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Research on Five Dual-Driven Models of Multi-Disciplinary Integrated Teaching in College Physics

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Abstract

In this paper, we have studied the teaching model of college physics that organically integrates the "five dual drives" of courses and scientific research, ideological and political education, psychology, information technology, and innovative experiments. Through theoretical analysis and case studies, we have found that the college physics teaching model that organically integrates courses and scientific research has broken through the inherent barriers of the long-term separation of basic course teaching and scientific research. It can effectively solve the pain points of traditional college physics teaching, which emphasizes knowledge over ability and exam-oriented over innovation, and achieve mutual empowerment and collaborative education between basic teaching and scientific research. The teaching model of college physics that deeply integrates courses with ideological and political education can adhere to the core idea of "unifying knowledge imparting and value guidance", and it is a feasible new teaching paradigm for implementing ideological and political education reform in public basic courses in colleges and universities in the new era and comprehensively improving the quality of talent cultivation. The teaching model of college physics that integrates courses with psychology and is supported by theories such as cognitive psychology, positive psychology, and motivational psychology has improved the quality of college physics classroom teaching in the new era and implemented effective teaching for all-round education. The teaching model of college physics that deeply integrates courses with information technology breaks through the limitations of shallow application of multimedia, solving the traditional teaching pain points of college physics such as the difficulty in abstract teaching, restricted experiments, and the difficulty in teaching students in accordance with their aptitudes. It closely conforms to the mainstream of the current digital reform of college physics teaching in universities. The teaching model of college physics that integrates courses with innovative experiments breaks the disconnection between theoretical teaching and standardized verification experiments, and runs through the entire teaching process with innovative design and independent exploration. This model is a novel reform for practical teaching of college physics in universities and the implementation of the goal of cultivating students through innovation and entrepreneurship.

Keywords

College Physics Teaching, Integration of Multiple Disciplines, Innovative Teaching Methods

1. Introduction

The traditional education model is far behind the times. To keep pace with the development of the era, educational reform is imperative. We will explore the practical application rules of the "Five-Driven" interdisciplinary integrated teaching model in college physics teaching, which integrates education through curriculum, scientific research, ideological and political instruction, psychological counseling, and information technology. The research significance lies in the following aspects:

Firstly, we must cultivate students' comprehensive application ability to solve complex problems. The core concepts of university physics (such as energy conservation, electromagnetism, quantum mechanics, etc.) lay the foundation for many disciplines. Through interdisciplinary integrated teaching, students can understand the applications of physical principles in various fields and improve their ability to apply knowledge comprehensively. Moreover, interdisciplinary integrated teaching helps students develop systematic thinking. Secondly, fostering innovative thinking and unlocking research potential often hinges on interdisciplinary integration. This is frequently a key driver of technological breakthroughs. Introducing interdisciplinary case studies into university physics courses can inspire students' innovative mindset; for example, applying physical principles from fields such as artificial intelligence (e.g., neural networks and statistical mechanics) through a multidisciplinary lens can help students adapt more rapidly to the research demands of emerging fields. Thirdly, we must boost learning interest and motivation. Diversify practical application scenarios for students' learning. Traditional physics teaching may strike students as dull due to its excessive abstractness. Integrating interdisciplinary cases, such as mechanics in aerospace engineering, magnetic resonance imaging in medicine, and optics and chromatics in art, can spark students' interest and facilitate goal-oriented learning. For instance, designing robots that integrate mechanical, electronic and physics knowledge allows students to intuitively perceive the practical value of physical laws. Fourthly, this caters to society's demand for interdisciplinary talents. Integrated teaching and research across multiple disciplines boost career competitiveness. Modern technology industries (such as new energy, artificial intelligence and bioengineering) require professionals who master physical principles as well as knowledge in other fields. The interdisciplinary competencies cultivated through multidisciplinary integrated teaching better align with market demands and enhance students' ability to manage complex systems. Fifthly, our research also aims to boost collaborative development and resource sharing across disciplines. Faculty teams co-design curricula to advance interdisciplinary research. Meanwhile, teaching resources can be optimized, with laboratory equipment (such as physics labs utilized for biomechanics experiments) and interdisciplinary project resources shared to raise resource utilization efficiency. Finally, our research will be of great significance for improving scientific literacy and social responsibility. Interdisciplinary integration facilitates the understanding of science and technology ethics. For instance, integrated teaching combining nuclear physics and energy policies can guide students to reflect on the social impacts of technological advancement. Addressing global challenges: Analyzing issues including the environment, energy and healthcare from multidisciplinary perspectives (e.g., renewable energy technologies require the collaboration of physics, chemistry and engineering) helps cultivate students' global vision and sense of responsibility.

