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Research on Teaching Reform for Cultivating Data Analysis Ability of Environmental Engineering Majors under the Digital-Intelligent Background: A Case Study of the Course Environmental Information and Statistical Analysis

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Abstract: Digital-intelligent technologies have been widely applied in ecological environment monitoring and governance, putting forward new requirements for the data analysis ability of environmental engineering professionals. The course Environmental Information and Statistical Analysis serves as an important carrier to cultivate students' capabilities in acquiring, processing, and analyzing environmental information. However, practical teaching still has prominent problems including weak connection of knowledge modules, insufficient practical training, loose combination between teaching contents and actual environmental issues, and evaluation methods that fail to reflect students' data analysis proficiency. Centering on the talent training demands of environmental engineering, this paper systematically optimizes training objectives, teaching contents, practical tasks, and evaluation modes with the whole process of environmental data analysis as the main line. A teaching model driven by real environmental issues and centered on cultivating data analysis ability is constructed. During course implementation, remote sensing, geographic information system (GIS), and environmental statistical analysis are organically integrated to guide students to complete the full workflow of data acquisition, data processing, spatial analysis, statistical interpretation, and engineering decision-making, and standardize the application of artificial intelligence-assisted learning. Based on score analysis of 193 students from the academic years 2023 to 2025, the results show that the average total course score reaches 86.19 points, the average usual score is 91.05 points, and the average final exam score is 81.33 points. Students show high learning participation, yet there is still room for improvement in their ability to comprehensively analyze and independently solve environmental problems. Practices prove that course reform shall further strengthen the in-depth integration of professional knowledge, data analysis methods, and engineering practice. Through case-driven teaching, practical training and multi-dimensional evaluation, students' data analysis and engineering application capabilities can be effectively fostered.

Keywords: Digital intelligence; Environmental engineering; Environmental information; Data analysis ability; Course reform

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1. Introduction

Ecological environment governance is transforming from experience-based decision-making to data-driven decision-making. The extensive application of remote sensing, geographic information system (GIS), automatic monitoring, Internet of Things, and artificial intelligence technologies has greatly improved the capacity for environmental data acquisition. Environmental governance has shifted from single-indicator monitoring to integrated analysis of multi-source data, imposing higher standards on the data analysis ability of environmental engineering talents [1–4]. Environmental engineering students are required to master not only pollution control theories and environmental monitoring technologies, but also the capacity to analyze environmental problems, interpret environmental processes, and support engineering decisions via multi-source environmental data, which constitutes a core component of talent cultivation in the new era [5–7]. Digital education and Emerging Engineering Education further push forward curriculum teaching reform. Professional accreditation of engineering education lays more emphasis on students' competence to analyze and solve complex engineering problems with modern tools, rather than mere knowledge memorization or software operation skills [8–10]. Therefore, professional courses need to restructure teaching objectives, contents, and evaluation modes around competency cultivation, enabling students to comprehensively utilize professional knowledge to solve practical problems under real engineering scenarios.

The course Environmental Information and Statistical Analysis is a key subject for training students' ability to obtain, process, and analyze environmental information, occupying a connecting position in the professional curriculum system. Nevertheless, problems such as loose correlation between knowledge modules and inadequate combination of practical teaching with environmental issues still exist in course delivery. Targeting the above deficiencies, this paper systematically optimizes training objectives, teaching contents, practical tasks, and evaluation systems throughout the full workflow of environmental data analysis with competency cultivation as the core thread. Combined with course implementation effects, the reform outcomes are analyzed to provide references for cultivating data analysis ability of environmental engineering majors under the digital-intelligent background.

2. Teaching reform design

2.1. Optimizing course objectives centered on data analysis competency

The curriculum reform adheres to competence orientation, extending the training objectives from knowledge acquisition and software application to the cultivation of environmental data analysis capabilities. It emphasizes that students can comprehensively apply technologies such as remote sensing, GIS, and statistical analysis to solve practical environmental problems. The curriculum objectives mainly cover three aspects: first, to master the basic theories and methods of environmental information acquisition, spatial analysis and statistical analysis, and understand the characteristics and applicable scopes of different types of environmental data; second, to select appropriate data sources and analytical methods for specific environmental issues, and complete data sorting, spatial analysis, statistical processing and result presentation; third, to interpret analytical results with professional environmental knowledge, recognize the impacts of data quality, spatial scales and analytical methods on results, properly leverage tools including artificial intelligence to assist analysis, and develop scientific engineering judgment capabilities.

2.2. Restructuring course teaching contents

The teaching contents are reorganized with the workflow of environmental data analysis as the main line, forming a teaching logic of "environmental problem–data acquisition–data processing–comprehensive analysis–engineering application." Each knowledge module maintains relative independence while forming organic connections around the complete data analysis procedure, highlighting the integration of professional knowledge and information technology. See **Table 1**.

Table 1. Optimization of course teaching contents

Teaching module	Teaching focus	Learning outcomes
Environmental Information Acquisition	Data sources, remote sensing data interpretation, data reliability analysis	Able to select appropriate data sources
Environmental Data Processing	GIS data sorting, unification of spatial reference, data quality inspection	Able to standardize environmental data processing
Spatial and Statistical Analysis	Spatial analysis, statistical analysis, thematic map production	Able to conduct comprehensive environmental data analysis
Comprehensive Analysis and Application	Environmental case study, AI-assisted analysis, governance suggestions	Able to compile comprehensive analysis reports

The teaching no longer centers on software function demonstration, but organizes teaching around environmental issues, guiding students to understand data sources, analytical procedures and result implications, so as to closely link knowledge learning with engineering practice.

