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Cultivation Model on Undergraduate Academic Literacy from the Perspective of the Implementation of Theoretical Physics Course Group

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Abstract:

The topic of improving undergraduate academic literacy has been drawing considerable attention from educators. This paper focuses on the applied physics major in local applied undergraduate colleges, considering the characteristics of physics-related majors. Aiming to cultivate student-centered academic literacy, the paper proposes a construction plan for the theoretical physics course group. Based on a multi-angle analysis, the research discusses some strategies and tailored suggestions for the construction of the course group, along with an analysis of its effectiveness.

Keywords:

Academic literacy
Course group
Construction strategy
Curriculum integration

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1. Introduction

At the beginning of 2021, the Ministry of Education of the People's Republic of China promulgated and implemented the "Undergraduate Thesis (or Design) Sampling Method (Trial)" (hereinafter referred to as the "Method"), emphasizing that the inspection of undergraduate theses should focus on "the significance of the topic, writing arrangement, logical construction, professional competence, and academic norms" [1]. One week later, a spokesperson from the Education Supervision Bureau of the Ministry of Education explicitly stated in a press conference that the inspection of undergraduate theses primarily focuses on the basic academic norms and basic academic literacy of undergraduate students [2]. The academic norms refer to the behavioral guidelines that need to be followed in academic activities, while academic literacy, as a basic proficiency of scientific research, is the ability to continuously apply scientific knowledge in academic activities. The inspection will underline academic norms and academic literacy. In terms of academic literacy, it is required that undergraduate theses demonstrate certain scientific levels and innovativeness. In terms of academic norms, the "Method" requires educators to exercise the bottom-line thinking in undergraduate teaching.

In the context of exploring new approaches to talent development in the "New Engineering" construction, Hubei Polytechnic University positions itself as an applied undergraduate institution serving regional economic development. Therefore, its talent cultivation model and emphasis on cultivation differ from that in Double First Class universities, especially in fundamental disciplines such as applied physics in regional universities. Considering the fact of established education rank and top-level design of talent cultivation programs, how to leverage the advantages of local applied universities, particularly in the field of applied physics, to further enhance the quality of undergraduate theses and talent cultivation poses a giant challenge for these universities. To solve this dilemma, this paper, from the perspective of constructing and implementing the theoretical physics course group, explores effective pathways to enhance students' academic literacy, helping them gain academic competence in solving complex problems in the ever-changing days, in the hope of promoting the quality of thesis writing ultimately [3].

2. Research background of the theoretical physics course group to cultivate the student's academic literacy

With the rapid development and widespread application of technology, there is a growing recognition of the fundamental principles of physics and their foundational role in modern technology. As core courses for talent cultivation in various physics-related majors, the four major mechanics courses encompass fundamental theoretical issues in almost all branches of physics. They serve as foundational courses bridging basic physics knowledge to advanced studies such as quantum technology and precision measurements [4]. These courses lay the groundwork for the study in the field of solid-state physics, semiconductor physics, and devices, as well as advanced quantum mechanics, solid-state theory, quantum statistical physics, quantum electrodynamics, etc. during the graduate period.

Simultaneously, they provide a solid theoretical foundation for conducting research and practical applications in areas such as optoelectronic materials and detection, and microelectronic devices, contributing significantly to the origin and development of modern technology. Furthermore, the topics of academic research and various professional graduation theses are intricately linked to the four major mechanics courses [5]. The physics-related theoretical and practical knowledge cited in the graduation theses can be found in these courses. Therefore, the quality of teaching and curriculum construction in the four major mechanics exert direct impacts on the quality of talent cultivation in physics-related majors. Thus, integrating the four major mechanics into a holistic and comprehensive course is one of the effective approaches to enhancing the academic literacy of undergraduate physics students, guiding and assisting them in developing and cultivating preliminary academic literacy.

