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An Exploration of Cultivating Students' Creative Thinking in Teaching Functions of Complex Variables

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Abstracts: As an important branch of higher mathematics, complex function occupies a core position in many fields such as mathematics, physics, and engineering, which not only involves rich theoretical knowledge but also shows great value in practical applications. Therefore, the teaching of complex functions is extremely important for students of mathematics and related majors. However, traditional teaching methods often emphasize theory over practice, lack effective ways to stimulate students' innovative thinking and limit the overall development of students' abilities. Based on this, this study will explore how to cultivate students' innovative thinking more effectively through the teaching of functions of a complex variable, aiming at finding and evaluating different teaching strategies and methods to better stimulate students' interest, improve their innovative and practical abilities, and promote the overall development of students' comprehensive abilities.

Keywords: teaching functions of a complex variable; students' innovative thinking; cultivation paths

Introduction

Innovative thinking is crucial to the development of mathematics and its related fields, which not only promotes the development of mathematical theory but also promotes the application of mathematics in solving practical problems. In the context of the current rapid development of science and technology, innovative thinking has become the key to driving the discovery of new theories, the invention of new technologies, and interdisciplinary research. Especially in advanced mathematical fields such as complex functions, innovative thinking can help students to deeply understand theories, discover new application areas, and even propose original mathematical models and solutions. Mathematics teachers in colleges and universities should highly agree with the importance of the cultivation of innovative thinking, and actively explore quality teaching paths from the perspective of top-level design and daily teaching, to build an efficient math classroom.

1. The Significance of Cultivating Students' Innovative Thinking in the Teaching of Complex Functions

1.1 Helps promote students' deep learning

Innovative thinking prompts students not only to be satisfied with the understanding and application of existing mathematical theories but also encourages them to question, explore, and go beyond the boundaries of existing theories. In the learning process of complex variable function, by stimulating students' innovative thinking, teachers will help students discover new theoretical connections and put forward original mathematical hypotheses or theoretical models, thus promoting the development of the field of mathematics. In addition, the cultivation of innovative thinking does not only include the application of formulas and theorems but also focuses on the understanding of the logical and philosophical basis behind mathematical concepts (Shu & Chen, 2023). It can be said that through the cultivation of innovative thinking in the teaching of functions of a complex variable, students can have a

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deeper understanding of the nature of the concepts of complex numbers and analytic functions so that they can better master and apply these concepts. Most importantly, students can also explore the application of complex functions in other fields such as physics, engineering, economics, etc., to promote the integration of mathematics and other disciplines and the innovative application of comprehensive knowledge.

1.2 Help students solve practical problems

Teachers in the teaching of functions of a complex variable will help students learn how to apply abstract mathematical theories to practical problem-solving. Innovative thinking encourages students to understand and analyze the nature of problems to find more effective solutions to complex real-world problems, therefore, the cultivation of innovative thinking in the teaching of complex variable function is crucial to enhance the innovative ability of scientific research and technology development. For example, in the fields of engineering design, data analysis, computer science, etc., the complex function and the innovative thinking method behind it can dramatically improve the efficiency and quality of problem-solving. Contemporary society faces many complex and changing challenges, such as climate change, economic crisis, technological innovation, etc. Through the cultivation of innovative thinking in the teaching of complex functions, students will be able to better apply mathematical tools and ways of thinking to analyze and solve global problems and contribute to the sustainable development of society.

1.3 Help promote the reform of math education

To cultivate students' innovative thinking, teachers need to adopt more active and interactive teaching methods, such as project-based learning and case studies, which can help to promote the innovation of teaching methods in the whole education field. Through the use of new teaching methods, students' interest in learning can be stimulated more effectively, and students' participation and learning effectiveness can be improved. To cultivate innovative thinking, the course content also needs to pay more attention to depth and breadth, rather than just traditional theoretical lectures, and teachers should integrate interdisciplinary content into the teaching of the function of a complex variable, combining the latest scientific research results and practical application cases, to make the teaching content more rich and cutting-edge. Moreover, the cultivation of innovative thinking helps to improve students' critical thinking, problem-solving ability, and innovation ability, which are the key literacy emphasized by modern education. Only by improving the teaching methods and contents can teachers cultivate these abilities of students more effectively, thus improving the overall quality of education.