In summary, interdisciplinary integrated teaching not only consolidates the core position of physics, but also cultivates students' comprehensive abilities, innovative thinking and practical skills to solve complex problems through cross-domain connections. This model conforms to the trend of interdisciplinary integration of modern science, and provides talent reserves for universities to cultivate interdisciplinary talents and address future scientific and technological challenges.

In China, many scholars have conducted research on the application of interdisciplinary and integrated teaching of college physics in Chinese universities. Chen *et al*. [1] conducted an exploratory study on the teaching reform of college physics courses based on the integration of theory and practice and the intersection of disciplines. They discussed the teaching reform practice of the interdisciplinary college physics course from aspects such as the redefinition of teaching objectives, the innovative design of teaching content, and the improvement of teaching methods. Cao *et al*. [2] conducted a study on the teaching reform of college physics for chemical-related majors from the perspective of interdisciplinary integration. They took the reconstruction of teaching content, the innovation of teaching methods and the optimization of evaluation systems as the core, integrated modern educational technology and implemented systematic reforms. Li *et al*. [3] conducted research on the "digital and intelligent" teaching path and other classroom aspects of the "College Physics Experiment" course. For the teaching of college physics experiment courses, they are committed to cultivating students' innovative ability and comprehensive quality, and have explored and practiced the "digital and intelligent" innovative teaching model of experimental courses. Wang *et al*. [4], starting from the educational goal of cultivating new engineering talents, proposed a reform plan for multi-disciplinary interdisciplinary innovative physics experiments under the background of new engineering, and elaborated in detail on the specific ideas and measures of the reform plan for the multi-disciplinary interdisciplinary innovative physics experiment course. Research shows that appropriately introducing interdisciplinary integration in the teaching process has profound significance for innovating the teaching mode of college physics. Yu *et al*. [5] conducted research on the interdisciplinary integration in college physics teaching. Based on their practical teaching experience and guided by examples in the classroom, they proposed specific methods for introducing interdisciplinary integration into college physics teaching.

In this article, we will study the teaching model of multi-disciplinary integration in college physics based on five dual drivers. We will explore the integration of college physics teaching with the teaching of cutting-edge and hot topics in scientific research, achieving a dual drive of curriculum-based education and research-based education, broadening students' horizons for knowledge, enriching their knowledge structure, and cultivating their initial scientific research capabilities. The dual-driven model of curriculum-based education and research-based education mainly organically integrates scientific research with the relevant knowledge points of college physics teaching, bringing students' thinking into the hotspots of cutting-edge research, broadening their horizons and expanding their knowledge base. Ultimately, it aims to cultivate students' pursuit of scientific truth and exercise their initial research capabilities, with the expectation of enhancing the driving force for students' education and scientific research. We will explore the integration of university physics course teaching with the history of physics for ideological and political education, achieving a dual drive of course-based education and ideological and political education, and cultivating students' sense of patriotism and patriotic spirit. The dual drive of integrating ideological and political teaching in course instruction mainly involves integrating the teaching of the history of physics and the spirit of scientists with college physics to carry out ideological and political education. In the process of college physics teaching, the teaching of the history of physics and the spirit of scientists is effectively inserted to achieve the dual drive of physics knowledge teaching and ideological cultivation. We will explore the integration of college physics teaching with psychology teaching, achieve dual drive of course-based education and psychological education, explore the psychological knowledge acquisition laws of students, and strive to achieve the maximum effect of knowledge acquisition in the course teaching process. The dual driving force of integrated teaching of college physics and psychology mainly focuses on strengthening psychological care for students from a psychological perspective. In the process of college physics teaching, we provide a bath of love to address students' psychological barriers in learning. Previously, we increased students' confidence in learning through psychological counseling. Ultimately, it aims to promote college physics teaching and achieve a win-win teaching and dual-driven situation of knowledge acquisition and psychological encouragement. We will explore the integration of innovative physics experiment teaching models in college physics courses, achieving a dual drive of course-based education and innovative experiment education. We will integrate computer software codes into innovative experiments to enrich students' knowledge structure, broaden their horizons, and cultivate their ability to integrate computer experiments to solve practical problems. The integration and innovation of the physics experiment teaching model in college physics courses mainly aims to promote a reform that stimulates students' thinking and innovates their experiments. This kind of innovative integration with curriculum teaching is mainly driven by the aim of requiring students to broaden their knowledge base, learn more knowledge points, and master more skills, with the expectation of reforming the traditional experimental style and ultimately achieving multi-dimensional improvement in knowledge, ability and skills in innovative experiments. We will explore the integration of information technology and artificial intelligence in the teaching of college physics courses, achieving a dual drive of course-based education and information technology-driven education, in order to broaden students' horizons. Cultivate students' ability to solve scientific problems. The deep integration of college physics course teaching with information technology and artificial intelligence is mainly aimed at reforming the pain points of rigid and inflexible traditional teaching thinking. Integrating information technology into course teaching and achieving dual drive will be conducive to invigorating the classroom atmosphere, broadening students' horizons, and cultivating their enthusiasm for learning and pursuit of higher-level skills. This dual drive will make the teaching mode more intelligent, information-based and scientific.

