experiential, allowing students to practice scanning and processing point cloud data to create accurate three-dimensional models of architectural features. The practical training component focuses on developing students' technical skills in using laser scanning equipment and software, ensuring that they are proficient in generating high-quality point cloud data for architectural mapping[7].

The practical training component of the teaching model focuses on developing students' technical skills in using laser point cloud scanning equipment and software. Students begin by learning how to set up and operate the scanning equipment, including calibration procedures and data capture strategies. They practice scanning various architectural features, such as walls, roofs, and ornamental details, to develop proficiency in generating high-quality point cloud data.

In addition to scanning, students also learn how to process the point cloud data using specialized software. They learn about data cleaning techniques, such as removing noise and outliers, as well as methods for aligning multiple scans to create a complete three-dimensional model of the architectural feature. Students also study techniques for extracting measurements and creating two-dimensional drawings from the point cloud data, allowing them to produce accurate architectural plans and elevations.

Throughout the practical training component, students receive guidance and feedback from instructors and technical experts[8]. They participate in group discussions and critiques, where they share their experiences and challenges in using the laser scanning equipment and software. These discussions provide opportunities for students to learn from each other and develop problem-solving skills in a supportive and collaborative environment.

3.3 Project-Based Learning

Students work on real-world projects where they apply their knowledge and skills in architectural mapping using laser point cloud technology. They are tasked with mapping specific Huizhou vernacular dwellings, focusing on capturing intricate details and spatial characteristics. This project-based learning component allows students to work in teams, simulating a professional environment where collaboration and communication skills are essential. Students are encouraged to think critically about the best approaches to mapping the dwellings, considering factors such as equipment selection, data capture strategies, and ethical considerations related to cultural heritage preservation.

The project-based learning component of the teaching model allows students to apply their knowledge and skills in architectural mapping using laser point cloud technology in real-world projects. Students work in teams to map specific Huizhou vernacular dwellings, focusing on capturing intricate details and spatial characteristics. They are responsible for selecting appropriate equipment, developing data capture strategies, and processing the point cloud data to create accurate three-dimensional models of the dwellings.

To ensure that students are prepared for the project-based learning component, they receive guidance and support from instructors throughout the process. They participate in workshops and seminars where they learn about best practices in architectural mapping, in`cluding equipment selection, data capture techniques, and ethical considerations related to cultural heritage preservation. Students also have access to technical resources, such as tutorials and online forums, where they can seek assistance and share their experiences with other students and professionals.

During the project-based learning component, students are encouraged to think critically about the best approaches to mapping the Huizhou vernacular dwellings[15]. They consider factors such as the architectural features of the dwellings, the equipment available, and the intended use of the three-dimensional models. Students also engage in discussions about the ethical implications of their work, considering the potential impacts of their mapping projects on the cultural heritage of the dwellings and the communities associated with them.

3.4 Technology Integration

In the final component of the teaching model, students are encouraged to explore and integrate other digital technologies, such as Building Information Modeling (BIM) and virtual reality, into their mapping projects. This allows them to develop a comprehensive skill set in utilizing digital tools for architectural mapping and preservation. Students learn how to leverage the strengths of different technologies to create immersive and interactive representations of the Huizhou vernacular dwellings. [10] They also consider the potential applications of these technologies in architectural design, conservation planning, and public engagement.

The final component of the teaching model focuses on encouraging students to explore and integrate other digital technologies into their mapping projects. Students learn about the potential applications of technologies such as BIM and virtual reality in architectural mapping and preservation[11]. They study the principles of BIM, including how it can be used to create digital representations of buildings and their components, and how it can support decision-making in architectural design and conservation planning.

Students also learn about the principles of virtual reality and its potential applications in architectural mapping. They study techniques for creating immersive and interactive representations of architectural spaces using virtual reality technologies, such as VR headsets and software. Students learn how to create virtual reality experiences that allow users to explore and interact with the three-dimensional models of the Huizhou vernacular dwellings, providing new perspectives on these historical structures.

Throughout the technology integration component, students are encouraged to think creatively about the potential applications of digital technologies in architectural mapping and preservation[12]. They participate in discussions and workshops where they explore the strengths and limitations of different technologies, considering how they can be used to enhance the understanding and preservation of cultural heritage sites. Students also have the opportunity to work with professionals and experts in the field, gaining insights into the practical applications of digital technologies in architectural practice and conservation.

4 IMPLEMENTATION AND EVALUATION

The proposed teaching model for architectural mapping, integrating laser point cloud technology, was implemented in an undergraduate course at Anhui Jianzhu University in China. This innovative approach aimed to enhance students' practical skills in architectural mapping while fostering their understanding of advanced technologies. The implementation and evaluation of this model involved several key steps, each designed to ensure the effectiveness and success of the teaching strategy.

4.1 Implementation Plan

4.1.1 Course preparation

Prior to the commencement of the course, extensive preparation was undertaken to ensure that all necessary resources were available. This included securing laser point cloud scanning equipment and software, as well as developing a comprehensive curriculum that integrated theoretical knowledge with practical applications. The curriculum was designed to cover topics such as the principles of laser scanning, data processing techniques, and the integration of point cloud data into architectural mapping projects.

4.1.2 Student grouping and project assignment

To facilitate collaborative learning and practical application, students were divided into groups of four to six members. Each group was assigned a specific Huizhou vernacular dwelling as the subject of their mapping project. This approach allowed students to work on real-world projects, enhancing their engagement and motivation.

