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Research on Teaching Practice of Advanced Mathematics Driven by Professional Integration and Process Evaluation

Yang Liu, Hairong Lian*

School of Science, China University of Geosciences (Beijing), Beijing 100083, China

***Corresponding author:** Hairong Lian, lianhr@cugb.edu.cn

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Abstract: Advanced mathematics is a fundamental core course for science and engineering disciplines, and its teaching quality directly affects students' subsequent professional learning and innovation ability. Currently, there are common problems in teaching, such as abstract content, professional disconnection, and single evaluation. This leads to insufficient learning motivation and weak application ability among students. This study takes the advanced mathematics course of geological majors as the carrier and constructs a three-dimensional teaching system of "professional integration leading, logical thinking as the core, and process evaluation driving": deeply integrating mathematical knowledge with the geological professional background, emphasizing logical explanations and guiding with original ideas; establishing a "monthly exam diagnosis-precise assistance-continuous tracking" process evaluation mechanism, conducting student situation analysis, weekly quizzes, and other targeted tutoring for students in the low-score segment. The research provides a feasible practical model for the teaching reform of advanced mathematics in geological colleges.

Keywords: Advanced mathematics; Professional integration; Process evaluation; Geology-related majors; Academic tracking

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1. Introduction

Advanced mathematics is a compulsory public course for science and engineering majors in universities, and it holds a crucial position in the talent cultivation system [1–2]. The teaching practice at Hohai University indicates that mathematics is not merely a tool-based discipline; it should also become the "innovation engine" for the education of new engineering disciplines [3]. For students majoring in geology, it not only lays the foundation for subsequent courses such as "Geostatistics," "Remote Sensing Geology," and "Hydrogeology," but also serves as an important carrier for cultivating quantitative analysis skills, logical

thinking abilities, and research innovation capabilities.

However, for a long time, the teaching of advanced mathematics has faced three major challenges: Firstly, there is a conflict between the abstraction of concepts and the cognitive abilities of new students [4]. The concepts and theorems in advanced mathematics are highly abstract and logical, while new students are still transitioning from elementary mathematics and their thinking patterns have not yet fully changed, which often leads to a sense of difficulty. Secondly, there is a disconnect between mathematical theories and professional applications [5]. Traditional teaching often follows the pattern of "definition-theorem-proof-examples," with insufficient integration of professional contexts, making it difficult for students to appreciate the value of mathematics in professional learning. Thirdly, the limitations of terminal evaluation, with the final exam score being the main criterion, lack process monitoring and feedback, making it difficult to promptly identify and solve problems in students' learning [6–7].

In 2020, the Central Committee of the Communist Party of China and the State Council issued the "Overall Plan for Deepening the Reform of Education Evaluation in the New Era," proposing that evaluation plans should be formulated categorically based on the characteristics of different entities, educational stages, and educational types, optimizing outcome evaluation, highlighting process evaluation, attempting value-added evaluation, and improving comprehensive evaluation [8]. Guided by this policy, constructing an advanced mathematics teaching path suitable for geological colleges has significant theoretical value and practical significance.

This paper takes the teaching of "Advanced Mathematics" for some students of the 2025 grade in the Earth Science and Resources College of China University of Geosciences (Beijing) as the basis, and attempts to form a three-dimensional teaching system of "professional integration leading, logical thinking as the core, and process evaluation driving," providing a reference for the teaching of advanced mathematics in similar institutions.

2. Teaching philosophy and system construction

Based on an understanding of students' characteristics, this research has established a three-dimensional teaching system that is "led by professional integration, centered on logical thinking, and driven by process evaluation."

2.1. Professional integration leads

Students majoring in geology will engage in geological surveys, resource exploration, and hydrogeological work in the future. These jobs cannot be accomplished without quantitative analysis and mathematical modeling. Therefore, in teaching, it is important to integrate mathematical knowledge with the professional background in an organic way, so as to establish a connection between the abstract mathematical concepts and specific professional issues.