3. Implementation strategies and construction strategies of the theoretical physics course group to improve students' academic literacy

3.1. Optimizing the course on the whole by conforming to the inherent logic and content

Given the interdisciplinary collaboration in science and technology, the integration of industry and education for collaborative talent development, and the overall reduction in theory teaching hours, the construction of the theoretical physics course group must embrace an overall viewpoint systematically [6]. Firstly, it is essential to clarify the hierarchy and connections within the course group (as shown in **Figure 1**) and develop proper curriculum plans and course syllabi. Adjustments should be made to eliminate redundancy among original courses, ensuring the well-designed content and integration of the five courses in the course group, ultimately achieving overall optimization. Secondly, to optimize overall course teaching, it is crucial to clarify the intrinsic connections between the theoretical framework and knowledge structure of the courses, following the inherent logic of course knowledge. A combined course system, such as mechanics and theoretical mechanics, thermodynamics and statistical mechanics, electromagnetics and electrodynamics, and atomic physics and quantum mechanics, should be established to optimize the structure of knowledge systems, build teaching resource platforms, alleviate conflicts between course content and hours, enhance classroom teaching efficiency, and promote the high-quality development of the course group [7].

Additionally, detailed analysis and adequate preparation during teaching should be conducted to erase the barriers between different courses and integrate the teaching content of the five courses. To improve classroom teaching efficiency, we need to clarify the intrinsic connections of the knowledge system and conduct teaching in specialized fields. For instance, these concepts including vibration equations, harmonic wave functions in mechanics, Bloch wave functions in solid-state physics, and matter-wave functions in quantum mechanics can be compared to each other and illustrated in teaching quantum mechanics, to deepen students' understanding of wave functions in the field of classical and quantum physics. The overall relationships within the course group are illustrated in **Figure 1**. The "unidirectional arrows" in the figure represent interactions, while the "feathered arrows" indicate derivations.

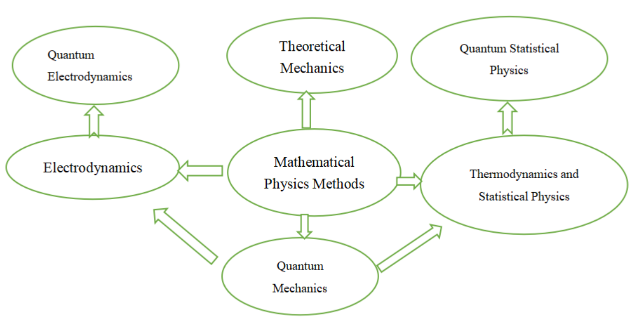

Figure 1. Holistic relationships among series courses within the course group

3.2. Enriching teaching methods and promoting pedagogical reform of course group through academic literacy cultivation

In addition to the more systematic curriculum framework, it is equally essential to reform classroom teaching methods by selecting research topics based on course knowledge. Upon the completion of the four major mechanics courses, instructors are encouraged to engage in topic-specific teaching or academic lectures staying abreast of academic trends. Such topics include classical cases, experiments, hot issues, and cutting-edge developments in theoretical physics [8]. The aim is to shift students from textbook learning to academic research and encourage them to explore basic research and accumulate analytical skills through literature review and data collection. For instance, specialized teaching can be conducted around the topic of harmonic oscillation and linear harmonic oscillator, which may start from the topic of vibration equation and energy in mechanics, followed by topics such as mechanical vibration in mechanics, mechanical wave functions, linear harmonic oscillator energy in statistical physics, quantum description of energy, matter-wave functions in quantum mechanics, Schrödinger equation, solving states and energy in quantum mechanics, Hermite polynomial properties, scientific computation, describing physical phenomena and laws based on graphs, and organizing the linear harmonic oscillator research process from classical to quantum physics, etc. By reforming teaching methods, students' competence in physical model construction and scientific paper writing will be boosted greatly [9].

3.3. Advancing the transformation of academic resources into teaching resources and the integration of research and teaching

The theoretical physics course group is the core curriculum for various physics majors and serves as the foundational course, aiming to improve undergraduate academic literacy and the quality of thesis writing. This requires the teachers undertaking the courses to not only fulfill routine teaching tasks but also keep pace with academic frontiers and current developments. They should combine their research findings with the teaching practice, with efforts to trigger students' interests in the field and stimulate their academic exploration desires. This is vital to the high-quality development of undergraduate talent (as illustrated in **Figure 2**). Undergraduate students in various physics majors have to complete the study of the four major mechanics courses, especially the quantum mechanics course, in the first semester of their junior year according to the curriculum plan of the talent development program. Then they will lay solid groundwork for further academic research. Simultaneously, students have learned the academic directions of teachers and research resources during their two years in university. Based on academic teams, academic mentorship or assistant class leader