4.1.3 Training and familiarization with technology

At the beginning of the course, students received training on the use of laser point cloud scanning equipment and software. This training was conducted by experienced instructors who provided hands-on demonstrations and guided practice sessions. The goal was to ensure that students were proficient in using the technology and could apply it effectively in their mapping projects.

4.1.4 Guided project execution

Throughout the course, students worked on their mapping projects under the guidance of instructors. Regular check-ins and feedback sessions were scheduled to monitor progress and address any challenges or questions that emerged. This ongoing support was crucial in helping students integrate laser point cloud technology into their mapping process and refine their skills.

4.1.5 Evaluation criteria

To assess the success of the proposed teaching model, clear evaluation criteria were established. At the end of the course, students' projects were evaluated based on the accuracy and completeness of their three-dimensional models. Additionally, their ability to effectively integrate laser point cloud technology into their mapping process was assessed. This holistic evaluation approach ensured that students were not only proficient in using the technology but also able to apply it in a meaningful and practical context[13-16].

4.2 Evaluation Process

4.2.1 Project evaluation

Each group's final project was evaluated by a panel of instructors and industry experts. The evaluation focused on the technical accuracy of the three-dimensional models, the completeness of the mapping, and the innovative use of laser point cloud technology. This rigorous evaluation process ensured that students received fair and constructive feedback on their work.

4.2.2 Student feedback

In addition to evaluating the final projects, student feedback was also collected to assess the effectiveness of the proposed teaching model. Students were asked to provide their perspectives on various aspects of the course, including the usefulness of the laser point cloud technology, the quality of instruction, and the overall learning experience. This feedback was invaluable in identifying areas for improvement and refining the teaching model for future iterations.

4.2.3 Instructor observations

Instructors also provided their observations and insights on the implementation of the teaching model. They noted any challenges or successes encountered during the course and offered suggestions for how the model could be further enhanced. These observations were combined with student feedback to create a comprehensive evaluation of the teaching model.

4.3 Outcomes and Insights

4.3.1 Improved technical skills

The implementation of the proposed teaching model resulted in significant improvements in students' technical skills in architectural mapping. Students demonstrated a high level of proficiency in using laser point cloud scanning equipment and software, and their final projects exhibited a strong understanding of data processing and integration techniques.

4.3.2 Enhanced practical application

By working on real-world projects, students were able to apply their theoretical knowledge in a practical context. This hands-on experience was invaluable in helping them develop a deeper understanding of architectural mapping and the role of technology in this field.

4.3.3 Positive student feedback

Student feedback on the course was overwhelmingly positive. Students appreciated the opportunity to work with advanced technology and felt that the practical projects had significantly enhanced their learning experience. Many students also commented on the effectiveness of the instructors' guidance and feedback throughout the course.

4.3.4 Areas for improvement

While the overall evaluation of the teaching model was positive, several areas for improvement were identified. Some students felt that the initial training on the laser point cloud technology could have been more comprehensive, and that additional practice sessions would have been beneficial. Instructors also noted that the time constraints of the course limited the depth of some topics and suggested that future iterations could be expanded to allow for more in-depth exploration of specific areas[12-16].

4.4 Future Directions

Based on the outcomes and insights from the implementation and evaluation of the proposed teaching model, several future directions have been identified.

4.4.1 Enhanced training and support

To address the feedback regarding the initial training on the laser point cloud technology, future iterations of the course will include more comprehensive training sessions and additional practice opportunities. This will ensure that students are fully proficient in using the technology before they begin their mapping projects.

4.4.2 Expanded course content

To allow for more in-depth exploration of specific topics, the course content will be expanded in future iterations. This may involve extending the duration of the course or incorporating additional modules that focus on specific aspects of architectural mapping and laser point cloud technology.

4.4.3 Incorporation of industry collaboration

To further enhance the practical application of the course, future iterations will seek to incorporate industry collaboration. This may involve partnering with architectural firms or other relevant organizations to provide students with real-world projects and feedback from industry professionals.

4.4.4 Ongoing evaluation and refinement

The proposed teaching model will continue to be evaluated and refined based on student feedback and instructor observations. This ongoing evaluation process will ensure that the course remains relevant, effective, and aligned with the evolving needs of the architectural mapping field.

5 RESULTS AND DISCUSSION

The results of the empirical research indicate that the proposed teaching model effectively enhanced students' skills in utilizing laser point cloud technology for architectural mapping. Students were able to create accurate three-dimensional models of Huizhou vernacular dwellings, capturing intricate details and spatial characteristics that would have been difficult to capture using traditional mapping methods.

Furthermore, students reported positive learning experiences, stating that the hands-on training and project-based learning approach helped them develop practical skills and apply theoretical knowledge in real-world contexts. They also appreciated the opportunity to work with advanced digital technologies and explore their potential applications in architectural preservation.

6 CONCLUSION

This study proposes a teaching model that integrates laser point cloud technology into the teaching of Huizhou vernacular dwelling mapping courses. The model addresses the challenges faced in traditional teaching methods and aims to enhance students' skills in utilizing digital technologies while preserving the cultural heritage of these ancient structures. The empirical research conducted in this study demonstrates the effectiveness of the proposed model in enhancing students' learning experiences and outcomes.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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