Firstly, the concept of derivatives is explained by introducing an example of geological change rates. The change in the surface elevation of a certain area over time can be described by the function $h(t)$. Then, the derivative represents the rate of change of the surface elevation at time t_0. Through such a case, students can intuitively understand the physical meaning of derivatives and appreciate their application value in geological dynamic monitoring. Secondly, the concept of definite integral is explained by introducing the problem of calculating mineral resource reserves. Suppose the grade (the content of useful components in a

unit volume of ore) of a certain ore body varies with depth, which can be represented by the function $p(x)$. Then, the total amount of mineral resources from depth a to b is a definite integral problem. Through the dynamic demonstration of the process of "division-approximation-summation-taking the limit" using the GeoGebra software, students can intuitively understand the essence of the definite integral and recognize its practical application in resource evaluation.

Through the above examples, students can truly experience the wide application of mathematics in the field of geology, thereby stimulating their interest in learning and enhancing their sense of professional identity.

2.2. Rooted in logical thinking

Advanced mathematics is not merely a set of calculation tools; it is also a way of thinking. In teaching, emphasis is placed on the logical explanation of mathematical theorems and conclusions. Starting from the basic ideas, it guides students step by step, cultivating their mathematical thinking ability and innovative consciousness.

2.2.1. Understanding the generation of mathematical ideas

Every mathematical concept and theorem has its own background and the problems it aims to solve. In teaching, it is important to guide students to trace the origin of the knowledge and understand how mathematicians discovered problems, thought about them, and solved them. For example, when explaining the concept of derivative, educators can first introduce the historical discussions on tangent lines and instantaneous velocities, allowing students to appreciate the inevitability of the emergence of the derivative concept.

2.2.2. Construct a systematic knowledge structure

The knowledge system of advanced mathematics has a strong logical progression. In teaching, it is important to guide students to understand the intrinsic connections between various knowledge points and construct a systematic knowledge structure. For example, from limits to continuity, from derivatives to differentials, it progresses step by step and is closely interrelated. Through the design of problem chains, it guides students to think actively and gradually deepen their understanding.

2.2.3. Cultivate the ability of knowledge transfer

In advanced mathematics, there are numerous analogical relationships between the calculus of single-variable functions and that of multivariable functions. In teaching, students are guided to achieve knowledge transfer and deepening through analogical generalization. For instance, the derivative of a single-variable function can be analogized to the partial derivative and directional derivative of a multivariable function. Through analogies, students not only can quickly master new knowledge but also cultivate analogical thinking and innovation abilities.

3. Process-oriented assessment-driven teaching

In view of the excessive proportion of summative assessment in traditional teaching evaluation and the fact that process evaluation is not scientific, this paper has constructed a process evaluation mechanism of

"monthly exam diagnosis-precise assistance-continuous tracking."

3.1. Monthly examination diagnosis

Two monthly exams are used as tools for diagnosing students' learning progress. The first monthly exam is scheduled in the middle of the semester, mainly to test the students' mastery of basic concepts and fundamental methods; the second monthly exam is arranged at the end of the semester, comprehensively assessing the students' ability to integrate and apply knowledge. Through the analysis of the exam results, timely problems in teaching and students' weak points in learning can be identified.

3.2. Focus on low-score students

After the first monthly exam, special attention was paid to students whose scores were 40 points or below. Specific measures included in-depth communication, understanding the reasons for students' learning difficulties, and helping them analyze the problems. Some students with poor grades developed anxiety and even self-doubt. Educators helped them build a positive learning attitude through encouragement and affirmation. For the key content of the courses, weekly tests were arranged to promptly check students' mastery of knowledge and immediately correct any problems that emerged. After class, one-on-one tutoring was provided for students with learning difficulties to help them solve specific problems.

3.3. Dynamically adjust teaching strategies

By establishing student learning records, continuous tracking of students' learning progress is carried out. For students in the lower score range, the changes in their weekly quizzes are closely monitored, and the tutoring strategies are promptly adjusted. For all students, through data such as classroom interaction, homework completion, and monthly exam results, the learning status of students is comprehensively understood, and the teaching progress and teaching methods are dynamically adjusted.