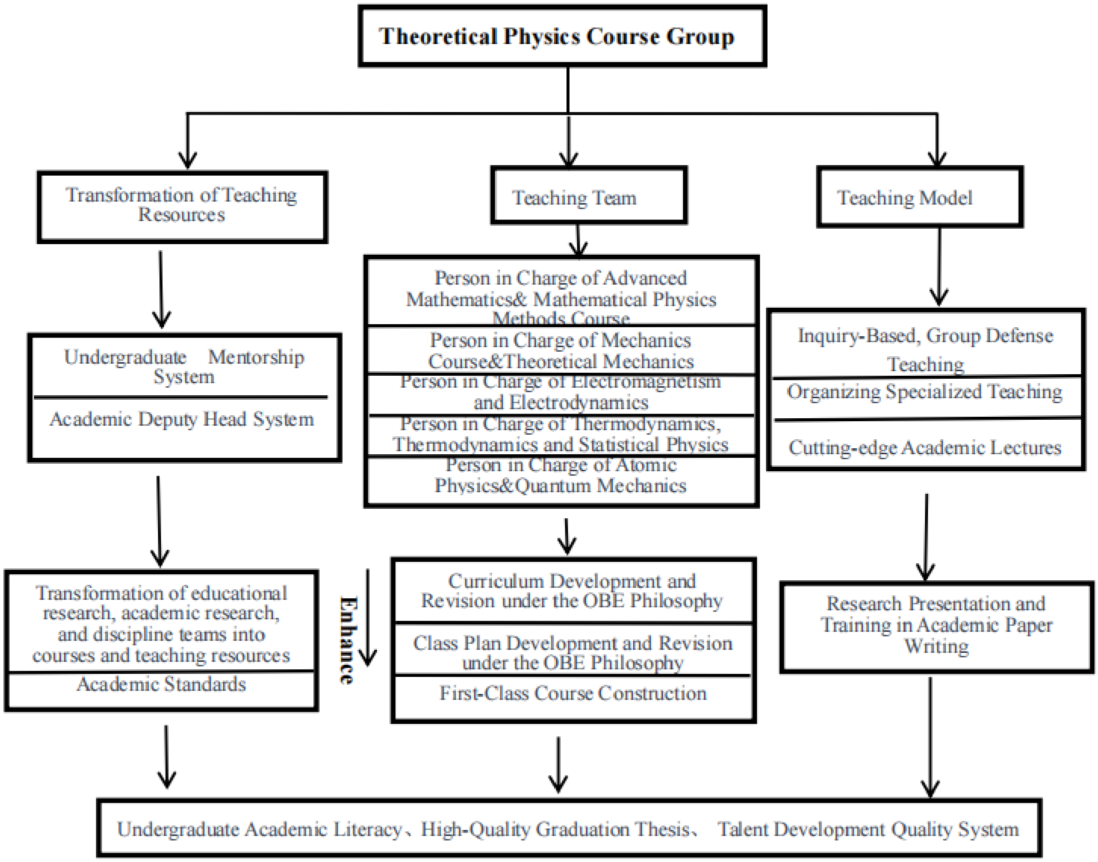

Figure 2. The construction process of theoretical physics course group

systems are implemented to create a platform for undergraduates during the junior year. This initiative provides a platform for undergraduates interested in research and offers academic guidance for students struggling with their studies. The integration of scientific research and teaching aims to elevate students' academic literacy, strengthen their exploratory abilities, and hone their thesis topic selection and writing skills [10].

The first students enrolled in the Applied Physics major in 2009 and graduated in 2013. In 2011, the university attempted to integrate Mathematical Physics Methods and the four major mechanics courses into a unified curriculum platform, marking the beginning of course group construction. In 2015, as the university's decision shifted from teaching-oriented to application-oriented, a new round of revisions to the talent development program was implemented across the entire university. Following the top-level design of the talent development program, the hours for theoretical courses in the Applied Physics major were significantly reduced. Courses such as Mechanics, Thermodynamics, Electromagnetics, Optics, and Atomic Physics were united into General Physics I and II with a total of 150 hours, while the four major mechanics courses into Theoretical Physics I and II with a total of 160 hours [11].

