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Teaching Methods of Mathematics Courses in Physics Majors: Taking Complex Functions as an Example

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Abstract: *In the training program for physics majors, mathematics courses serve as both the theoretical foundation and research tools. However, the gap between their abstract nature and professional application often leaves students struggling with "focusing on computational skills while lacking physical interpretation." Complex functions, as a key node connecting mathematical analysis with core courses such as field theory and quantum mechanics, and as an important component of mathematical physics methods, have wide applications in fields such as electromagnetism and quantum mechanics. Yet, traditional teaching methods emphasize theoretical derivation and neglect the integration of physical context, making it difficult for students to establish the connection between mathematics and physics. This paper takes complex functions as an example to explore reform paths for teaching methods in mathematics courses for physics majors. Through literature research, interviews, and case analysis, it points out that while the traditional lecture method has advantages in systematic knowledge delivery, it is deficient in cultivating application abilities. Comprehensive improvement strategies are proposed, including integrating modern teaching technology, strengthening practical teaching, and implementing personalized teaching. Teaching effectiveness evaluation shows that after improvements, students have made significant progress in the depth of knowledge understanding and comprehensive abilities, and learning motivation, providing an operable new paradigm for teaching mathematics courses in physics majors.*

Keywords: *Complex Function Teaching, Physics Major, Method Reform, Integration of Mathematics and Physics, Practical Teaching*

1. Introduction

Mathematics courses are the core foundation for cultivating talent in physics majors, and their teaching quality directly affects students' depth of understanding of physical theories and their application abilities. Complex functions, as an important part of mathematical physics methods, are widely used in electromagnetism, quantum mechanics, fluid mechanics, and other fields. Traditional teaching methods often focus on theoretical derivation and ignore the integration of physical background, leading to difficulties for students in connecting mathematical tools with physical problems. Exploring teaching methods for complex functions that meet the needs of physics majors has important theoretical value and practical significance. The application of complex function theory in physics can be traced back to the 19th century. For example, the Cauchy integral theorem is used to solve boundary value problems in electromagnetic fields, and the residue theorem simplifies complex integral calculations in quantum scattering theory. According to statistics, content related to complex functions accounts for over 15% of the course hours in the physics major curriculum at the Massachusetts Institute of Technology (MIT), with tight connections to subsequent courses. In the teaching of physics majors in some domestic universities, the complex functions course still suffers from disconnection in teaching content. Textbooks are mostly presented in a purely mathematical form, lacking physical examples. For instance, although the properties of analytic functions are derived in detail, they are not combined with solving La-place's equation for electrostatic potential. Teaching methods are singular, relying on the "blackboard + exercises" model, where students passively receive knowledge. A survey of five universities showed that only 23% of physics majors could independently apply complex functions to physical problems. Learning motivation is insufficient; physics students are more concerned with the practicality of mathematical tools, but traditional teaching fails to highlight this value.

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Domestic scholars have explored teaching methods for mathematics courses in physics majors from various angles, mainly focusing on curriculum reform, integration of ideological and political education, application of computational tools, and optimization of teaching practices. Liu Wenjun, in the context of emerging engineering education, proposed that mathematical physics methods courses should strengthen the orientation towards physical applications and adopt a "problem-driven + case-based teaching" model to enhance students' engineering thinking[1]. Zhang Dingzong and Wang Xinwen, based on the requirements for teacher certification, emphasized improving the mathematical and physical literacy of normal university students through a three-stage teaching model of "theory-practice-reflection"[2]. Zhang Lihua et al. constructed an "online-offline blended" teaching framework, using micro-lectures and virtual simulation experiments to assist in the geometric intuitive teaching of complex functions[3]. Yan Linli et al. explored the mining of ideological and political elements in mathematical physics methods courses, cultivating students' scientific spirit through the rigor of analytic functions[4]. Qin Lirong et al. further proposed integrating the history of physics into teaching to enhance cultural confidence[5]. Yu Min's interdisciplinary research, although focused on junior high school physics, offers reference strategies for teaching the physical applications of complex functions through its "mathematical tool visualization" approach[6]. Tan Jia et al. systematically analyzed the auxiliary role of MATLAB in complex function graphing and residue calculation, proving its ability to reduce the difficulty of understanding abstract concepts[7]. Zheng Yong proposed a dual-track model of "mathematical software + physical analogy" for teaching Euler's equation, using vibration models to explain the physical meaning of complex exponential functions[8]. Li Qingliu emphasized the need to balance theoretical derivation and numerical computation to avoid the weakening of mathematical thinking due to over-reliance on tools[9]. Tian Xiuyun et al. found through comparative experiments that tiered teaching can improve the efficiency of teaching complex functions[10]. Yang Yuntong et al. combining engineering certification standards, proposed reconstructing teaching content based on "outcome orientation", integrating conformal mapping with electromagnetic field boundary problems[11]. Lu Junguo et al. pointed out that electronics majors need to strengthen example teaching of complex functions in signal processing[12].