1.4 Help to improve students' comprehensive quality

Cultivating innovative thinking in the teaching of the function of a complex variable can stimulate students' creativity and encourage them to think about original problems and explore the unknown, which is not only valuable in the fields of mathematics and science but also important in art, design, business, and other fields. Successful use of creative thinking in problem-solving can greatly enhance students' self-confidence and self-efficacy, and a positive mental state can help students remain optimistic and persistent in the face of challenges, which can lead to better achievements in their personal and professional lives (Wu & Kang, 2023). The cultivation of innovative thinking encourages students to continue to learn and explore new knowledge, which is an important part of lifelong learning. In the rapidly changing modern society, lifelong learning has become the key to personal development, and innovative thinking provides an important cognitive tool and motivation for this purpose.

2. The Current Situation of Cultivating Students' Innovative Thinking in the Teaching of Functions of a Complex Variable

2.1 Lack of diversified and innovative teaching content

Currently, the teaching of the function of a complex variable often pays too much attention to the teaching of theoretical knowledge, ignoring the importance of the application of theoretical knowledge to practical problem-solving, which leads to the difficulty of students understand the value of the application of the function of a complex variable in practice, which in turn limits the development of

innovative thinking. Teachers design courses that lack integration with other disciplines such as physics, engineering, economics, etc., making the teaching content seem isolated and detached from reality, and the lack of an interdisciplinary perspective of teaching is not conducive to the development of students' comprehensive knowledge structure and innovation ability. In addition, if the setting of teaching content ignores the interests and needs of students and lacks relevance and attraction, it will not be able to stimulate students' interests, and students' enthusiasm for exploring new knowledge and developing innovative thinking will be inhibited.

2.2 Over-emphasizing theory and neglecting the cultivation of innovative ability

Schools do not provide enough opportunities for school-enterprise cooperation or internship practice, and teachers themselves lack the teaching ability to combine practical applications and practical activities, so students will find it difficult to translate theoretical knowledge into practical applications, which is not conducive to students' understanding of the application of the function of a complex variable in the real world (Zhang & Wang, 2023). Although some teachers are trying more innovative teaching methods such as project-based learning, flipped classrooms, case studies, etc., the application of these methods in the teaching of the function of a complex variable is not common, and the lack of such innovative teaching methods will inevitably lead to a lack of opportunities for students to develop innovative thinking through practical operation and exploration. From this point of view, college administrators and teachers should make a change from the concept.

2.3 Failure of assessment methods to integrate the demonstration of innovative ability

The existing assessment system relies too much on the traditional written examination in the teaching of complex functions, which mainly evaluates the students' memorization and understanding of theoretical knowledge, and the written examination makes it difficult to comprehensively assess the students' innovative thinking and practical application ability, thus neglecting the cultivation and evaluation of these key abilities. The lack of direct evaluation of students' innovative thinking and practical skills in the assessment system, such as performance in project work, case studies, experimental design, etc., is not conducive to motivating students' efforts in innovation and practice and restricts the demonstration and development of these abilities. In addition, the assessment criteria are too rigid and uniform and do not take into account the special interests, strengths, or innovative attempts of individual students. The one-size-fits-all approach to assessment inhibits the development of students' individualized and innovative thinking and makes the teaching and learning process monotonous and rigid. The existing assessment system implementation process kind of teachers only focuses on the results, ignoring the importance of the learning process and methods, and does not take into account the students in the problem-solving process of innovative ideas, exploration methods, and learning attitudes, which leads to students also focus on the results, ignoring the cultivation of innovative thinking and spirit of exploration.

