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Evaluation and Enhancement Strategies of Geomorphology Experimental Teaching Based on CIPP Model: A Case Study of Jiaying University

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Abstract: This study developed and operationalized a CIPP-based evaluation framework to assess geomorphology experimental teaching at Jiaying University. Integrating Delphi method, Analytic Hierarchy Process, and expert survey, a four-dimensional indicator system comprising 4 1st-level, 10 2nd-level, and 20 3rd-level indicators was constructed with high reliability and expert consensus. The overall evaluation score (95.34) indicates generally high instructional quality. However, a systemic gap was identified: Results and Effectiveness scored lowest across all dimensions, with five 3rd-level indicators, related to instructional reflection, student feedback, and scholarly output, falling markedly below the mean. This reveals a critical disconnect between teaching execution and tangible educational outcomes. To address this gap, a four-dimensional enhancement framework is proposed. Its core strategies include revitalizing experimental materials, embedding regional geomorphic contexts, adopting scaffolded supervision supported by AI-enabled feedback, and most critically institutionalizing an OBE-aligned closed-loop feedback mechanism that recursively links teaching execution to curricular improvement and scholarly valorization. This study extends the applicability of the CIPP model to geoscience education and offers a replicable, diagnostics-driven blueprint for pedagogical enhancement.

Keywords: CIPP Model; Evaluation; Enhancement Strategies; Geomorphology Experimental Teaching; Case Study

1. Introduction

Geography is distinguished by its integrative analysis of human–environment systems, necessitating pedagogical approaches that bridge theoretical abstraction and empirical reality [1]. Experimental teaching constitutes a cornerstone of this endeavor, playing an indispensable role in cultivating geographically literate professionals. By transforming abstract principles into concrete, spatially explicit experiences, geographical experiments are critical for developing foundational competencies, including field observation, sample analysis, spatial simulation, and holistic problem-solving [2]. This pedagogical mode is therefore essential not only for knowledge transmission but also for shaping sophisticated geographical reasoning and fostering robust research and practical skills.

Within this framework, geomorphology occupies a pivotal position as a core sub-discipline concerned with the characteristics, genesis, evolution, and anthropogenic modification of Earth's surface landforms. The inherent complexity of geomorphological processes, operating across vast spatial and temporal scales, renders experimental teaching particularly vital. Through methodologies such as laboratory simulations (e.g., of fluvial and aeolian dynamics), physical model construction, sedimentological analysis, digital terrain modeling [3], and virtual field exercises, students acquire an intuitive understanding of protracted endogenic and exogenic processes [4]. These experiences are fundamental for mastering skills in landform identification, process analysis, and geochronological techniques. Consequently, the efficacy of geomorphology experimental teaching directly shapes students' depth of understanding in Earth system science and underpins their professional preparedness for careers in education, research, environmental management, and spatial planning [5].

Despite widespread recognition of its importance, the systematic evaluation and evidence-based enhancement of geomorphology experimental teaching remain underdeveloped areas within geography education scholarship. Prevailing assessment paradigms often rely excessively on summative academic performance metrics, exhibiting limitations such as a focus on terminal outcomes over learning processes and a dependence on subjective appraisals rather than objective, multi-source evidence [6]. Such approaches are inadequate for deconstructing the complex causal relationships among instructional design, resource allocation, pedagogical processes, and dynamic learning outcomes. The CIPP (Context, Input, Process, Product) evaluation model [7], characterized by its systematic, process-sensitive, and improvement-oriented architecture, offers a promising theoretical framework to address these shortcomings [8]. However, its application to the specific domain of geomorphology experimental instruction confronts significant conceptual and methodological challenges, revealing distinct research gaps: (1) Indicator Development and Quantification: Operationalizing contextual requirements, resource inputs (e.g., equipment, faculty), interactive teaching processes, and multidimensional learning outcomes (e.g., skill acquisition, critical thinking, innovation capacity) into a valid, reliable, and quantifiable indicator system remains non-trivial. (2) Process Data Capture: Critical, real-time data on classroom dynamics such as student-instructor interactions, problem-solving trajectories, and collaborative learning behaviors, are notoriously difficult to capture in an automated, standardized, and scalable manner. (3) Mechanistic Interrogation: A paucity of empirical research exists that utilizes the interconnected CIPP dimensions to analyze the integrated impact mechanism, namely how contextual factors, inputs, and processes interact synergistically to determine final pedagogical products. This gap often forces improvement strategies to rely on anecdotal experience rather than data-driven diagnostics. Extant literature predominantly features qualitative case studies or isolated assessments of single dimensions, leaving a conspicuous void in research that employs comprehensive, full-cycle quantitative evaluation to inform integrated teaching enhancement strategies.

