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Exploring Ideological and Political Elements in the Course of Complex Analysis

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ABSTRACT
"Complex Functions and Integral Transformations" is a foundational theoretical course for engineering majors in higher education, building upon and extending advanced mathematics. Aligned with the ideological-political curriculum design framework, this study proposes methods to integrate ideological and political elements into the teaching of Complex Functions and Integral Transforms. The approach seeks to strengthen students' theoretical mastery while fostering their ideological awareness. Through concrete examples from the course content, the paper systematically identifies and incorporates these elements into pedagogy. Furthermore, classroom practice demonstrates how this integration encourages critical thinking, multidimensional problem analysis, and improved problem-solving skills.

KEYWORDS
Complex functions and integral transformations; Complex Analysis; Ideological and political education; Mathematics education

1 Introduction

Amid the ongoing wave of deepening reforms in higher education, the integration of ideological and political education into curricula has become a crucial measure for implementing the fundamental task of fostering virtue through education, and is now being extensively and thoroughly incorporated into various specialized courses.As a distinctive and profound branch of mathematics, complex variable theory not only provides indispensable support for numerous fields including theoretical physics, aerospace engineering, and signal processing, but also offers abundant opportunities for ideological and political education in its teaching process.[1]

Complex Variables for Engineering is a follow-up course of higher mathematics, compared to higher mathematics, Complex Analysis content is more difficult, the class time is relatively small, the challenge for students is greater, many students are prone to produce difficult psychology.And the Complex Analysis is the basis of many subsequent courses in engineering majors, is a theory and practice more closely linked to the course, so the teaching effect of the Complex Analysis course is very important to the students' subsequent learning and development.[2] Complex Analysis serves as a foundational course for many subsequent engineering disciplines and represents a subject with strong theory-practice integration. [3] Therefore, the instructional quality of this course significantly impacts students' future academic and professional development. The integration of ideological and political elements into the teaching process serves dual pedagogical purposes: it facilitates simultaneous knowledge acquisition and values education while enhancing student engagement. This approach fosters students' exploratory mindset and systematically guides them in establishing appropriate worldviews and value systems.[4]

This paper takes Complex Functions and Integral Transforms, a national "Eleventh Five-Year Plan" textbook for general higher education, as a case study to systematically explore ideological and political elements, providing pedagogical support for teaching Complex Variables. Through a structured analysis of these elements, the study guides students in comparing concepts, theories, and methods with their real-number counterparts in Advanced Mathematics, enhancing comprehension and analytical skills. This approach cultivates students' learning competencies while offering valuable insights for related teaching practices.

2 Ideological and Political Education Case Studies in Complex Analysis Courses

The study of complex variables extends the research domain from real numbers to complex numbers, where the function's domain undergoes fundamental changes, introducing numerous novel challenges in this expanded number system. Complex function theory fundamentally relies on limits to examine function behavior—including continuity, differentiation criteria, analytic properties, and integral representations—in the complex plane. When developing ideological and political education components for complex analysis courses, instructors should carefully select representative knowledge points and teaching cases from the curriculum content. Through in-depth analysis of the inherent ideological-political elements within these mathematical concepts, and by skillfully integrating them into teaching practice, educators can effectively combine knowledge delivery with value guidance to achieve a synergistic

educational outcome.

2.1 History of Complex Analysis and the Spirit of Scientific Inquiry

At the beginning of teaching a course, it is necessary to make a macro introduction to the course, aiming at helping students to recognize the course's development history and scope of application, deepening students' understanding and laying a foundation for their subsequent learning. The discipline's historical progression mirrors mathematicians' intellectual paths. Incorporating their stories into instruction helps students understand theoretical development while inspiring scientific rigor and innovation.

The development of complex analysis can be traced back to the 18th century. The development of complex analysis progressed through three pivotal historical phases. In the late 18th century, mathematicians formally embraced the concept of complex numbers, with Euler and d'Alembert independently deriving the fundamental partial differential equations now known as the d'Alembert-Euler conditions. The 19th century witnessed rigorous systematization through Cauchy and Riemann's work, particularly their formulation of the Cauchy-Riemann equations which became central to the theory of analytic functions. The early 20th century saw remarkable expansion of the field through contributions by Weierstrass's student Mittag-Leffler from Sweden, and French mathematicians Poincaré and Hadamard, whose collective work significantly broadened the scope of complex function theory, establishing new research directions in value distribution, complex dynamics, and geometric function theory.[5]Combined with the history of the development of the complex function theory, students are guided to understand the difficulty of academic development, to appreciate the hardship and difficulty of the development and progress of a discipline, and to cultivate the spirit of down-to-earth and hard work.

