Received: 24 Apr. 2025 | Revised: 03 Apr. 2025 | Accepted: 10 May. 2025 | Published online: 26 May. 2025

RESEARCH ARTICLE

Contemporary Education and Teaching Research
2025, Vol. 6 (5)200-206
DOI: 10.61360/BoniCETR252018350508

Exploration of Project-based Teaching Reform of GIS Technology and Application Courses in Higher Vocational Colleges

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Abstract: With the widespread application of Geographic Information System (GIS) technology in various fields, the demand for cultivating GIS professionals in higher vocational colleges has become increasingly urgent. However, the current teaching of GIS technology and application courses faces numerous challenges and fails to meet the requirements of industry development. This paper analyzes the current status of GIS course teaching in higher vocational colleges, identifies deficiencies in the curriculum structure, teaching methods and content, and student capability cultivation goals. It proposes targeted project-based teaching reform strategies, including the construction of a "task-driven + modular integration" curriculum system and the development of real-world oriented project resources. The implementation effects of the reform are also analyzed, aiming to provide references for improving the teaching quality of GIS courses in higher vocational colleges and cultivating high-quality applied GIS talents.

Keywords: GIS technology and application, Project-Based teaching, teaching reform

1. Introduction

Geographic Information System (GIS) is an emerging technology integrating geography, surveying, computer science, and other disciplines, playing a crucial role in smart cities, natural resource management, environmental monitoring, and other fields. Higher vocational colleges, as important bases for cultivating applied talents, bear the responsibility of delivering professional GIS technical personnel to society. However, the traditional teaching model of GIS technology and application courses can no longer meet the industry's rapid development requirements for practical and innovative capabilities of talents. Project-based teaching, which uses real projects as carriers and closely integrates theoretical knowledge with practical operations, can effectively enhance students' comprehensive vocational capabilities. Therefore, conducting research on project-based teaching reform of GIS technology and application courses in higher vocational colleges has significant practical and applied value.

2. Analysis of the Current Situation and Problems of Teaching GIS Courses in Higher Vocational Colleges

2.1 Unreasonable curriculum structure

At present, the GIS curriculum structure in some higher vocational colleges still follows the traditional discipline-oriented course design model, emphasizing the systematicness and completeness of theoretical knowledge while neglecting the core position of practical capability cultivation in

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vocational education. As a result, the proportion of practical teaching is relatively low. For example, in some colleges, the theoretical teaching hours for GIS courses far exceed the practical training hours, severely restricting students' mastery of key GIS skills and accumulation of operational experience. Due to limited practical opportunities, students find it difficult to internalize abstract theoretical knowledge into transferable practical abilities, weakening their adaptability to real-world work scenarios. Moreover, there is a lack of scientific logical connection and in-depth integration among course contents, with issues such as content repetition, knowledge gaps, and logical disconnection between different courses. These problems not only restrict the development of students' comprehensive GIS technical literacy but also affect the realization of higher vocational education's function in serving regional economic and industrial development.

2.2 Lagging teaching methods and content

In the current practice of GIS course teaching in higher vocational colleges, the traditional approach of "teacher lecturing and students listening" still prevails. The teaching process is centered around the teacher, neglecting the active role of students. The lack of integration of diverse teaching methods such as heuristic, inquiry-based, and task-driven approaches results in a classroom environment that lacks interactivity and practicality. Students remain in a passive state of receiving information, making it difficult to stimulate their interest in learning and proactive thinking.

From the perspective of teaching content, some colleges have textbooks with long update cycles and outdated content that is disconnected from the development of the GIS industry. Emerging technologies such as big data GIS, 3D visualization GIS, Web GIS, and mobile GIS, which have developed rapidly in recent years, have not been effectively integrated. For example, some textbooks still focus primarily on the basic operations of ArcGIS software, while barely touching on emerging trends such as spatial data processing based on the Python language and the integration of geographic information systems with artificial intelligence. This leaves students with little exposure to the most cutting-edge application directions in the industry. Moreover, it creates a significant gap between teaching outcomes and the employment needs of enterprises, thereby affecting the employment quality and career adaptability of graduates (Niu, 2025).