To address these gaps, this study employs the CIPP model to construct and implement a tailored, quantifiable evaluation index system for geomorphology experimental teaching at Jiaying University. By systematically collecting and analyzing data across all four stages—Context, Input, Process, and Product—this research aims to achieve a precise diagnostic assessment of teaching effectiveness. The analytical integration of these dimensions is designed not merely to yield a more holistic and objective performance measure but, more critically, to identify key leverage points and systemic bottlenecks that influence outcomes. Based on this diagnosis, targeted and actionable strategies for pedagogical enhancement are formulated. Theoretically, this study contributes by refining and operationalizing the CIPP model within a specific, high-stakes disciplinary context, thereby advancing the empirical rigor and granularity of geographical pedagogy evaluation. Practically, it delivers an evidence-based, scalable decision-support framework capable of guiding the reform of experimental teaching in geomorphology and cognate geoscience disciplines. Ultimately, this work seeks to inform the strategic optimization of educational resources, foster innovative teaching models, and elevate the overall quality of professional training in the geographical sciences.

2. Method

To ensure the scientific validity and practical utility of the evaluation framework, the screening of indicators and the construction of the system in this study strictly adhered to the principles of operability, typicality, comprehensiveness, and disciplinary relevance. Specifically, the selection process emphasized not only the feasibility of implementation in practical teaching assessment and the accessibility of data but also the representativeness of the indicators in capturing the core characteristics of geography and the critical aspects of geomorphology experimental teaching. Concurrently, the evaluation system was designed to comprehensively cover multiple dimensions of experimental teaching, including its Foundational Context, Program Planning, Implementation Process, and Results and Effectiveness, while deeply integrating the systems-thinking paradigm inherent to geographical research. Furthermore, this study gave particular consideration to the unique attributes of the geographical discipline and the distinctive features of geomorphology experimental teaching. The design of the indicators explicitly embodies the regional and practical orientation of geography, necessitating alignment with the discipline's holistic perspective. Based on the aforementioned principles and considerations, multiple rounds of screening and optimization were conducted on the initially proposed indicator pool. The objective was to select a parsimonious yet robust set of core indicators characterized by strong representativeness and sufficient discriminative power. This approach ensures that the evaluation system is structurally coherent and conceptually focused while avoiding redundancy and overlap among indicators, thereby minimizing subjective bias and enhancing the objectivity, reliability, and validity of the assessment outcomes.

2.1 Indicator Screening and Preliminary Construction of the Evaluation System

Based on the structural framework of the CIPP model, the four dimensions including Contextual Foundations, Program Planning, Implementation Process, and Results and Effectiveness, were established as the 1st-level indicators for evaluating geomorphology experimental teaching [9]. Subsequently, by integrating the Undergraduate Teaching Level Assessment Index System for Regular Higher Education Institutions and considering the specific context of geomorphology experimental teaching at Jiaying University, each first-level indicator was further delineated according to its structural characteristics. This process resulted in the identification of 10 2nd-level and 24 3rd-level indicators, thereby constructing the preliminary framework of the geomorphology experimental teaching evaluation index system.