3. Path of Cultivating Students' Innovative Thinking in the Teaching of Functions of a Complex Variable

3.1 Emphasize the top-level design and rationally design the teaching syllabus

Under the background of rapid development of science and technology and economic globalization, innovative thinking has become a necessary quality for students. The syllabus is a basic document to guide teaching, and its design directly affects the selection of teaching content, the application of teaching methods, and the setting of assessment methods. A reasonable syllabus can ensure the comprehensiveness and foresight of the teaching content, guide teachers to adopt more innovative and diversified teaching methods, and is of great significance in stimulating students' interest, cultivating their innovative thinking ability, and adapting to the challenges of the future society.

The syllabus should be formulated in line with the overall educational strategies and goals of the school, such as improving the quality of education and building special disciplines. When formulating the syllabus, educators need to consider the school's resources and conditions, such as faculty, laboratory equipment, learning platforms, etc., to ensure that the

implementation of the syllabus can be carried out smoothly under the existing resources and conditions, and at the same time, promote the rational use and optimization of resources. Through comprehensive consideration of the development trend of education, the overall strategy of the school, and the application of the complex function of the future, colleges, and universities can formulate a forward-looking and practical syllabus of the complex function of the top design not only helps to improve the quality of teaching but also promotes the development of students' comprehensive ability, so that the students are better adapted to the needs of the future society.

3.2 Optimize teaching content and improve classroom teaching efficiency

The prevailing problem in the current teaching of functions of a complex variable is the singularity of the teaching content and the lack of practice, which makes it difficult for students to apply theoretical knowledge to practical problem-solving. With the updating of educational concepts and the development of technology, the optimization of teaching content has become the key to improving teaching quality and efficiency. Optimizing teaching content can ensure that students are exposed to the latest theories and technologies while focusing their learning on cultivating practical ability and innovative thinking (Si & Wei, 2023). By incorporating more practical cases and application problems into the teaching content, students can better understand and absorb complex theoretical knowledge.

For the knowledge point of Integration of Functions of Complex Variables, teachers can first introduce the basic concepts of integration of functions of complex variables, such as integration along curves, Cauchy's Integral Theorem, Cauchy's Integral Formula, etc., and then put forward practical problems related to electromagnetism, such as the use of complex integrals for calculating the electric field or the magnetic field, to attract the attention of the students and satisfy the interest of the students in physics or engineering. If conditions permit, teachers can allow students to use computational software to perform numerical integration calculations to increase hands-on experience. Finally, the application of complex integrals in other fields, such as fluid dynamics and economics modeling, is explored to demonstrate its wide range of practicality, and students are encouraged to think about how to apply complex integrals to other fields of their interest, which in turn promotes the development of innovative thinking.

3.3 Innovative teaching mode, rich classroom teaching methods

In advanced mathematics courses such as complex functions, it is difficult to stimulate students' interest and innovative thinking only through traditional classroom lectures. Innovative teaching modes and rich teaching methods can more effectively attract students' attention, and increase their participation and learning motivation, and these methods can promote students' understanding and mastery of complex mathematical concepts from different perspectives and levels so that the classroom teaching effect is constantly improved (Guo, 2021).

Taking "series and the theory of retention" as an example, after the teacher explains the basic concepts of series (such as the Taylor series, and Laurent series) and the basis of the theory of retention (definition and calculation of retention), he or she uses intuitive graphs and mathematical demonstrations to explain the convergence of series and the physical meaning of retention. Students are then guided to explore how to use series and retention theory to solve real-world problems by selecting examples that are relevant to their major or have practical applications, such as real-world problems in engineering, physics, or economics, such as circuit analysis, fluid dynamics problems, or predictions in economic models. The instructor engages students in group discussions to identify key problems and solutions, and utilizes interactive teaching tools, such as response systems or online surveys, to gather student feedback and understanding. Practice problems related to the case are assigned after class to allow students to practice the application of grade and retention theory in person, and the teacher provides timely step-by-step guidance and feedback to help students understand and master the complex calculation process.