2.3 Ambiguous goals for student ability training

Higher vocational education is oriented towards job capabilities. However, in actual GIS teaching, some colleges lack systematic goal-setting centered on professional capabilities in curriculum design and teaching implementation. Specifically, on the one hand, the teaching goals of courses do not clearly point to the specific skill requirements of GIS job positions. Students find it difficult to form a clear understanding of the structure of professional capabilities during their learning process and cannot accurately determine which knowledge and skills they should focus on mastering. On the other hand, the teaching content is disconnected from the evaluation standards of capabilities. The course evaluation overly emphasizes knowledge assessment while neglecting the assessment of core professional qualities such as project execution capabilities, collaborative communication skills, and problem-solving abilities. This weakens the relevance and effectiveness of teaching and leaves teachers without clear guidance in choosing teaching strategies and evaluating teaching outcomes. The teaching content also fails to focus on the actual needs of students. In the long run, this will affect the establishment of students' professional capability systems, reduce their core competitiveness in the job market, and is not conducive to the continuous reform and quality improvement of higher vocational GIS courses.

3. Project-based Teaching Reform Strategy for GIS Technology and Application Courses in Higher Vocational Colleges

3.1 Construction of a "task-driven and modular integration" curriculum system

To break through the constraints of traditional disciplinary systems on curriculum structure and fully reflect the basic concept of “integration of work and study” in vocational education, the core orientation should be the capability requirements of GIS industry positions. The curriculum structure should be redesigned to build a new “task-driven + modular integration” curriculum system. This system uses real work tasks as carriers and divides the course content into several core modules, including basic theoretical knowledge, data acquisition and processing, spatial analysis and modeling, and GIS application development. Each module is designed around multiple specific work tasks. For example, in the “data acquisition and processing” module, typical tasks such as “digitization of topographic maps,” “GPS and GNSS data acquisition and processing,” and “interpretation and vectorization of remote sensing images” can be set. Through the completion of these tasks, students gradually master the relevant knowledge, operational skills, and logical processes, thereby enhancing the relevance and effectiveness of learning. In addition, each module should strengthen the logical relationship and internal connection of the technical process, building a closed-loop GIS technology cognition system from data acquisition to application development. This helps students fully understand the overall workflow of GIS projects, improves their systematic thinking and comprehensive application abilities, and lays a solid foundation for future job positions (Yang et al., 2025).

3.2 Development of real-world oriented typical project resources

The effectiveness of project-based teaching hinges on the authenticity and typicality of project resources. Therefore, it is essential to deeply explore real industry needs and develop typical project resources that closely resemble actual application scenarios to enhance the vocational orientation and practical value of teaching tasks. The project topics should cover a wide range of key application areas such as urban and rural planning, land and resources investigation, ecological environment protection, public safety, and intelligent transportation. For example, project topics such as “Analysis of Urban Land Use Status and Planning Suggestions,” “Remote Sensing Monitoring and Assessment of Regional Ecological Environment,” and “GIS Simulation of Disaster Risks and Emergency Plan Development” can be designed to truly replicate the typical work processes of GIS practitioners. During the project development process, industry resources should be fully utilized, and GIS experts from enterprises and institutions should be invited to participate in project design and review. This ensures that the projects meet high industry standards and advancedness in terms of technical approach, data sources, and solutions. Meanwhile, based on students’ ability levels and learning progress, project resources should be divided into three levels: basic, comprehensive, and innovative, to meet the differentiated needs of different stages of teaching. Basic projects can focus on basic skill training such as map production and spatial data entry; comprehensive projects emphasize the collaborative application of multiple GIS technologies to enhance students’ problem-solving abilities; innovative projects guide students to explore cutting-edge technologies such as 3D GIS, Web GIS, and IoT GIS, stimulating their innovative thinking and research potential.

3.3 Optimization of teaching organization and implementation pathways

The transformation of teaching organization methods is a key link in the smooth implementation of project-based teaching. The “project team system” should be the main teaching organization model, with students divided into several project teams based on their interests and abilities. Each team is responsible for a complete teaching project, simulating the project collaboration mechanism in real workplaces. In this process, teachers shift from traditional “lecturers” to “project guides” and “process managers.” They guide students in formulating feasible project plans, organizing division of labor and collaboration, and solving problems encountered during implementation. The specific implementation path should follow a complete teaching process of "project introduction to task decomposition to knowledge explanation to practical operation to result presentation to evaluation and feedback." In the project introduction stage, industry cases, actual project videos, or project results are introduced to arouse students' interest and clarify learning objectives. The task decomposition stage refines the project implementation steps, enabling students to understand the responsibilities of each link. The knowledge explanation stage is embedded in task requirements, achieving synchronous generation of knowledge and skills through a "learning-by-doing" approach. The practical operation stage is the core of project advancement, where students' technical and soft skills are comprehensively exercised through hands-on operation and team collaboration. The result presentation stage organizes students to report on project progress and achievements, promoting learning exchange and experience summarization. Finally, in the evaluation and feedback stage, teachers and students jointly review the project completion quality, enhancing students' self-reflection and continuous improvement capabilities (Fan et al., 2020).