2.2 Indicator and Evaluation System Optimization

To further refine the initially constructed indicator system, the Delphi method was employed to solicit expert opinions. A structured consultation questionnaire was developed and distributed to a panel of five experts specializing in geography. The panel demonstrated a high degree of authority, with an aggregate expert authority coefficient of 0.92, indicating that the consultation results possessed considerable reliability.

Based on the feedback received from the first two rounds of consultation, the initial set of 3rd-level indicators was systematically refined. This process involved merging conceptually related indicators, removing redundant ones, and adjusting the logical sequence of others to enhance the coherence and clarity of the framework. The final round of consultation yielded a unanimous consensus, with 100% of the experts expressing agreement on the finalized structure comprising 4 1st-level indicators, 10 2nd-level indicators, and 20 3rd-level indicators.

2.3 Indicator Weights Determination

The relative weights for indicators were calculated using the Analytic Hierarchy Process (AHP). Data were obtained through a structured questionnaire based on a 5-point Likert scale, which was distributed to a panel of 32 experts in the field of geography. A 100% valid response rate was achieved.

Data analysis were conducted using STATISTICA 6.0 software. After confirming that all individual expert judgment matrices met the consistency requirement, the weights for the 1st-level, 2nd-level, and 3rd-level indicators were derived. These weights were subsequently integrated to construct the finalized evaluation index system (Table 1).

2.4 Evaluation Data Acquisition and Calculation

To operationalize the constructed evaluation framework, a survey was administered to the 2024 cohort of geography science (teacher education track) undergraduates at Jiaying University. The questionnaire was designed based on the evaluation index system developed in the preceding stages. A total of 56 questionnaires were distributed. All questionnaires were collected and, upon screening, deemed valid, resulting in a 100% valid response rate. The reliability coefficient for the collected data was calculated to be 0.994, confirming that the dataset is both valid and reliable for subsequent analysis.

The scores obtained from the questionnaire survey served as the direct evaluation values for each 3rd-level indicator. The evaluation score for each 2nd-level indicator was derived by calculating the weighted sum of the scores of its constituent 3rd-level indicators. And the score for each 1st-level indicator was computed as the weighted sum of its corresponding 2nd-level indicators. The overall evaluation score for geomorphology experimental teaching was determined by aggregating the weighted scores of all 1st-level indicators.

Table 1. Evaluation Indicator System for Geomorphology Experimental Teaching (Percentage Values in Parentheses Indicate the Weight of Each Indicator at Its Respective Tier.)

1st-level indicators	2nd-level indicators	3rd-level indicators
Contextual Foundations (40%)	Faculty Allocation (26%)	Faculty Professional Title Structure (52%) Student-Faculty Ratio (48%)
	Experimental Facilities (27%)	Indoor Laboratory Equipment (49%) Fieldwork Conditions (51%)
	Teaching Regulations(25%)	Teaching Management Regulations (52%) Laboratory Safety and Management Protocols (48%)
	Experimental Materials(22%)	Laboratory Manuals (50%) Experiment Reports etc. (50%)
Program Planning (21%)	Experimental Plan (50%)	Experimental Teaching Syllabus (49%) Experimental Teaching Plan (51%)
	Experimental Projects(50%)	Project Establishment Plan (52%) Project Implementation Scheme (48%)
Implementation Process (10%)	Teaching Process(100%)	Teacher Instruction and Supervision (46%) Student Laboratory Performances (54%)
Results and Effectiveness (29%)	Experimental Summary (33%)	Instructional Summary and Reflection-Faculty (51%) Project Synthesis Report-Students(49%)
	Experimental Outcomes (34%)	Laboratory Grades (55%) Student Feedback and Evaluations (45%)
	Instructional Achievements(33%)	Teaching Research and Reform Projects (49%) Academic Outputs like Publications, Awards etc. (51%)

The evaluation score S for geomorphology experimental teaching is expressed by the following formula:

$$S_{i-1} = \sum_{i=1}^{n} x_i \cdot A_i \quad (1)$$

where: Xi represents the weight of the indicator at each level, Ai denotes the score of the indicator at each level, and n indicates the number of indicator levels, taking values of 1, 2, or 3 corresponding to the 1st-, 2nd-, and 3rd-level indicators, respectively.