2.3. Building progressive practical tasks

In accordance with the formation law of data analysis competency, four tiers of practical tasks are set up: recognition, operation, analysis and application. The basic stage focuses on training students to identify environmental information and standardize data processing. The advanced stage carries out spatial and statistical analysis training targeting specific environmental problems. The comprehensive stage requires students to analyze real environmental cases, interpret results, and put forward governance suggestions, gradually forming complete data analysis thinking.

2.4. Improving course evaluation system

The course continues to assign equal weights of 50% to continuous assessment and the final examination, yet the evaluation focus shifts from the learning process to competency demonstration. Usual performance is assessed based on class assignments, individual homework, group projects, and course presentations, focusing on students' capacities in data acquisition, processing, analysis, and result output. The final exam reduces mechanical memorization questions and increases items of case analysis, method selection, result interpretation and comprehensive application, guiding students to synthesize professional knowledge for environmental problem analysis.

3. Teaching implementation

3.1. Scenario-oriented teaching driven by environmental issues

Traditional knowledge-centered lecturing is replaced by scenario teaching taking typical environmental problems as entry points, guiding students to comprehend relevant theories and methodologies during problem analysis. For instance, in remote sensing teaching, practical cases such as lake area variation, urban spatial expansion, and vegetation coverage change are introduced to help students recognize the application value of remote sensing data in dynamic environmental monitoring.

3.2. Strengthening cultivation of data processing and comprehensive analysis capabilities

Aiming at students' insufficient data awareness and the tendency of prioritizing tool operation over result interpretation, the course reinforces training on data processing and comprehensive analysis. In data analysis tasks, students are required to systematically record basic information including data source, collection time, spatial scope, coordinate system, variable definitions and data resolution, and conduct quality control such as data format inspection, missing value filling and outlier identification. In comprehensive practice, students shall complete the full analytical workflow from problem definition, data sorting and method selection to result presentation and limitation discussion.

3.3. Standardizing the application of artificial intelligence tools in course learning

In response to the impacts of rapid AI development on learning modes, the course explores AI-assisted teaching and clarifies its application boundaries. Students are allowed to utilize AI tools to assist in understanding professional concepts, analyzing program codes, and optimizing data visualization, but they must conduct professional review and verification on all AI-generated content. Teachers guide students to identify potential defects in AI outputs such as ambiguous data sources, unreasonable method selection, and overgeneralized conclusions, cultivating students' judgment ability on intelligent tool results.

4. Analysis of course reform effects

4.1. Analysis of students' academic performance

To evaluate the reform outcomes, statistical analysis is carried out on scores of 193 students taking Environmental Information and Statistical Analysis from the academic years 2023 to 2025, including 73 students in 2023, 54 in 2024, and 66 in 2025. Total score consists of 50% usual performance and 50% final exam. See **Table 2**.

Table 2. Course score statistics (2023–2025 academic years)

Academic year	Number of students	Average usual score	Average final score	Average total score
2023	73	93.64	84.38	89.01
2024	54	89.13	81.71	85.42
2025	66	89.74	77.65	83.70
Overall	193	91.05	81.33	86.19

Statistical results show satisfactory overall academic performance across three academic years, with an average total score of 86.19, average usual score of 91.05, and average final exam score of 81.33. Usual scores are generally higher than final exam scores, indicating that students can complete class and practical tasks well, and the reform has achieved positive results in boosting learning participation and practical enthusiasm. However, gaps exist in students' comprehensive analytical capacity reflected by final examinations. Paper analysis reveals that most students master environmental data processing and basic analytical methods, yet they remain weak in the theoretical basis for method selection, in-depth interpretation of environmental processes, and judgment on data applicability and limitations. It demonstrates that the reform has improved students' data processing skills, while further strengthening students' comprehensive research and judgment based on data remains a priority of subsequent teaching optimization.

4.2. Reform achievements and improvement directions

After the implementation of course reform, the connection between teaching contents and practical environmental engineering scenarios is strengthened, and students gradually shift from merely mastering technical approaches to solving environmental problems via data analysis. Classroom teaching has evolved from pure knowledge instruction to a combination of case analysis and task-driven practice, lifting students' classroom engagement and independent inquiry awareness.

Meanwhile, several areas requiring continuous improvement are discovered during implementation. Restricted by limited class hours, the number of comprehensive data analysis projects is insufficient, and students lack in-depth practice on complete analytical workflows. Future curriculum construction will center on competency objectives, introduce more representative environmental data analysis projects, increase independent practice and presentation sessions, and strengthen full-process training covering data acquisition, processing, analysis, and result interpretation.

5. Conclusion

Against the digital-intelligent development background, cultivating data analysis ability of environmental engineering majors requires not only the mastery of software and intelligent tools, but also comprehensive capacity to solve real environmental problems supported by data. Centered on competency training objectives, this course optimizes teaching contents, practical tasks, and evaluation modes. Through case analysis, data practice and process feedback, students are guided to master the complete workflow of data acquisition, processing, analysis and result interpretation.

Analysis of examination results of 193 students from 2023 to 2025 shows favorable reform effects with an average total score of 86.19. Usual scores are generally higher than final scores, proving students perform well in class participation and task completion, yet their capacity for comprehensive data analysis and independent judgment on complex environmental problems still needs improvement. Subsequent curriculum development will further integrate practical demands of environmental engineering, introduce more real-scenario data analysis tasks, expand independent research and presentation sessions, and perfect the procedural evaluation index system. Training on data quality control, uncertainty analysis, and standardized AI-assisted learning will be enhanced to continuously improve students' ability to identify and evaluate problems and support decision-making with environmental data.

Disclosure statement

The author declares no conflict of interest.

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