3.4 Enhancing teacher professionalism and project management capabilities

High-quality project-based teaching relies on a team of teachers with dual-qualification qualities. To this end, higher vocational colleges should systematically strengthen the professionalization and practical capability development of the GIS faculty. On the one hand, teachers should be organized to regularly participate in domestic and international cutting-edge GIS technology training, industry certification exams, and pedagogy workshops to master the latest technologies such as big data analytics, spatial modeling, and the integration of artificial intelligence with GIS, thereby broadening their knowledge horizons and professional literacy. On the other hand, conditions should be actively created to support teachers' involvement in real-world GIS projects in enterprises. Through forms such as job rotation, horizontal project collaboration, and joint research, teachers can deepen their understanding of industry needs, accumulate project management experience, and enhance their practical guidance capabilities. Meanwhile, a joint faculty mechanism of "on-campus + off-campus" should be established, hiring engineering technicians, senior planners, and GIS system developers with industry backgrounds as part-time teachers to participate in project-based course teaching and guidance. By jointly conducting lectures, practical courses, and training camps with enterprises, a faculty structure characterized by "industry leadership, on-campus dominance, and collaborative education" can be built to comprehensively improve the professionalism, engineering nature, and project-based teaching capabilities of the teaching team.

3.5 Advancing the construction of digital teaching resource platforms

In the context of highly developed digital technology, constructing a digital teaching resource platform that integrates resource integration, task assignment, process tracking, and outcome evaluation is an important means of promoting project-based teaching reform in GIS courses. The platform should cover modules such as teaching presentations, project case libraries, data resource packages, video teaching materials, simulation experiment systems, and project outcome display systems to support the informatization management and service of the entire teaching process. Moreover, building a flexible and open online learning space to achieve a blended teaching model that combines online and offline learning can effectively break through the limitations of time and space, expanding the channels for students' self-directed learning and multidimensional interaction. Students can independently access learning resources, upload project outcomes, and engage in group collaboration and communication through the platform, while teachers can use it to monitor learning progress in real time, provide task guidance, and conduct phased evaluations. By leveraging the digital platform, the accessibility of teaching resources and the efficiency of teaching organization can be enhanced, while also promoting the realization of students' personalized learning methods and improving overall teaching quality and management standards (Huang et al., 2025).

3.6 Improving a diversified teaching evaluation mechanism

To scientifically and fairly measure the actual effectiveness of project-based teaching, it is essential to establish a comprehensive evaluation system based on multidimensional, multi-subject, and multi-process criteria, breaking away from the traditional single knowledge-based evaluation mode dominated by end-of-term written exams. The evaluation content should cover students' mastery of professional knowledge, practical skill operation capabilities, performance in project execution, teamwork abilities, innovative awareness, and comprehensive capabilities in solving practical problems. In terms of evaluation subjects, a diversified participation mechanism integrating "teacher evaluation + student peer evaluation + student self-evaluation + enterprise evaluation" should be constructed to comprehensively assess students' learning outcomes from multiple perspectives. For instance, teachers should focus on evaluating the accuracy of technical operations, the quality of task completion, and professional standards; student peer and self-evaluations should concentrate on participation in the process, teamwork performance, and personal reflection capabilities; while enterprise expert evaluations should provide feedback based on criteria such as professional quality, practical ability, and job fit. Project outcome presentations and defenses can also serve as an important evaluation method, enhancing students' abilities in expression, presentation, and dialectical thinking. Through a scientific and diversified evaluation mechanism, students can be more effectively guided to focus on the learning process and capability development, while also providing feedback for teachers to improve teaching design, forming a virtuous cycle of mutual teaching and learning improvement.