2.5 Multivariate Statistical Analysis

Multivariate statistical analysis and the generation of figures were conducted using STATISTICA software (Version 6.0)

3. Results

3.1 Assessment Results of 1st-level Indicator and Overall Evaluation

The scores for each 1st-level indicator and the overall evaluation score for geomorphology experimental teaching, calculated using Equation (1), are presented in Figure 1. As illustrated in Figure 1, the overall evaluation score is 95.34, indicating that the geomorphology experimental teaching is generally performing at a high level.

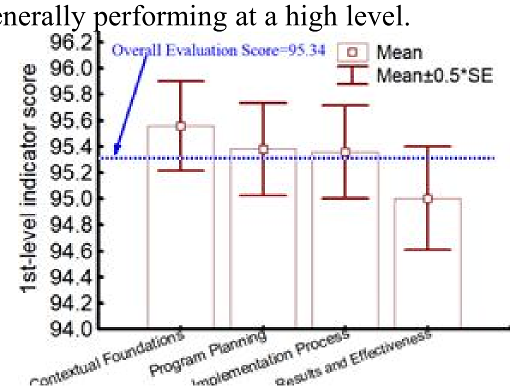

Figure 1. Variation in Scores Among the 1st-level Indicators

Figure 1 also reveals the scores of the four 1st-level indicators in descending order: Contextual Foundations, Program Planning, Implementation Process, and Results and Effectiveness. All of these 1st-level indicator scores exceed 94.00, with relatively minor variation among them.

It is worth noting that Results and Effectiveness received the lowest score among the 1st-level indicators, with a mean value of 95.00 and a minimum value of 72.89. This suggests that, in comparison with Contextual Foundations, Program Planning, and Implementation Process, the Results and Effectiveness dimension of geomorphology experimental teaching still warrants further improvement and enhancement.

3.2 Assessment Results of 2nd-level Indicators

The scores for each 2nd-level indicator of geomorphology experimental teaching, computed using Equation (1), are illustrated in Figure 2. As shown in Figure 2, the mean score of all 2nd-level indicators is 95.33.

Three 2nd-level indicators including Experimental Materials (under the 1st-level indicator Contextual Foundations), and notably Experimental Outcomes and Instructional Achievements (both under the 1st-level indicator Results and Effectiveness) scored below this overall mean. In contrast, all remaining 2nd-level indicators exceeded this average value.

This indicates that, apart from the area of Experimental Materials, there remains considerable scope for further improvement and enhancement in geomorphology experimental teaching, particularly with respect to the attainment of Experimental Outcomes and Instructional Achievements.

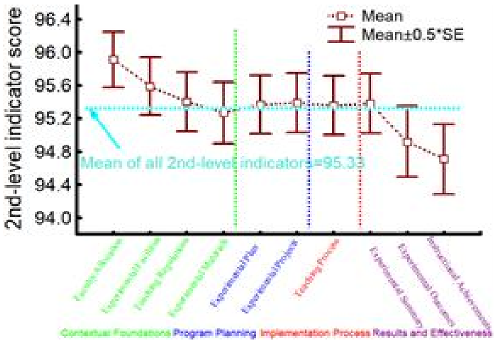

Figure 2. Variation in Scores Among the 2nd-level Indicators

3.3 Assessment Results of 3rd-level Indicators

The scores for each 3rd-level indicator of geomorphology experimental teaching, computed using Equation (1), are displayed in Figure 3. As presented in Figure 3, the mean score of all 3rd-level indicators is 95.33.