2. Theoretical Analysis of Five Dual-Driven College Physics Teaching Models

In the first model, we integrate courses with research to implement a teaching-driven approach in college physics.

College physics is a compulsory basic course for science and engineering majors, featuring both instrumental, logical and physical ideological characteristics. Traditional teaching has a significant disconnection from scientific research activities. Ordinary undergraduate students lack channels to participate in scientific research, and there is a disconnection between theoretical courses and cutting-edge research. Therefore, they do not meet the demand for cultivating top-notch talents in new engineering and basic disciplines. We will emphasize the integration of science and education and break down the barriers between teaching and research, using research to support teaching and teaching to consolidate the foundation of research. This will give rise to a new teaching model for college physics that organically integrates course teaching and scientific research.

Firstly, we implement the policy of integrating scientific research into the curriculum, transforming the cutting-edge achievements in physics, scientific research thinking, experimental methods, and real scientific research challenges into classroom teaching resources. Secondly, we carry out curriculum education research. Build an introductory research ladder based on basic physics knowledge points to cultivate students' essential logical, experimental and data analysis qualities for scientific research. Secondly, we implement the integration of the main body. Teachers are both lecturers and researchers, while students are both classroom learners and junior participants in scientific research. Finally, we implement the unification of our goals. The course objective has been upgraded from mastering physical formulas and theorems to "consolidating the foundation of physics + shaping scientific thinking + possessing basic research and innovation capabilities".

Our integration model is divided into five organically linked modules: classroom theoretical teaching, physics experiment teaching, extracurricular scientific research expansion, assessment and evaluation system, and teacher support system, achieving full-process integration of science and education. We adopt a strategy of enriching teaching content through scientific research, continuously updating classroom materials with the latest research achievements of teachers, addressing the issues of lagging and outdated content in college physics textbooks, and creating distinctive and high-quality courses. We support scientific research and innovation through teaching. Undergraduate innovation projects and classroom inquiry discussions can generate new ideas and simple experimental plans, providing low-cost exploration directions for teachers' research and forming a complementary relationship between teaching and research. We are promoting the implementation of curriculum reform. We will foster distinctive teaching resources such as school-based experimental textbooks, research case libraries, and online micro-lessons to support the construction of first-class undergraduate courses.

However, the implementation of this teaching model also faces some challenges, mainly manifested in the following aspects. Teachers mainly face conflicts in teaching and research energy, difficulties in transforming cutting-edge content into teaching, insufficient supporting resources and assessment incentives, and great pressure in guiding learning in new classrooms. For students, the main tasks are to break through the rigid exam-oriented thinking, make up for the lack of research tools and literature literacy, bear the increasing academic pressure, and adapt to the process-based inquiry assessment. Both sides are also constrained by the class hour structure, the scarcity of high-quality teaching cases, and the inherent concepts of learning and work.

The second model is that we integrate courses with ideological and political education to implement a teaching-driven approach in college physics.

College physics is a compulsory public basic course for science and engineering majors in colleges and universities, and it is the core carrier for implementing ideological and political education in courses. For a long time, traditional college physics teaching has been plagued by problems such as emphasizing formula derivation over value guidance, and focusing on knowledge I parting over spiritual cultivation. The classroom only focuses on theoretical knowledge and problem-solving training, cutting off the scientific spirit, family and country stories, and dialectical materialist thought behind physical knowledge. Teachers separate knowledge teaching from value shaping, believing that ideological and political education is the exclusive task of ideological and political courses, which leads to the division between knowledge education and moral education.