Foreign research places more emphasis on empirical analysis and innovation in interdisciplinary teaching methods, with significant achievements particularly in technology integration and learning psychological mechanisms. Matthew Mears et al. through mixed-methods research, found that programming tools can effectively reduce mathematics anxiety among physics majors, but "psychological barriers " need to be addressed[13]. Amanda de Barros Lima et al. based on experiential learning theory, developed mathematical modeling experiments in optical physics, proving that interactive digital teaching aids can improve learning outcomes for complex functions by up to 23%[14]. Jeremy Levy and Chandralekha Singh proposed a "quantum-first" teaching method, combining analytic continuation of complex functions with the quantum superposition principle to help first-year students establish mathematical-physical associative thinking[15]. Julio Elias Normey Rico's control engineering research, although not directly related, provides a new paradigm for the physical application of complex functions through its "basic mathematics-engineering problem" mapping method[16]. Donovan Skye et al. anatomy experiment, although in the medical field, offers reference value for optimizing the allocation of class hours for complex functions through its "time allocation-learning effect" curve[17].

In summary, domestic research focuses on constructing and reforming teaching models within a macro-system framework, emphasizing the integration of ideological and political education, with content that is rich and closely aligned with local educational policy needs. Foreign research, on the other hand, is more adept at micro-empirical analysis and theory-driven approaches, delving into learning psychology and exploring teaching interventions based on specific learning theories. Existing research still has areas for further deepening: firstly, when domestic research emphasizes "application," it often focuses on introducing cases, but lacks in-depth discussion on the internal mechanism of how physical thinking can inversely reshape mathematics teaching; secondly, although foreign research pays attention to psychology, there is relatively little systematic teaching research specifically targeting "complex functions," which is crucial for physics students; thirdly, neither has yet formed a complete set of solutions that tightly integrate the needs of physics, cognitive rules, and teaching practices to stimulate the intrinsic learning motivation of physics students. This study will build on the solid foundation of domestic reforms, absorbing the foreign emphasis on learning psychology and experiential learning, to propose and construct a "physics-needs-oriented immersive teaching model." Its core is not satisfied with the simple accumulation of cases, but is committed to analyzing the physical picture and thinking paradigm behind each core concept of complex functions, achieving deep integration of mathematics and physics at the cognitive level. By creating a complete "learning context" that starts from physical problems and ultimately returns to physical explanations, and designing

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project-based learning activities, it systematically resolves students' "psychological barriers ," transforming instrumental learning into meaningful exploration. This provides a new paradigm with greater explanatory power and operability for teaching mathematics courses in physics majors.

2. Related Theoretical Foundations

2.1 Basic Theory of Complex Functions

Complex functions, as a core content of mathematical physics methods, require the optimization of teaching methods to be based on a solid theoretical foundation. Complex functions study functions defined on the complex domain. The basic concepts include analytic functions: if a function f(z) is differentiable everywhere in a region, it is said to be analytic in that region. Analytic functions satisfy the Cauchy-Riemann conditions:

$$\frac{\partial u}{\partial x}=\frac{\partial v}{\partial y},\quad \frac{\partial u}{\partial y}=-\frac{\partial v}{\partial x} \tag{1}$$

where

$$f(z)=u(x,y)+\mathrm{i}v(x,y). \tag{2}$$

This property is of great significance in physics. For example, in two-dimensional electrostatic field problems, the potential $\varphi(x,y)$ and the stream function

$$\psi(x,y)=0 \tag{3}$$

constitute the real and imaginary parts of an analytic function, satisfying Laplace's equation

$$\nabla^2\varphi(x,y)=0. \tag{4}$$

Cauchy Integral Theorem and Residue Theorem: The Cauchy integral theorem states that the integral of an analytic function along a closed path depends only on the singularities inside the path, and the residue theorem further simplifies the calculation of complex integrals. For example, in quantum mechanics, the calculation of Green's functions often involves contour integrals in the complex plane, where the residue theorem can significantly reduce computational complexity.