4. Analysis of the Implementation Effects of Project-Based Teaching Reform in GIS Technology and Application Courses at Higher Vocational Colleges

4.1 Significant improvement in students' comprehensive abilities

Through the systematic advancement of project-based teaching reform, students at higher vocational colleges have shown marked improvements in their comprehensive abilities across multiple dimensions. Firstly, in terms of practical operation capabilities, students have become proficient in using mainstream GIS software such as ArcGIS and QGIS to conduct the entire workflow of spatial data acquisition, processing, analysis, and visualization. For example, in completing the "Urban Land Use Analysis" project, students have mastered key skills such as data repository building and spatial overlay analysis, and are able to independently output result maps and write analysis reports. Secondly, in terms of innovation capabilities, project tasks often involve multi-source data integration, algorithm selection and optimization, and information visualization. Students need to extend their existing knowledge systems to explore and propose feasible innovative solutions, such as the prototype development of interactive map platforms based on Web GIS. Meanwhile, through multi-project collaboration practices, students' teamwork and organizational communication skills have also been continuously honed. They can reasonably divide labor, collaborate effectively within a team, actively express their views, and jointly solve problems, making them more adaptable to the requirements of future job positions for composite technical talents (Ma & Liao, 2024).

4.2 Significant enhancement of teaching interactivity and student engagement

The project-based teaching model has effectively broken through the limitations of traditional "teacher-lecturing, student-listening" rote teaching methods, greatly enhancing classroom interactivity and student participation. Under the project team-based teaching arrangement, students engage in in-depth discussions and collaborative work around project goals, creating a more vibrant classroom atmosphere. Faced with specific problems during project implementation, students need to continuously consult materials, seek help from peers, or ask teachers for guidance. This “problem-guided - active exploration” learning model significantly improves students’ self-directed learning abilities and inquiry awareness. Moreover, teachers have shifted from traditional knowledge transmitters to facilitators, assistants, and evaluators, placing greater emphasis on the interactive process with students. For example, in the “Ecological Sensitive Area Site Selection Analysis” project, teachers set contextual tasks to guide students in independently designing analysis paths and technical processes, enhancing their ability to identify and solve problems. The teaching process has become more open-ended and generative, forming an integrated, interactive teaching ecosystem of “teaching - learning - doing - evaluating.”

4.3 Initial effectiveness of teaching feedback and evaluation mechanisms

With the deepening of project-based teaching reform, diversified teaching evaluation and feedback mechanisms have been gradually established and are functioning effectively, providing scientific evidence for the continuous optimization of teaching quality. The reform has discarded the traditional single evaluation method dominated by end-of-term written exams and constructed a comprehensive evaluation system that includes formative, summative, and terminal evaluations. In practice, teachers provide professional evaluations based on students’ technical operation performance, document writing quality, and presentation skills during projects. Student self-evaluation and peer evaluation are also included to supplement from perspectives such as subjective feelings and collaborative contributions. Meanwhile, some projects introduce enterprise expert evaluations to assess students’ professional quality and project implementation capabilities from a real-work perspective, enhancing the effectiveness and relevance of evaluations. Through the diversified feedback mechanism, teachers can promptly identify issues in teaching design and implementation, such as overly difficult projects or unreasonable task assignments, and adjust teaching content or methods accordingly. Students can also clearly recognize their shortcomings in knowledge understanding, skill mastery, and teamwork, clarifying their future directions for improvement and learning paths. This forms a closed-loop teaching improvement system of “evaluation - teaching - learning” (Wu, 2024).

Conclusion

In summary, project-based teaching reform in GIS technology and application courses at higher vocational colleges is an effective approach to meet industry development needs and enhance the quality of talent cultivation. Through the implementation of a series of reform measures, including the construction of a rational curriculum system, the development of real-world oriented project resources, the optimization of teaching organization and implementation pathways, the enhancement of teacher capabilities, the advancement of digital resource platform construction, and the improvement of diversified teaching evaluation mechanisms, the existing problems in traditional teaching can be effectively resolved. This leads to an enhancement of students’ comprehensive abilities and teaching quality. However, project-based teaching reform is an ongoing process that requires continuous experience summarization and optimization of the reform plan according to industry development and student needs, in order to cultivate more high-quality applied GIS talents that meet the demands of social development.

Conflict of Interest

The authors declare that they have no conflicts of interest to this work.

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How to Cite: Li, X., & Huo, W. (2025). Exploration of Project-based Teaching Reform of GIS Technology and Application Courses in Higher Vocational Colleges *Contemporary Education and Teaching Research*, *06*(5), 200-206. https://doi.org/10.61360/BoniCETR252018350508

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