Research on the Teaching Reform of Geographic Information System Based on the Cultivation of Application Ability

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Abstract. This study takes the teaching reform of Geographic Information System Course for urban and rural planning major as the core, and puts forward a three-level progressive teaching framework of "basic theory - core application - project practice" in view of the problems existing in the current course, such as practice disconnection and low student participation. By integrating the needs of planning and design courses, five teaching modules, including GIS data collection, spatial analysis and urban simulation, were constructed, and real planning cases were innovatively used to create practice scenes and establish an interactive connection mechanism for the course group. In the implementation of the reform, project-based teaching is emphasized, and a multiple evaluation system is constructed. The practice shows that the mode effectively improves the students' spatial analysis ability and software application level, promotes the deep integration of GIS technology and planning and design practice, and provides a feasible path for cultivating application-oriented planning talents.

Keywords: Geographic information system; Teaching reform; Curriculum integration; Practical ability.

1 Introduction

1.1 Purpose and Significance of the Study Purpose

Purpose of the Study

Based on the specific requirements and applications of GIS software in planning and design courses, this study aims to promote the two-way integration between the Geographic Information Systems (GIS) course and senior-level planning and design courses, thereby constructing an application-oriented GIS curriculum system that aligns with societal development needs.

Significance of the Study

(1) Enhancing Teaching Quality: Curriculum integration ensures that teaching content closely aligns with industry demands, while diversified teaching methods

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effectively boost students' learning interest and engagement, thereby elevating overall teaching quality.

(2) Urgency of Practical Competency Development: In the face of complex and dynamic real-world planning challenges, theoretical instruction alone is insufficient to meet industry requirements. By integrating curricula, this study strengthens the connection between theory and practice, enhancing students' problem-solving abilities and positioning this approach as a critical direction for educational reform.

(3) Strengthening Employability: Students will not only master robust GIS technical skills but also learn to flexibly apply them in planning and design practices, meeting the market demand for interdisciplinary talents and significantly improving their career competitiveness.

(4) Promoting Interdisciplinary Convergence and Innovation: The integration of GIS and planning-design curricula fosters deep collaboration between these two fields, stimulating students' innovative thinking and driving advancements in both disciplinary development and practical applications[1].

1.2 Analysis of Current Teaching Challenges

(1) Low student motivation

(2) Fragmented practical content

(3) Lack of innovation and engagement in course design

(4) Marginalized course status

(5) Insufficient practical sessions

(6) The combination with the application of urban and rural planning is not close enough1.3 GIS Technology Needs in Urban-Rural Planning[2]

1.3 Analysis of GIS Technology Requirements in Urban and Rural Planning

The demand for GIS technology in urban and rural planning is primarily reflected in the following aspects:

(1) Providing Precise Geographic Data: GIS systems can deliver detailed geographic data, enabling planners to understand natural conditions such as terrain and landforms, thereby facilitating more informed planning and design.

(2) Analyzing Socioeconomic Data: GIS supports the analysis of socioeconomic data, including population distribution and traffic flow, providing evidence for rational urban layout planning. Spatial analysis techniques, such as delineating buffer zones for land-use restrictions, can mitigate noise pollution or traffic congestion.

(3) Simulating Urban Development: GIS systems can model potential urban development challenges, such as flooding and traffic bottlenecks, allowing planners to proactively address these issues and enhancing the scientific rigor and foresight of urban planning.

(4) Integrating and Analyzing Multidimensional Data: GIS enables the integration and analysis of multidimensional datasets, combining geographic data with socioeconomic, environmental, and infrastructure data to support data-driven decision-making.

(5) Site Investigation and Spatial Analysis: During site investigations, GIS systems manage spatial data (e.g., land use, road networks, and municipal facilities). Overlay analysis functions in GIS facilitate floor area ratio (FAR) calculations, land suitability evaluations, spatial structure assessments, and traffic network optimizations[3].

(6) Smart City Applications: GIS plays a critical role in smart city development by enabling the aggregation, governance, and integration of spatiotemporal data resources, thereby providing unified services for smart city applications such as urban monitoring and resource management[4].

In summary, GIS technology is indispensable in urban and rural planning. It not only provides accurate geographic data but also supports socioeconomic analysis, urban development simulation, and multidimensional data integration, empowering planners to make scientifically grounded and forward-looking decisions.

2 Curriculum Teaching Reform

2.1 Reform of Teaching Content

During the teaching process, a curriculum structure centered on the "foundational theory - core applications - project-based practice" framework is adopted, accompanied by a "progressive deepening, bidirectional integration" pedagogical approach. Theoretical learning is complemented by hands-on practical sessions. The course aligns GIS teaching practices with tasks from senior-level planning and design courses, such as preliminary site analysis and traffic analysis, to seamlessly integrate GIS theory into practical applications, enabling students to "apply knowledge into practice."[5]

Based on the requirements of urban and rural planning, five core learning modules are defined: GIS fundamentals, Spatial data collection and editing, Projection and spatial database construction, Visualization and cartographic output, Spatial analysis

Key priorities and challenges are summarized in Table 1. Teaching challenges are identified based on three dimensions: students' knowledge gaps, theoretical complexity, and operational difficulties in procedural steps.