Conformal Mapping: Analytic functions have the property of conformality, which can be used to solve physical problems under complex boundary conditions. For example, in fluid mechanics, the Schwarz-Christoffel transformation can map irregular regions to the upper half-plane, thus simplifying the solution of potential flow problems.

Physical applications include Electromagnetism: When solving two-dimensional electrostatic field problems, the complex potential function

$$\varphi(Z)=\varphi(x,y)+i\psi(x,y) \tag{5}$$

can simultaneously describe the potential distribution and electric field lines; Quantum Mechanics: Analytic continuation techniques are used to study the S-matrix in scattering problems, and the residue theorem plays a key role in calculating Feynman integrals; Heat Conduction: Complex variable methods can be used to solve unsteady heat conduction equations, such as transforming partial differential equations into integral problems on the complex plane through Fourier transforms. These applications show that complex functions are not only mathematical tools but also bridges for solving physical problems. Therefore, their teaching methods must emphasize the integration of physical background.

2.2 Teaching Method Theories

Constructivism: The core view is that learning is a process where students actively construct knowledge. Teachers should provide contextualized problems to guide student exploration. For example, when explaining the Cauchy integral theorem, students can first be allowed to try calculating a few physical problems before summarizing the general rule, rather than directly giving the theorem. A

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survey by the Mathematical Association of America (MAA) showed that in classes using constructivist teaching, students' problem-solving abilities improved by 25% (MAA, 2019).

Cognitive Load Theory: Learning efficiency is limited by working memory. Teaching should reduce extraneous cognitive load and optimize the presentation of knowledge. The concept of conformal mapping in complex functions is relatively abstract. One can first demonstrate the transformation effect through fluid simulation animations before introducing the mathematical formulation. An experiment in Germany showed that teaching combined with dynamic visualization can increase the understanding rate of abstract mathematical concepts by 40% (Koller et al., 2021).

2.3 Mathematical Physics Equations and Their Symmetry

Usually, second-order partial differential equations are divided into elliptic equations, hyperbolic equations, and parabolic equations. In physics, elliptic equations correspond to potential equations, corresponding to steady-state fields, describing states; the quadratic terms are fully symmetric, leading to the time-independent Schrödinger equation. Hyperbolic equations correspond to wave equations, corresponding to wave fields, describing processes, with some symmetry breaking, leading to the Klein-Gordon (KG) equation. Parabolic equations correspond to transport equations, corresponding to diffusion fields, describing processes, with complete symmetry breaking, leading to the general Schrödinger equation. Solutions of elliptic equations should possess certain symmetries, and all steady-state fields have some symmetry, at least when the higher-order terms, or the coefficients and constant terms in the equation exhibit symmetry in x, y, z, etc., such as in Poisson fields. Parabolic equations, when developed with imaginary time, become the Schrödinger equation, connected to wave equations. Other equations, when developed with imaginary numbers, lead to various equations and their corresponding fields transforming into each other. For example, the elliptic equation (i)'=-1 becomes the hyperbolic equation, and vice versa. The complex number i can be related to relativity, while the parabolic equation is a non-relativistic approximation.

For the corresponding physical equations, the wave equation describes various periodicities, wave properties, including economic and market cycles, and human biorhythms. The heat conduction equation describes various decay, unidirectional evolution, birth and death processes, including ecology, population, and human growth and aging. The steady-state field equation describes various stable distributions, such as the relatively stable stages of human development. The latter two describe the increase and stabilization of entropy, etc. They have mathematical correspondences, including all linear equations.