In the new era, colleges and universities should implement the fundamental task of fostering virtue and nurturing talent, and comprehensively promote the construction of ideological and political education in courses, so as to enable various professional courses to undertake the function of educating people. College physics combines the attributes of natural science with the value of humanistic education, and is rich in ideological and political elements. Therefore, a three-in-one teaching model of ideological and political education in courses is constructed, which integrates knowledge imparting, ability cultivation and value shaping, achieving the same direction and organic penetration of physics course teaching and ideological and political education.

Our model will implement knowledge as the body and ideological and political education as the soul. We take the teaching of basic physics theories as the main body, with implicit infiltration of ideological and political education, and conduct ideological and political lectures independently without deviating from the content of the physics major. We will implement the unification of three-dimensional education. We will complete the imparting of basic physics knowledge, training in scientific experiments and modeling skills, and shaping correct worldviews, outlooks on life and values simultaneously. We will implement full coverage throughout the entire process. We will incorporate all teaching links, including theoretical classes, physics experiments, after-class assignments, assessment and evaluation, and extracurricular expansion. We will carry out two-way collaborative integration. We will explore the internal ideological and political resources of the physics discipline, avoid the rigid accumulation of external ideological and political materials, and achieve a deep integration of professional teaching and ideological and political education.

We will implement a blended stratified teaching approach, using online push of ideological and political science popularization resources for self-study and offline small-class group thematic discussions. We adhere to the principle of "prioritizing physics and supplementing ideological and political education", control the duration of ideological and political content, and avoid putting the cart before the horse. We will implement regular cross-disciplinary joint teaching and research. We will establish clear scoring criteria for experimental integrity, classroom presentations, and practical reports to reduce subjective judgment. We will implement a dynamic update of the ideological and political material library, simultaneously updating the cutting-edge achievements in domestic physics such as major space projects, quantum technology, and nuclear fusion of the current year, to ensure the timeliness of the materials.

However, the implementation of this model will also face many challenges. For teachers: The core issues are the difficulty in precisely integrating professional teaching with ideological and political content, the large workload of lesson preparation and teaching method reform, the difficulty in implementing soft evaluation, conflicts in research and teaching energy, and insufficient professional ability in ideological and political education. For students: The core issues are the cognitive rejection of the integration of ideological and political education into science subjects, the inability to adapt to the shift in learning mode from exam-oriented problem-solving to critical thinking and practice, the increased burden of various process-oriented assessments, and the difficulty in transforming value guidance from classroom cognition to self-academic research and ideological awareness.

The third model is that we integrate the curriculum with psychology to implement a teaching-driven approach in college physics.

College physics, as a core basic course in the first year of science and engineering, generally faces practical teaching problems such as students' heavy fear of difficulty, weak learning motivation, high cognitive threshold, low classroom efficiency, and serious polarization. Firstly, from the perspective of psychological cognition, physics encompasses abstract models, vector operations, and microscopic laws. It is difficult for students to transform their concrete thinking into abstract logical thinking, leading to cognitive overload. Secondly, from an emotional perspective, uneven physical foundations and repeated failures can easily lead to helpless anxiety in learning physics. Secondly, from the perspective of motivation, most students believe that physics has nothing to do with their major, lack internal learning motivation, and passively deal with classes and exams. Finally, from the perspective of classroom adaptation, traditional teaching adopts a uniform pace and teaching methods, ignoring the differences in students' cognitive levels, learning styles, and personality psychology, and thus fails to teach students in accordance with their aptitudes.

To provide theoretical support for solving the above problems, we have constructed a new teaching model that deeply integrates college physics courses with psychology from educational psychology, cognitive psychology, positive psychology, and the construction of novel learning theories. This model incorporates psychological laws throughout the entire process of teaching design, classroom implementation, experimental teaching, student situation guidance, and evaluation, and optimizes the entire teaching and learning process based on students' psychological characteristics.

We will implement the optimization of cognitive efficiency, reduce the difficulty of understanding, follow the cognitive laws of the human brain to break down abstract physical knowledge, reduce rote learning, enhance the efficiency of knowledge absorption, and fundamentally lower the perception of the difficulty of physics learning. We will implement the regulation of negative learning emotions, shape a healthy learning mindset, effectively alleviate psychological problems such as physical anxiety, fear of difficulties, and learned helplessness, enhance learning confidence, and form a positive learning mindset that is not afraid of difficult problems and dares to make mistakes. We will enforce the long-term internal learning motivation Through hierarchical task, professional associations, interesting experiments, lets the student perception of physics practical value, a change from "forced learning" to active exploration; We will implement individualized adaptation, achieve teaching based on students' aptitudes, take into account students of different foundations and learning styles, narrow the gap between the two extremes, and enable each student to have a learning experience that suits their own abilities.