Several 3rd-level indicators fell below this overall mean. Specifically, two indicators nested under the 1st-level indicator Contextual Foundations and the 2nd-level indicator Experimental Materials, namely, Laboratory Manuals and Experiment Reports and Supplementary Documentation, both scored below the average. Likewise, two indicators situated under the 1st-level indicator Program Planning, namely, Experimental Teaching Syllabus (under the 2nd-level indicator Experimental Plan) and Project Establishment Plan (under the 2nd-level indicator Experimental Projects), also registered scores below the mean.

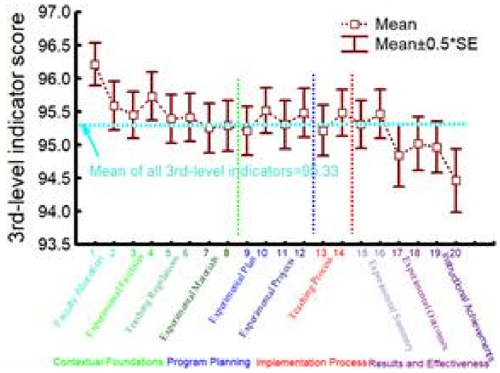

Figure 3. Variation in Scores Among the 3rd-level Indicators

Furthermore, Teacher Instruction and Supervision, a 3rd-level indicator subsumed under the 1st-level indicator Implementation Process and the 2nd-level indicator Teaching Process, similarly fell short of the average threshold.

Most notably, a cluster of five 3rd-level indicators under the 1st-level indicator Results and Effectiveness all scored below the overall mean. These include: Instructional Summary and Reflection-Faculty (under the 2nd-level indicator Instructional Summary and Reflection—Faculty); Laboratory Grades and Student Feedback and Evaluations (both under the 2nd-level indicator Experimental Outcomes); and Teaching Research and Reform Projects as well as Academic Outputs (e.g., Publications, Awards) (both under the 2nd-level indicator Instructional Achievements).

These suggest that beyond the five identified areas such as Laboratory Manuals, Experiment Reports, Experimental Teaching Syllabus, Project Establishment Plan, and Teacher Instruction and Supervision, there remains considerable scope for further improvement and enhancement in geomorphology experimental teaching. This is particularly salient with respect to the five indicators associated with instructional reflection, student performance and feedback, and scholarly output, all of which are integral to the outcomes and effectiveness dimension.

4. Discussion

The evaluation results provide granular insights into the specific strengths and vulnerabilities of the current geomorphology experimental teaching framework at Jiaying University. While the overall evaluation score (95.34) and the mean score of all3rd-level indicators (95.33) suggest a generally high level of instructional quality, the identification of ten 3rd-level indicators falling below this threshold warrants systematic attention. These deficiencies, distributed across all four dimensions of the CIPP model, collectively point to a misalignment among instructional inputs, processes, and outcomes. More critically, the clustering of five underperforming indicators within the Results and Effectiveness dimension, particularly those related to instructional reflection, student performance feedback, and scholarly output, reveals a discernible gap between the delivery of experimental teaching and its tangible educational impacts. This pattern is not merely a matter of isolated weaknesses but signals a systemic issue: the current model excels in resource allocation and procedural execution yet falls short in cultivating a closed-loop feedback mechanism that translates teaching activities into measurable learning outcomes and professional scholarship.

4.1 Strengthening Contextual Foundations: Revitalizing Experimental Materials

The below-average scores for Laboratory Manuals and Experiment Reports etc. reflect an erosion of foundational teaching resources. It is recommended that the department undertake a comprehensive revision of laboratory manuals to align with contemporary geomorphological concepts, field techniques, and digital analysis tools (e.g., GIS, remote sensing, UAV-based topographic surveying). Furthermore, the format and content of experiment reports should be restructured to shift from descriptive accounts to inquiry-based documentation that requires students to formulate hypotheses, interpret spatial data, and critically evaluate methodological limitations. Introducing digital templates and e-portfolios could also enhance the accessibility and pedagogical consistency of these materials.