Mathematical physics equations in spherical and cylindrical coordinates generally reduce to Legendre and Bessel equations. When the equations themselves are generalized, in various coordinate systems, and extended to n-dimensional space, there should be various special functions. Many current mathematical physics equations can be unified into the Sturm-Liouville (SL) equation:

$$\frac{d}{dx}\left(p(x)\frac{dy}{dx}\right)-q(x)y+\lambda\rho(x)y=0 \tag{6}$$

For each type of equation, such as the SL equation, there may be a unified general solution. The Legendre equation, Hermite equation, and Laguerre equation can be unified in form as a special case of the SL equation with q=0:

It is known that the differential forms of the Legendre function is

$$P_t(x)=\frac{1}{2^t l!}\frac{d^t}{dx^t}\left(x^2-1\right)^t, K(x)=x^2-1, f=0 \tag{7}$$

The differential forms of the Hermite function is

$$H_n\left(x\right)=(-1)^n e^{x^2}\frac{d^n}{dx^n}e^{-x^2}, K=1, f=x^2 \tag{8}$$

The differential forms of the Laguerre function is

$$L_n(x)=e^x\frac{d^n}{dx^n}(e^{-x}x^n), K=x, f=x \tag{9}$$

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These three special functions can be formally unified as

$$S_n(x) = Ce^{f(x)} \frac{d^n}{dx^n}\left(e^{-f(x)} K^n(x)\right) \tag{10}$$

If this holds after generalization, then certain quantities such as P"(.z) , l, m can be developed into non-integers, etc. The v, l, mof Bessel functions and various special functions can be correspondingly generalized to arbitrary real numbers, complex numbers, etc. Thus, their differential, integral forms, or the functions themselves must be developed... The Yang-Baxter equation was obtained by Yang Zhenyu for the one-dimensional quantum many-body problem

$$H = \sum_i p_i^{\,2} + 2c\sum_{i>i} \delta\left(x_i - x_j\right), \tag{11}$$

where A(u) and B(v) are two matrices. In 1972, R.J. Baxter also discovered this equation in two-dimensional classical statistical mechanics. The Yang-Baxter equation is

$$A(u)B(u+v)A(v) = B(v)A(u+v)B(u) \tag{12}$$

This is a generalization of AB=BA, a kind of non-commutative algebra analogous to trilinearity, potentially leading to the breakdown of the Pauli exclusion principle (PEP) and nonlinear theories, etc. This can be arbitrarily developed, extended to multiple functions and arbitrary combinations, etc. This equation has been used in conformal field theory, knot theory, braid theory, operator theory, Hopf algebras, quantum groups, and the topology of two-dimensional manifolds.

2.4 Mathematical and Physical Quantities

Mathematically: Scalar → Vector → Tensor. Physically: Energy → Energy flow (corresponding to momentum) → Momentum flow

$$\frac{\partial(mv_i)}{\partial x_j} = M\left\{ij\right\} \ . \tag{13}$$

one component is a scalar, n components form an n-dimensional vector. A special case with two components is a spinor, later generalized to Dirac spinors, etc. Generally, scalars and three-dimensional vectors can be combined into four-dimensional vectors. Vector particles and scalar particles can correspondingly be combined into four-dimensional vector particles.

The author has explored tensors, spinors, twistors, etc., developed from scalars and vectors, and their applications in physics... Twistors are a generalization of the concepts of vectors, tensors, and spinors. They can include self-dual Yang-Mills (YM) gauge fields. Complex conjugation corresponds to quantization by replacing with $-\frac{\partial}{\partial Z_i^a}$. Any massive system can be a composite object of two or more twistors. The essence of the Riccati equation is that it represents the torsion-free nature of space.

The dot product determines the metric of the manifold, the cross product determines the torsion of the manifold; it determines algebraic properties. This is algebra applied to geometry. Non-commutative multiplication is characteristic of rings and operators; mathematics where addition is non-commutative can be analogously generalized. In algebraic systems, multiplication and addition are both operations, symmetric to each other. There are also twistors, their fractional dimensions, complex dimensions, etc.

Leptons (e, v) are twistor pairs of minimal mass states, essentially related to the two-dimensional unitary group, connected to weak interactions. (e, v)can serve as its doublet integral representation, corresponding to scattering amplitude calculations without ultraviolet divergence. Triplets constitute the Weinberg-Salam theory, sextets form grand unification, which can be generalized to higher rank, higher dimensions, curved space... Further, covariant differentiation and the spin field in general relativity corresponding to quantum mechanics should be discussed.