Our model will address the core pain points of traditional university physics classes, such as dullness, low participation, and students' resistance to learning, and enhance classroom interactivity and students' sense of gain. Form a psychological adaptive characteristic teaching design, enrich teaching methods, and promote the reform and innovation of college physics classroom teaching; Realize the integration of teaching and mental education, and cultivate students' psychological qualities of tenacity, rationality and confidence.

However, the implementation of this teaching model is confronted with some challenges. Due to the lack of systematic psychological knowledge among teachers, it is difficult to precisely match the content of physics majors with psychological laws. The workload of teaching design is huge, and the impetus for advancement is insufficient under the dual pressure of scientific research and teaching. For students, exam-oriented thinking is rigid and they resist self-reflective learning. It is prone to breed negative psychological states such as fear of difficulties and inferiority complex.

The fourth model is that we integrate courses with information technology to implement a teaching-driven approach in college physics.

College physics contains a large number of abstract microscopic models, and traditional teaching has obvious limitations. With the popularization of modern information technologies such as digital campuses, virtual simulation, online teaching platforms, simulation software, and big data analysis of students' learning situations, information technology is no longer merely an auxiliary tool for the classroom, but a core carrier for re-configuring the teaching process and reshaping the relationship between teaching and learning. As a result, we rely on digital tools to connect the entire teaching chain before, during and after class, solving the pain points of traditional physics teaching such as difficulty in visualization, limited practice, difficulty in teaching students in accordance with their aptitudes, and closed teaching time and space, and creating a teaching model that deeply integrates college physics courses with information technology.

We will integrate the entire process and incorporate information technology throughout all teaching links, including pre-class preview, in-class teaching, physics experiments, post-class expansion, assessment and evaluation, and student situation analysis. We will build six interactive modules as follows: online pre-class self-study, offline smart classroom teaching, virtual-real integrated physics experiments, digital after-class expansion, big data multi-dimensional evaluation, and digital teacher guarantee, to form a closed-loop integrated teaching system. We will lower the threshold for understanding abstract knowledge, effectively alleviate the fear of learning physics, and enhance the efficiency of knowledge absorption. We will break through the limitations of experimental resources, enhance practical innovation capabilities, achieve personalized autonomous learning, and actively expand channels for students' independent exploration.

In terms of implementation methods, we will innovate the shortcomings of traditional college physics teaching, such as being dull, static and lacking in visualization, enrich the forms of classroom presentation, and enhance the appeal and interactivity of the classroom. We will automate data statistics, online assignment marking, and simulated automatic scoring to reduce teachers' repetitive work, allowing them to focus more on teaching design, personalized Q&A, and thinking guidance. We will form standardized teaching resources that blend online and offline, and assist in the application and construction of first-class blended online and offline courses and virtual simulation experimental courses.

However, the effective implementation of this model poses certain challenges for teachers and students. For teachers, their information technology application capabilities are insufficient, the burden of creating high-quality digital resources is heavy, it is difficult to manage the informatization of large-class classrooms, students' learning situation data cannot be deeply utilized, and there is a lack of institutional incentives. For students, electronic products are highly distracting, excessive reliance on simulation weakens their ability to make inferences, uneven software and hardware conditions, and perfunctory handling of online check-in tasks, etc.

The fifth model is that we integrate courses with innovative experiments to implement a teaching-driven approach in college physics.

There are two prominent shortcomings in traditional college physics teaching: the disconnection between theory and experiment and the single level of experimental education. Students only master basic operations and lack innovative training in problem discovery, scheme design, and independent exploration, which makes it difficult to meet the requirements of new engineering for cultivating innovative science and engineering talents. Innovative experiments are characterized by openness, inquiry and comprehensiveness, and can serve as a carrier to connect theoretical courses with the cultivation of innovation ability. Deeply integrate course teaching with innovative experiments, smooth out the entire chain from theoretical learning, basic practical operation to independent innovation, and make up for the deficiency of traditional teaching innovation cultivation.

We will break the current situation where theoretical courses are separated from verification physics experiments. We will incorporate innovative, design-oriented and inquiry-based experiments throughout the entire course process, achieving the integration of theoretical knowledge learning, basic practical operation training and innovative design practice. We will deepen theoretical understanding through innovative experiments and support experimental innovation with theories. Solve the problems of the solidification of traditional experimental procedures, the lack of space for independent exploration, and the weak innovation ability of students.