4. Teaching practice process

This course is "Advanced Mathematics," and the target audience is undergraduate students of the Earth Science and Resources College of China University of Geosciences (Beijing), with a total of approximately 158 students. The course content covers functions and limits, derivatives and differentials, the mean value theorem for differentials and the application of derivatives, indefinite integrals, definite integrals and their applications, etc. The teaching period lasts for one semester, totaling 96 class hours.

After the first monthly exam, a statistical analysis of the class grades was conducted. The results showed that some students generally had weak foundations and improper learning methods, and lacked confidence in their studies. By implementing the aforementioned teaching measures for students with lower grades, including establishing assistance files, conducting individual conversations, organizing weekly tests, forming study partner groups, and strengthening after-class tutoring, the academic performance and learning efficiency of these students were effectively improved.

Furthermore, while providing precise assistance, educators have also continuously improved classroom teaching. Specifically includes:

Optimize Teaching Design: Based on the problems revealed in the students' monthly exams, the teaching priorities and key points were adjusted. For instance, it was discovered that students had difficulty

understanding the concept of limits. Therefore, in the subsequent teaching, more explanations and exercises on the idea of limits were provided.

Enrich Teaching Cases: Constantly develop and accumulate teaching cases related to the geoscience discipline, making the mathematical content more closely aligned with professional reality. For instance, when explaining the maximum value of a function, introduce the issue of the optimal mining plan in the development of mineral resources.

Strengthen Teacher-Student Interaction: By adopting the "problem chain" teaching method, through a series of progressive questions, students are encouraged to think actively. Students are motivated to raise questions and express their opinions, creating a positive and lively classroom atmosphere.

Empower Teaching with Information Technology: Use the GeoGebra software to create dynamic course resources, visually presenting abstract concepts such as limits, derivative definitions, and integration. Utilize online learning platforms for classroom interaction and instant quizzes to promptly understand students' learning progress.

By analyzing the academic performance of students who took multiple exams, the changes in their scores demonstrated a significant improvement in teaching effectiveness. From the first monthly exam to the second monthly exam and to the final exam, the overall average score of the class continued to rise; the pass rate significantly increased; the excellence rate also grew; and the degree of score dispersion gradually decreased, indicating that the overall level of students was becoming more balanced. The tracking analysis of students in the lower score range showed that after targeted assistance, their average score significantly improved, the pass rate increased significantly, and some students achieved a leap from failing to passing or even achieving a medium level. Particularly, students who originally had weak foundations, had a sense of fear of difficulties, or were passive in their studies gradually mastered learning methods through individual conversations, weekly quizzes, dynamic demonstrations, and mutual assistance groups, and their scores steadily improved. Although some students still failed, they had found their learning direction. Overall, the process evaluation and precise assistance mechanism effectively promoted the academic progress of all students, especially those in the lower score range. However, the internal differences among the lower-scoring students have expanded. In the future, personalized assistance strategies need to be further optimized.

5. Conclusion and prospect

This paper is based on the teaching practice of the "Advanced Mathematics" course at the School of Earth Sciences and Resources of China University of Geosciences (Beijing), and has explored the construction of a three-dimensional teaching system of "professional integration as the lead, logical thinking as the foundation, and process evaluation as the driving force." Through one semester of teaching practice, the following main conclusions have been drawn:

1. Professional integration teaching can effectively stimulate students' interest in learning and their sense of professional identity. By combining mathematical concepts with practical professional problems, students can appreciate the value of mathematics in their professional studies and shift from passive learning to active exploration.

2. Logical explanations help cultivate students' mathematical thinking abilities and innovative consciousness. By guiding students to understand the development process of mathematical ideas and master

the internal logic of mathematics, it lays a foundation for subsequent learning and research activities.

3. Process-based evaluation and precise assistance mechanisms are effective means to promote the development of all students; problems in students' learning can be promptly identified and solved, especially helping students in lower score ranges achieve academic progress.

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