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3. Analysis of the Current State of Complex Function Teaching Methods

3.1 Problems in Course Objective Setting

Unclear Connotation of Teaching Objectives: The complex functions course has problems with unclear connotation in teaching objectives, especially in local application-oriented undergraduate normal universities. The course objectives fail to fully reflect the characteristics of teacher education programs, differing little from the objectives of complex functions courses offered in other majors. This situation violates the "outcome-oriented" educational philosophy, meaning that course objectives should clearly reflect the core abilities and qualities students need in specific professional fields. Disconnection from Contemporary Development: Some teaching objectives have not been updated in a timely manner and are disconnected from current social and technological developments. The application fields of complex functions are constantly expanding, and teaching objectives should adapt accordingly, guiding students to learn and apply the latest theories and methods. The setting of course objectives should focus on supporting the achievement of graduation requirements, reflecting the "outcome-oriented" educational philosophy. Under the requirements of the secondary certification standard for teacher education programs, the program training objectives have clear requirements for students' long-term career development plans, especially focusing on the career goals students should achieve about five years after graduation. As one of the professional courses, the complex functions course should not only impart solid professional knowledge but also serve long-term career goals. Specifically, the course objectives should be closely set around deepening subject literacy, improving comprehensive education ability, and cultivating collaborative spirit to ensure that students can transform these learning outcomes into effective teaching skills in future educational practice. Through such course setting and teaching implementation, it can be ensured that students can reach the career development height expected by professional certification about five years after graduation.

According to the supporting relationship between the complex functions course and the specific indicator points of graduation requirements, the teaching objectives of the complex functions course can be set from four aspects: subject foundation, subject ability, general knowledge, and collaboration. Taking the mathematics and applied physics teacher education program in a local application-oriented undergraduate institution as an example, Table 1 shows the specific teaching objectives for the complex functions course formulated by the research group, and Table 2 shows the supporting relationship between the course objectives and the graduation requirements.

Table 1 Teaching Objectives of Complex Variable Function Course

Course goal	
objective1	Master the basic knowledge of complex function. Including complex geometric meaning, complex function, analytic function, complex series, complex integral, residue and other knowledge of the basic concepts, basic theory, calculation methods, familiar with their definitions and usage.
objective 2	Master the basic skills for the application of complex variable functions proficiently. Compare and analyze the theoretical knowledge of the complex number field learned with that of the real number field, and deeply understand their similarities and differences. Apply the basic theories, formulas and rules of this course to conduct logical deduction, reasoning and accurate calculation, so as to cultivate rigorous and meticulous logical thinking ability.
objective 3	Develop practical ability. With the help of the extended complex knowledge, we can solve the problems which are difficult to conquer in the real number domain. Integrate the knowledge and methods involved in this course. Combine the mathematics subject knowledge, do a good summary and induction work, strengthen team cooperation, fill the gap in their own mathematical theory system.
objective 4	Cultivate learning ability and logical thinking ability. In the learning process of complex variable function course, students need to master and understand many basic definitions and theoretical deduction.

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Table 2 Supporting Relationship between Course Objectives of Complex Variable Function and Graduation Requirements

Firewood requirements	Graduation requirement index point	Course marking
Discipline accomplishment	Discipline foundation: master the basic knowledge and problem-solving methods of the latest mathematics discipline, the basic ideas and methods of the theoretical system of mathematics discipline.	objective 1
	In terms of subject ability abstraction, logical reasoning, mathematical operation and other mathematical disciplines of professional ability, basically able to use mathematical methods to solve other subjects or social practical problems	objective 3, objective 4
	General knowledge: have general knowledge, master the latest basic theories of physics, computer, English and other related disciplines, and initially form the ability and consciousness to integrate the knowledge of related disciplines	objective 2, objective 3
Communication and cooperation	Collaboration: Understand the significance of teamwork, adhere to the spirit of teamwork, and participate in group learning, discussion and teamwork learning activities with a proactive attitude, and share learning experiences.	objective 3, objective 4

3.2 Problems in Course Teaching

In the teaching process of the complex functions course, there exists an emphasis on theoretical foundation and neglect of practical application. The teaching content of the complex functions course has long focused on the theoretical level, overemphasizing the completeness of the logical system, while rarely involving the value of complex functions in practical applications and the development of modern technology. Such teaching content fails to fully demonstrate the practicality and contemporaneity of the course. There is a lack of diversity in teaching methods. In the teaching of the complex functions course, the traditional teacher-centered lecture method dominates. This method ignores the student-centered educational philosophy, resulting in low student participation in the teaching process, mainly manifested as some students not previewing before class, not listening attentively in class, not reviewing promptly after class, and being unable to complete assigned homework independently.