2.2 Enhancing Students' Innovative Problem-Solving Capabilities Through Applied Knowledge Transfer

When studying the limits of complex functions, one must examine whether the limits of their real and imaginary parts (as bivariate functions) exist. This requires students to have a solid grasp of bivariate function limits from advanced calculus and the ability to apply existing knowledge to solve new problems. For the computation of complex function limits, one can establish a connection between the limit of a complex function and those of bivariate real-valued functions. Specifically, the limit of a complex function can be decomposed into the limits of its real and imaginary parts—each treated as a separate bivariate real function. This approach transforms problems in complex analysis into familiar problems in real analysis. Conversely, if the limit of either the real or imaginary part (as a bivariate real function) fails to exist, this suffices to prove the non-existence of the original complex-valued function's limit.

The integral of an analytic function can be transformed into line integrals of two bivariate real-valued functions. This conversion reduces the integration problem in complex analysis to computing line integrals of real-valued functions, a well-established technique in multivariable calculus.Moreover, in formal terms, the complex integral can be interpreted as integrating the product of functions $\boldsymbol{f(z)=u+iv}$ and $\boldsymbol{dz=dx+idy}$, ultimately yielding line integrals of real-valued functions. By converting to line integrals and incorporating the computational methods from Advanced Mathematics, these integrals can be evaluated using parametric equations of the integration curves.

2.3 The Cauchy Integral Formula and Its Correspondence with Objective Laws of Nature

Within the theoretical framework of complex analysis, the Cauchy integral formula shines as a brilliant centerpiece whose significance cannot be overstated. This cornerstone theorem not only holds paramount theoretical and applied value in mathematical sciences, but also inherently embodies profound ideological elements that provide unique, invaluable material for integrating value education into specialized mathematics instruction.

From a philosophical perspective emphasizing the universal interconnectedness of things and the objectivity of natural laws, the Cauchy integral formula stands as a vivid and compelling exemplar.The formula demonstrates that when a function is analytic within a simply connected domain, the function value at any interior point can be expressed through a boundary integral along the boundaries of the region. This mathematical formula profoundly reveals the intrinsic connection between the function inside the region and its boundaries. This connection is not constructed arbitrarily by the subjective will of human beings, but is an inherent law that exists objectively in the mathematical world and is not shifted by the will of human beings. Extending this concept to the real world is of profound significance.In both natural systems and social environments we inhabit, all phenomena exist in a state of intricate universal interconnection. Taking the ecosystem as an example, various organisms have formed an intricate food chain and food web, which are interdependent and constrained by each other and affect the whole body. Any increase or decrease in the number of organisms or any change in their state of existence may have a significant impact on the balance of the entire ecosystem. Turning to the economic sphere, there is also a strong correlation between different industries. The manufacturing

industry cannot develop without the support of the raw material supply industry, which in turn creates business opportunities for downstream industries such as sales and logistics.This teaches us to guide students to learn to observe and analyze problems in a comprehensive and connected way, to deeply respect the objective laws of the development of things, and to resolutely avoid falling into the misunderstanding of subjective assumptions and one-sided cognition, so as to cultivate students with a scientific and rational way of thinking.

2.4 Infinite Series and Dialectical Materialism

The convergence of complex series is rigorously defined by the limit existence of their partial sum sequences. This mathematical construct explicitly demonstrates the fundamental property transition from finite summation to infinite summation, thereby providing a precise embodiment of the quantitative-to-qualitative transformation principle in dialectical materialism.Students are guided to understand the relationship between quantitative and qualitative changes when verifying the convergence of series. In life, every small effort that keeps accumulating will produce a qualitative leap in the future. Students are guided to be practical and diligent, to work hard and build a solid foundation for their future. The convergence of infinite series is like two fundamental states in the process of development of things.When a series converges, its terms follow an ordered and predictable path, progressively approaching a definite limit. This process mirrors how phenomena in the natural world evolve steadily toward predetermined outcomes under the guidance of inherent laws, exemplifying the stability and regularity intrinsic to developmental processes.In contrast, divergent infinite series exhibit unbounded and irregular oscillations in their partial sums as terms accumulate. This shows that various situations will be encountered in the process of development, and the path of development is by no means always smooth and unchanging.

In the study of series, we go from complex series to complex function term series, following the learning pattern of going from the shallow to the deep, from the simple to the complex, and from the special to the general, to help students understand the definition and application of series. In the study and application of series, students are guided to understand complex term series through real term series, complex function term series through real function term series, and to solve the determination of convergence of complex series in conjunction with the known determination of convergence of real series. Students find similarities and corresponding theorem-propositions to infinite series in higher mathematics in some general conclusions about power series, helping them to understand and apply complex series. Through teaching by example, the dialectical way of thinking of opposition and unity, particular and general, concrete and abstract is integrated into the teaching to help students form a learning style that is compatible with themselves.