3.4 Combining theory and practice, focusing on school-enterprise cooperation

School-enterprise cooperation provides a bridge that closely links the education system with industry,

making education closer to actual needs and enhancing students' competitiveness in employment. Through school-enterprise cooperation, students can come into contact with the application of the function of complex variables in practical work, to better understand the practical significance of theoretical knowledge, this mode of cooperation can also provide students with a real working environment so that they can learn and use the function of complex variables in practice, and improve the student's ability to solve practical problems (Chen et al., 2020).

For example, colleges and enterprises can cooperate to set up projects of practical significance, so that students can participate in them under the guidance of enterprise mentors, and apply the theoretical knowledge of the complex function to practical problem-solving. Colleges and universities should provide internship opportunities so that students can directly experience and learn the application of the complex variable function in enterprises. Teachers incorporate actual cases of enterprises in the course design so that students can feel the practical application value of the learning content in the learning process. Or invite enterprise experts into the classroom to share their experience and cases of the application of the complex function in real work. If conditions permit, universities and enterprises jointly establish research and development platforms to encourage students to participate in the actual research and development work and carry out innovative practices. Through a variety of ways, students can combine the theoretical knowledge of the complex function with practical problems in the actual research and development process and carry out innovative thinking and solution development.

3.5 Based on professional needs, carry out hierarchical classification teaching

Different professions have different needs for the understanding and application of complex functions, as engineering majors pay more attention to its application in practical problem solving, while mathematics or physics majors pay more attention to theoretical depth (Tan, 2020). Hierarchical classification teaching can better meet differentiated needs and provide more personalized and specialized teaching content, which can help stimulate students' learning interest and improve learning efficiency, as well as cultivate students' innovative thinking and application ability.

When teachers explain "conformal mapping and conformal mapping", they first analyze the needs of students' majors. For example, engineering students need to apply conformal mapping to electromagnetic field design, while computer science students are more concerned about its application in image processing, and then design different teaching contents. In classroom teaching, group teaching or segmented teaching methods are flexibly adopted to provide specialized explanations for students of different majors, and interactive teaching methods, such as group discussion and experimental practice, are adopted to enhance student's learning interest and participation. Teachers should also encourage students to participate in relevant project-based learning, e.g. engineering students can design small projects involving electromagnetic fields, and computer science students can develop simple image processing programs. Necessary guidance and support will be provided by teachers to help students apply their theoretical knowledge in practice. It should be noted that teachers should flexibly adjust the content and methods of hierarchical categorization teaching according to students' feedback and learning effects, to adapt to the learning needs and progress of different students.

3.6 Improve the evaluation system and promote the overall development of students

A comprehensive evaluation system can more accurately assess students' abilities in various aspects such as theoretical knowledge, practical application, and innovative thinking. Teachers should actively introduce diversified evaluation methods such as project-based assessment, oral presentations, teamwork, etc. to measure students' practical ability and innovative thinking, and encourage students to participate in discussions, presentations, and practical projects as part of the evaluation. Attention is paid not only to evaluating the final learning outcomes but also to the performance in the learning process, such as students' participation, thinking process, and innovative attempts, to promote active participation and continuous improvement in the learning process. Of course, teachers should also encourage students to carry out self-evaluation and peer evaluation to help

students establish self-reflection and enhance their independent learning ability and critical thinking (Zhang et al., 2020). Most importantly, the evaluation system is combined with students' future vocational skills and practical application ability to ensure that the evaluation content and standards match the skills required in the actual work. For example, evaluation is carried out through practical case analysis and work simulation to make the evaluation closer to practical application.

Summarize

To summarize, as an important part of higher mathematics education, the teaching of complex variable functions has a profound impact on the professional development of students and the cultivation of innovation ability. Therefore, teachers should continue to study and improve teaching methods, improve the quality of teaching, and adapt to the inevitable requirements of the development trend of education and social needs. Teachers should explore in depth how to effectively combine teaching theory and practice, how to assess and promote the development of students' innovative thinking, as well as how to respond to the rapidly changing educational environment and social needs through teaching innovation, to provide support for students to become composite talents.

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Conflict of Interest

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

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