Teaching content lacks elements highlighting the characteristics of teacher education programs. For example, the connection with secondary school mathematics content is insufficient. Secondary school mathematics education emphasizes cultivating students' core mathematical literacy, including mathematical concepts, scientific thinking, and scientific inquiry. Because the textbooks for mathematics courses in normal universities and the teaching of most professional courses ignore the objective requirement of "possessing certain secondary school mathematics teaching ability," considering this requirement should only be met by courses like secondary school curriculum standards and textbook analysis. The exploration of ideological and political elements in teaching is insufficient. Curriculum ideology and politics is an important way to improve the quality of talent cultivation and practice teacher ethics. However, in the teaching of complex functions, the exploration and integration of ideological and political elements are obviously insufficient. Teachers often only focus on the teaching of course content, neglecting the important role of curriculum ideology and politics in the educational process. There is a lack of effective evaluation and feedback mechanisms in teaching. Since students' learning effects cannot be promptly fed back during the teaching process, teachers cannot track and understand them in time, making it impossible to adjust teaching targetedly.

3.3 Problems in the Course Assessment and Evaluation System

Currently, the main problems in the assessment and evaluation system of the complex functions course in university teacher education programs include a lack of process assessment and relatively singular evaluation methods. The current assessment methods for the complex functions course mainly rely on class attendance, homework, and final exam scores, with little assessment of learning processes such as classroom performance, extracurricular learning, chapter tests, midterm exams, and experimental processes. This assessment method focuses too much on the final exam results, ignoring students' performance and progress throughout the entire learning process. This leads students to often only care about the final exam results, neglecting the importance of daily learning and continuous

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improvement. The assessment content is relatively singular, emphasizing theory over practice. The assessment content of the complex functions course emphasizes theoretical knowledge, with little assessment of practical application. Since complex functions have strong applicability, neglecting the practical part in actual evaluation is not conducive to cultivating students' ability to think, analyze, and solve complex engineering problems. This assessment method limits the comprehensive development of students and fails to fully reflect the application value of complex functions in practical engineering. It ignores differentiated evaluation for students at different levels, unable to stimulate the learning interest and potential of students at different levels, affecting teaching effectiveness. Some students may experience adverse effects on their academic performance due to maladaptive assessment methods, which could undermine their learning confidence.

4. Improvement Strategies for Complex Function Teaching Methods

4.1 Integrating Modern Teaching Technology

The integrated application of modern teaching technology is an important way to improve the teaching effectiveness of complex functions. By reasonably using multimedia, online platforms, virtual simulation, and other technical means, the limitations of traditional teaching can be significantly improved. The application of multimedia technology can break through the limitations of traditional blackboard writing. When explaining the geometric characteristics of complex functions, using dynamic geometry software can intuitively display the function transformation process on the complex plane. For example, when teaching conformal mapping, the process of Schwarz-Christoffel transformation can be demonstrated through animation, allowing students to clearly observe the transformation relationship from complex regions to simple regions. Teaching practice at the California Institute of Technology shows that the accuracy rate of understanding the concept of conformal mapping improved in classes using visualization teaching.

4.2 Strengthening Practical Teaching Links

Strengthening practical teaching links is key to cultivating students' application abilities. Through various forms such as experimental courses, project training, and scientific research practice, students' ability to use complex functions to solve practical problems can be effectively enhanced. According to the "student-centered" concept of teacher education program certification, the course syllabus should be written and teaching methods designed based on the core ability and quality requirements for graduates, and based on the actual needs of basic education reform and social development during the teaching process of the complex functions course. In terms of teaching content, the combination of theory and practice should be strengthened so that students can more intuitively understand the practical application and value of complex functions. In course teaching, a series of vivid and inspiring practical cases can be introduced combined with the latest application results in engineering fields. These cases not only cover multiple fields such as electrical engineering, signal processing, and control systems but also closely track the latest research trends and developments in the field of complex functions. The design of experimental courses should highlight physical characteristics. The practical orientation of the course can be enhanced by designing discipline-specific experimental modules, including "Electrostatic Field Distribution Analysis via the Complex Potential Method" and "Residue Theorem Applications in Quantum Mechanics". Each experimental project should include four links: problem introduction, theoretical analysis, numerical calculation, and result discussion. The "Complex Function Physics Experiment" course offered by Beijing University of Aeronautics and Astronautics includes 8 required experiments and 4 optional experiments. The excellent rate in the evaluation of students' practical ability increased from 28% to 65%.