4.2 Optimizing Program Planning: Enhancing Curricular and Project Design

The suboptimal scores for Experimental Teaching Syllabus and Project Establishment Plan indicate a need for greater curricular coherence and foresight. The syllabus should be refined to explicitly articulate the progression of experimental competencies from foundational field skills to independent research design. In parallel, the establishment of experimental projects should be more closely integrated with regional geomorphological characteristics (e.g., the red bed landscapes, river terraces and Potholes of eastern Guangdong) to strengthen students' sense of place and applied research capabilities [10]. Collaborative design of project themes with local natural reserves or geological survey units could further enhance the authenticity and academic rigor of these experiments.

4.3 Refining Implementation Process: Elevating Pedagogical Guidance

The below-average score for Teacher Instruction and Supervision underscores a critical pedagogical bottleneck. Although faculty possess strong disciplinary expertise, the findings suggest that instructional delivery during experimental sessions may lack sufficient scaffolding for student autonomy. It is proposed that a structured supervision model be adopted, wherein faculty progressively withdraw direct guidance as students advance, transitioning from "instructor-as-demonstrator" to "instructor-as-facilitator". The integration of just-in-time teaching strategies with generative AI-powered mobile field guidance tools can further enhance real-time feedback during outdoor experiments [11,12]. Furthermore, regular peer observation and teaching workshops should be institutionalized to foster a culture of pedagogical reflection among faculty [13].

4.4 Advancing Outcomes and Effectiveness: Closing the Feedback and Scholarship Loop

The most pronounced deficiencies reside within the Results and Effectiveness dimension [14], particularly across five indicators: Instructional Summary and Reflection-Faculty, Laboratory Grades, Student Feedback and Evaluations, Teaching Research and Reform Projects, and Academic Outputs (e.g., Publications, Awards). These findings collectively indicate that the current experimental teaching system is better at generating instructional activities than at capturing, reflecting upon, and disseminating their educational value. To address this, three interconnected strategies are proposed. First, a formalized post-experiment debriefing protocol should be introduced, requiring both faculty and students to submit structured reflective summaries. Such reflections should not merely serve archival purposes but actively inform subsequent syllabus revisions and project redesigns, thereby establishing a closed-loop feedback mechanism grounded in OBE principles between teaching execution and curricular improvement [15,16]. Second, the assessment system for laboratory grades should be diversified to include process-oriented criteria such as field observation accuracy, problem-solving strategies, and collaborative competence, rather than relying predominantly on final report quality. Third, a departmental incentive scheme should be developed to encourage the transformation of experimental teaching innovations into scholarly outputs. Faculty members, particularly undergraduates, should be encouraged to publish pedagogical research papers derived from geomorphology experiments, participate in academic competitions, or apply for patents. Outstanding experiment reports may also be developed into conference presentations or co-authored technical notes. Such initiatives not only elevate the academic profile of the geomorphology experimental teaching program but also help reinforce students' identity as emerging geoscientists.

5. Conclusion

This CIPP-based evaluation of geomorphology teaching at Jiaying University reveals high overall quality (95.34) yet a systemic gap: Results and Effectiveness scored lowest, with five indicators on reflection, feedback, and scholarship below average, underscoring a disconnect between instruction and tangible outcomes. To bridge this gap, we propose an OBE-aligned closed-loop feedback mechanism linking teaching execution to curricular improvement and scholarly valorization. This study extends CIPP to geoscience education and offers a diagnostic blueprint for pedagogical enhancement. Closing the feedback loop is essential to transforming experimental teaching into a catalyst for student development and scholarly contribution. It holds the potential to elevate geomorphology experimental teaching from operational competence toward pedagogical excellence.

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