To ensure the quality of teaching after the reduction of theoretical hours, the teaching outlines for Mechanics and Theoretical Mechanics, Thermodynamics and Statistical Physics, Electromagnetics and Electrodynamics, and Atomic Physics and Quantum Mechanics were coordinated and planned based on the theoretical physics teaching platform established in 2011. Some assigned teachers undertake the task of the design and development of each combined course. To transform academic resources into course resources, some institutions and regulations such as the undergraduate mentor system and academic deputy class leader system were formulated and implemented within the course

Table 1. Summary of postgraduate enrollment and publication of academic papers by graduates in the Applied Physics Major of Hubei Polytechnic University since the establishment of the major

Graduation year	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Admission percentage (%)	28.00	24.00	19.44	18.60	17.54	15.58	13.16	11.70	17.81	12.82
Provincial journals /articles	5	6	4	5	5	3	2	0	0	0
SCI-indexed articles	2	1	0	1	2	0	0	0	0	0

group.

To assess the practical effects of theoretical physics course groups, the research collected the number of academic papers published by undergraduate students and the number of students who accessed postgraduate careers with theoretical physics as their major. Furthermore, a contrast between numbers was conducted vertically and quantitatively before and after the establishment and reform of the course group [12].

To study the overall impact of the theoretical physics course group construction on students' academic literacy and course-based education in the Applied Physics major of Hubei Polytechnic University, this research compared the enrollment rates and numbers of academic papers published by previous graduates before and after the construction of the theoretical physics course group, as shown in **Table 1**. As seen from **Table 1**, the enrollment rates for the first (graduate in 2013) and second (graduate in 2014) graduating classes are on the rise, indicating that teachers gradually became familiar with the course teaching in the specialized field, and students' learning capacity improved correspondingly. After the revision of the talent development program in 2011, a course group combining Mathematical Physics Methods and the four major mechanics courses was introduced into the teaching of specialized courses. However, when the class adopted this teaching method in 2015, it was found that the enrollment rate for postgraduate studies decreased compared to the previous year, suggesting a decline in students' learning capabilities and specialized understanding [13].

Afterward, with the continuous improvement of the theoretical physics course group construction, the enrollment rate for postgraduate studies increased year by year, indicating that both teachers and students were gradually adapting to the new course group teaching mode, and the teaching quality was improving. With the advance of a combined course group including Mechanics and Theoretical Mechanics (offered in the second semester of the sophomore year and the first semester of the junior year), the enrollment rate for postgraduate studies for the first graduating class after the reform (graduate in 2018) continued to increase without fluctuation. This is the obvious evidence that the combined teaching mode hardly affects the teaching outcome and the quality of talent development. Along with the further implementation of the course group construction, the recent three years witnessed a significant increase in enrollment rate for postgraduate studies successively [14]. The percentage of admissions in **Table 1** refers to the number of recent graduates who have received admission notices for postgraduate studies, as a percentage of the total number of postgraduates in the current year.

To further analyze the publication of academic papers by undergraduate students in the Applied Physics Major of Hubei Polytechnic University, a more in-depth analysis was conducted over the years. Thanks to the implementation of measures to cultivate students' academic literacy and optimize the teaching mode of the theoretical physics course group from 2013 (when the undergraduate students enrolled in 2011 began to take the theoretical physics course) to 2015, and the continuous improvement and integration of the implementation plan, there has been a breakthrough in the number of academic papers published by undergraduate students since 2016. Since then, the high-quality academic thesis under the guidance of teachers has been published consistently and increasingly. These results indicate that the improvement in the quality of course-based education and academic literacy of undergraduates attributed to the teaching mode of the theoretical physics course group undoubtedly [15].

4. Conclusion and insights

Guided by the requirement from the Ministry of Education of the essential academic competence in undergraduate theses, this paper proposes a strategy for constructing a more comprehensive and three-dimensional theoretical physics course group under the background of substantial reduction of theoretical course hours in regional applied undergraduate universities. This strategy aims to encourage students majoring in Applied Physics to acquire systematic professional knowledge in physics. The paper concludes with the practical effectiveness of constructing the theoretical physics course group. It indicates that the construction of the theoretical physics course group ensures the continuity and completeness of the core physics courses in talent cultivation following the requirements of "new engineering education."

Currently, research on the construction of theoretical physics course groups and the impact on the cultivation of academic literacy for undergraduate students is still in the exploratory stage. This paper also provides insights into students' problem-solving competence conveyed in physics equations and formulas and suggests strategies to enhance their ability to interpret and predict physical phenomena.

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Disclosure statement

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