Table 1. Key and difficult points of the course

Learning module	Key points of practical teaching	Difficulties in practical teaching
GIS foundation	GIS function characteristics, application fields, ArcGIS software composition	The relationship between geospatial characteristics and attributes of elements, and the basic characteristics of spatial analysis
Spatial data acquisition and editing	Attribute table editing, spatial element drawing, editing modification, CAD software data conversion	The quick query method of attribute table, the use of editor, and the difference between drawing command and modifying command
Projection and	Basic theory of coordinate system	Accuracy of geographical registra-

spatial data base building	and projection, geographical registration, database construction process, topology analysis	tion, framework design of database, topology analysis and data inspection
Visual expression and data output	Data symbolization, map layout design, map output vector overlay analysis	Symbolic differences of different data characteristics such as category, grade and quantity, characteristics of layout view and content composition of standardized map
Spatial analysis	Network analysis, 3D analysis, grid spatial analysis, grid calculator use	Application scenarios and operation processes of various spatial analysis, selection basis and quantitative methods of analysis indicators

2.2 Case-Based Practical Scenarios

Real-world planning cases are used to simulate GIS applications, addressing the gap between classroom learning and professional practice. Teaching strategies include:

(1) Problem-driven software operations
(2) Interactive explanations for complex theories
(3) Progressive task design to enhance analytical skills
(4) Repeated demonstrations for common challenges.

2.3 Long-Term Curriculum Group Development

An interconnected GIS curriculum system is established, linking practical content across related courses to reinforce GIS applications throughout professional training (see Figure 1).

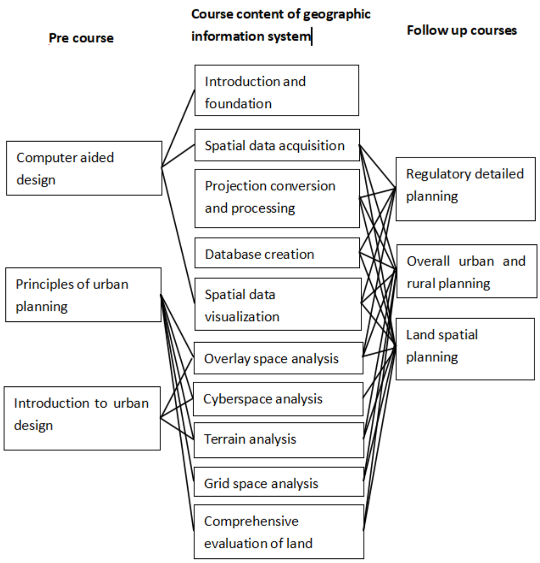

Fig. 1. Connection between GIS course content and related courses

2.4 Reform of the Assessment System

Build a diversified core knowledge and skills system and optimize the assessment methods. The course assessment mainly includes three parts: practical operation on the computer, data analysis combined with the design course, spatial analysis, urban development simulation and other content mapping and daily performance. The practical operation assessment is to test the students' practical ability within the specified time according to the set task objectives; The mapping of data analysis, spatial analysis and urban development simulation combined with the design course is the integration and connection with the senior planning and design course; The classroom performance assessment is to examine the attendance rate, the enthusiasm of answering questions, the degree of completing practical content, and the practical application ability of students in the process of computer teaching at ordinary times.

2.5 Reform of Teaching Methods

Reform Strategies Tailored to Urban Planning Students and GIS Course Characteristics

Based on the learning profiles of urban planning students, their academic proficiency, and the unique demands of the Geographic Information Systems (GIS) course, the following reforms are proposed:

(1) Leveraging Online Platforms for Self-Directed Learning:

Autonomous Topic Selection: Utilize digital platforms to enable students to independently choose research topics (e.g., urban heat island analysis, green space accessibility studies), thereby enhancing hands-on skills and learning engagement.

Interactive Skill Development: Design web-based exercises (e.g., real-time GIS data collection, collaborative mapping) to foster technical competency and creativity.

(2) Curriculum Optimization and Project-Driven Knowledge Integration:

Content Refinement: Streamline teaching materials by prioritizing core concepts (e.g., spatial analysis workflows, geodatabase management) and eliminating redundancies.

Systematic Knowledge Structuring: Adopt project-based learning (e.g., simulating urban expansion scenarios, optimizing public transit networks) to interconnect fragmented knowledge points, ensuring a holistic understanding of GIS applications in urban planning.

3 Distinctive Innovations

(1) Enhanced Teaching Methods with Active Participation in Pedagogical Reform
(2) Expanded Engineering Application Practices
(3) Comprehensive Practical Training for Robust Professional Skills[6]
(4) Strengthened Comprehensive Application Assessment

4 Conclusion

The proposed "foundational theory–core application–project practice" three-tiered progressive teaching model, driven by course cluster interactions and real-world planning cases[7], effectively bridges the gap between GIS education and practical planning needs. Post-reform data show:

42% increase in excellence rates for spatial analysis assignments,

91% pass rate in cross-course comprehensive application assessments,

35% improvement in software operational efficiency.

The "case introduction–task-driven–feedback loop" framework has deepened the integration of GIS technology with planning design workflows. Current limitations include delayed updates to case libraries and high costs of cross-course coordination. Future priorities involve:

Establishing dynamic case update mechanisms,

Developing virtual simulation platforms (e.g., 3D city modeling tools),

Advancing BIM+GIS+VR convergence for immersive learning[8].

This study provides a replicable pathway for cultivating digitally empowered urban-rural planning professionals, aligning with global trends in smart city education.

Funding Project

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