4.3 Adopting Flexible and Diverse Teaching Methods

Complex functions is an abstract and challenging mathematics course. Therefore, it is necessary to adopt flexible and lively teaching methods to improve students' learning interest and understanding ability. For example, Situational Teaching Method: Combine the theoretical knowledge of complex functions with practical applications, introducing them through specific engineering cases or practical problem situations, making it easier for students to understand abstract concepts. For example, the practical applications of complex variable functions in electrical engineering and signal processing can be introduced; meanwhile, the project-driven learning teaching method should be adopted. Specifically, some small-scale projects or tasks can be designed to enable students to apply the knowledge of complex variable functions in the process of solving practical problems.

This method not only improves students' hands-on ability but also stimulates their learning interest and initiative; Multimedia Teaching Method: Use computer simulation software and multimedia technology to display the dynamic changes and application scenarios of complex functions. Animated and graphical demonstrations can help students understand complex mathematical concepts more intuitively; Interactive Teaching Method: Increase interaction between teachers and students through classroom discussions, group work, Q&A sessions, etc., encouraging students to ask questions and share their understanding and insights to promote deeper learning and exchange; Flipped Classroom Teaching Method: Adopt the flipped classroom teaching model, providing part of the teaching content to students in advance through videos, literature, etc., for self-study before class. Class time is then used for discussion, Q&A, and problem-solving, strengthening the understanding and application of knowledge.

4.4 Constructing a Diversified Assessment System

Traditional assessment methods such as written exams are important but are no longer sufficient to comprehensively evaluate students' abilities. Therefore, more diversified assessment methods should be introduced, such as project assignments, group discussions, and open-ended problem solutions. Such assessment methods can not only examine students' mastery of basic knowledge but also evaluate their innovative thinking, teamwork, and problem-solving abilities. Greater emphasis should be placed on the assessment of practical application capabilities. To enhance students' practical ability and innovative spirit, more practical application content should be introduced into assessments. For example, design cases based on engineering applications, allowing students to apply the theoretical knowledge of complex functions in the process of solving practical problems. Such assessment methods not only help students deeply understand the knowledge they have learned but also exercise and enhance their practical ability and innovative thinking.

Set a certain proportion of open-ended questions to allow students to demonstrate their independent thinking ability and creativity. These questions can be ones that require students to prove, derive, or propose solutions, helping to cultivate students' critical thinking and innovative awareness. Strengthening the two-way feedback mechanism is essential. The two-way feedback mechanism requires teachers not only to regularly provide feedback to students on learning outcomes, learning methods, and learning attitudes, helping students clarify their progress and shortcomings, but also to actively listen to students' voices, collecting their opinions and suggestions on course content, teaching methods, learning resources, etc. Through student feedback, teachers can more accurately grasp students' learning needs and further optimize teaching content and methods.

5. Conclusion

In summary, this paper, by exploring the reform path of teaching methods for complex functions in physics majors, found that the traditional lecture method, while ensuring the completeness of the knowledge system, has significant deficiencies in cultivating students' application abilities, and students' ability to solve physical problems is weak. Secondly, the blended teaching model integrating modern teaching technology significantly improved the teaching effectiveness. In addition, strengthening practical teaching links is crucial for the cultivation of application abilities, and personalized teaching methods effectively improved the learning experience. Research shows that the teaching model reform based on the trinity of "problem orientation + modern technology support + practical ability cultivation" is an effective way to improve the teaching quality of complex functions in physics majors. Future research can focus on developing AI-based learning analysis systems to achieve precise teaching; constructing an inter-school complex function teaching case database; exploring the application of virtual reality technology in the geometric intuition teaching of complex functions, which will help further improve the teaching quality of mathematics courses in physics majors.

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