3 Strategies for Integrating Ideological and Political Education into Curricula

Curriculum-based ideological and political education should not mechanically highlight political points or deliver disconnected ideological instruction. Rather, it must be organically integrated with course content to achieve a "subtle yet profound" effect—stimulating students' independent thinking and spontaneously elevating their ideological awareness through natural cognitive engagement. In implementation, curriculum-based ideological education should prioritize effective knowledge delivery while demonstrating the humanistic dimension of values education.First, identify ideological and political elements that align with students' psychological characteristics, enabling self-directed value internalization. Second, instructors should adopt empirically validated pedagogical approaches that resonate with learners, facilitating active engagement. Finally, curate instructional cases that simultaneously demonstrate disciplinary knowledge and embody ideological-political education principles.

In the ideological and political education of complex analysis courses, case-based teaching serves as an instructional approach that integrates theoretical knowledge with practical applications. Teachers can select some cases with real-world significance and lead students to analyze and discuss them. Taking the application of complex analysis in image processing as a case study, instructors can demonstrate practical examples where complex functions are used for image denoising and enhancement. Subsequently, they can guide students to reflect on the societal significance of image processing technologies and explore how such techniques can serve the greater good, thereby fostering students' sense of social responsibility. In the process of discussion, teachers should encourage students to speak actively, fully express their views and ideas, and guide them to think deeply and communicate. Teachers can also give timely guidance and comments to help students better understand and master knowledge, while guiding students to establish correct values.

In the ideological and political education of complex analysis courses, problem-oriented and heuristic teaching methods serve as pivotal pedagogical approaches to stimulate critical thinking and facilitate the integration of mathematical knowledge with ideological cultivation. By setting up problems carefully, students are guided to think deeply about the close connection between mathematical knowledge and the connotation of Civics in the process of solving complex function problems.For example, when explaining the analyticity of functions of a complex variable, you

can set up such questions as, "From the perspective of the development of mathematics, how was the concept of analytic function gradually formed and perfected? How does this process reflect the scientific spirit of mathematicians?" This question combines mathematical knowledge with the history of mathematics, guiding students to review the development of the concept of analytic function, and letting them understand the scientific spirit of mathematicians who continue to break through traditional thinking and pursue rigor and precision in the process of exploration.In the process of thinking about this problem, students can not only better understand the concept of analytic function, but also draw spiritual strength from the story of mathematicians, and cultivate their creative thinking and truth-seeking attitude.

In the context of ideological and political education within complex analysis courses, organizing collaborative group work and project-based learning serves as an effective pedagogical approach to cultivate students' teamwork competencies and sense of social responsibility.When forming a group, teachers should fully consider students' learning ability, personality traits, interests and other factors to make scientific and reasonable grouping. In the process of cooperative learning in small groups, teachers should clarify the responsibilities of each member to ensure a clear division of labor and responsibility.The selection of projects should be closely centered on the knowledge and application of the function of a complex variable, while combining with the value-based educational elements to design projects with practical significance and challenges.For example, with the project theme of "Application of complex function in power system", students are required to use the knowledge of complex function to analyze the harmonic problems in the power system and propose corresponding solutions. During the implementation of the project, students are guided to think about the importance of power resources to the development of the country and the life of the society, and how to improve the stability and reliability of the power system through their own efforts, so as to cultivate a sense of social responsibility among them.

4 Conclusions

New Engineering is a new direction of education reform based on the requirements of national strategic development, the new situation of international competition, and the requirements of moral education. Under the leadership of moral education and facing the rapidly changing future, we should pay attention to cultivating students' ability of inheritance and innovation, the idea of crossover and fusion, and the consciousness of coordination and sharing, and cultivate talents of all-around development with a new concept and a new mode. In the actual lectures, we should focus on the combination of theory and practice, and the combination of intellectual and moral education, to enhance the students' ability to analyze and solve problems, to strengthen the improvement of moral cultivation, and to lay a solid foundation for the students' future.

As a core foundational course in engineering education, complex analysis provides a unique platform for integrating ideological and political education into technical instruction. By strategically embedding value-based learning elements throughout the curriculum, this approach simultaneously enhances students' mathematical proficiency and cultivates their ideological awareness, helping them establish proper worldviews, values, and moral character. Such integrated education not only strengthens analytical skills but also fosters the development of well-rounded engineering talents equipped to contribute to socialist modernization. Through practical applications like analyzing harmonic phenomena in power systems or modeling signal processing solutions, students gain both technical expertise and social responsibility awareness, embodying the complete educational mission of combining knowledge acquisition with moral development.

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