We adhere to the unity of theory and practice, providing theoretical support for innovative experiments through classroom theories, and in turn, verifying and expanding classroom knowledge through innovative experiments. We adhere to the unity of basic training and innovative exploration, and will set up experimental tasks in layers, taking into account both the cultivation of basic abilities for all students and the innovative improvement of outstanding students. We will adhere to the integration of classroom teaching and extracurricular scientific and technological innovation, and open up channels for in-class experiments, open laboratories, subject competitions, and the cultivation of major innovation projects.

The entire model consists of five major modules: pre-embedding innovative clues in theoretical classes, three-stage progressive experimental teaching, extracurricular open innovation training, multi-dimensional integrated assessment, and faculty and laboratory support, forming a closed-loop education system.

However, the implementation of this model poses certain challenges to both teachers and students. For teachers, they lack experience in guiding scientific research-based innovation, have insufficient energy in topic development and full-process guidance, and it is difficult to implement multi-process assessment. For students, reliance on standardized experiments, weak independent exploration ability, exam-oriented mentality leading to insufficient participation enthusiasm, and lack of comprehensive qualities in hands-on and data processing, etc.

3. Method and Analysis of Typical Cases

For the dual-driven teaching model of integrating five types of course teaching, our integration approach mainly involves multi-dimensional integration based on the characteristics of the subject and knowledge. The integration of science and education throughout the entire process is achieved through five organically linked modules: classroom theoretical teaching, physics experiment teaching, extracurricular scientific research expansion, assessment and evaluation system, and teacher support system. Implement a blended stratified teaching approach, adopt online push of ideological and political science popularization resources for self-study, and conduct small-class group theme discussions offline. Integrate information technology throughout all teaching links, including pre-class preview, classroom teaching, physics experiments, post-class expansion, assessment and evaluation, and student situation analysis. We will build an online pre-class self-study system and an offline smart classroom teaching system. Below, we list two example cases for illustration and analysis.

Case 1. A Teaching Case Analysis of "Solar Nuclear Fusion and Neutrino

Detection" Integrating Scientific Research, Ideological and Political Education, and Psychology in University Physics

I) Key points of knowledge and teaching objectives

Core knowledge points are the mass-energy equation, nuclear reactions, neutrino physics, and stellar energy mechanisms. We will adopt three integrated main lines to advance teaching. We integrate cutting-edge research into professional knowledge, incorporate the values of ideological and political education for the country and the family into the classroom, and use positive psychology to regulate the fear of difficulties.

Our core objectives are to require students to master the mass-energy relation and the energy release principle of light nuclear fusion; enable students to understand the solar neutrino deficit problem and the core detection principle of China's Jiangmen Neutrino Experiment; and train students to quantitatively estimate the energy production of stellar nuclear reactions using physical formulas. Students will gain a full understanding of the complete research chain of cutting-edge major scientific facilities in fundamental physics, thereby fulfilling the goal of cultivating their research literacy. Students will learn about China's breakthroughs in nuclear physics and astrophysics from following others to matching global leading levels, foster confidence in science and technology, and comprehend the strategic value of fundamental science for national energy supplies, deep space exploration, and national defense security. They will also study the spirit of scientists who have persisted for decades and overcome numerous hardships in research. These efforts serve to realize the goal of integrating ideological and political education into teaching. From a psychological perspective, the curriculum alleviates students' fear and anxiety about microscopic particles and complex nuclear physics formulas. It cultivates students' academic self-efficacy through tiered learning tasks and positive incentives, and actively guides students to develop a growth mindset that recognizes research failures as normal and breakthroughs as attainable through perseverance. This achieves the goal of integrating psychological guidance into teaching.

II) Teaching process and links

Firstly, it comes from the situational introduction of the course. We adopt a three-dimensional model featuring psychological preparation, scientific research questioning, and ideological and political foreshadowing to introduce new lessons. To address students' common psychological issues—their perception that the concept of neutrinos is abstract and their tendency to avoid learning about it—we utilize Acceptance and Commitment Therapy for psychological integration to reduce anxiety. We integrate scientific research by posing the solar neutrino missing puzzle. We then put forward the core question, "Why does the country invest huge funds to launch the Jiangmen Neutrino Experiment?" to realize ideological and political integration.

Secondly, it comes from the mainstream knowledge teaching. We guide students to derive the mass-energy equation $E=mc^2$, calculate the mass defect and released energy from the fusion of four protons into a helium nucleus, and explain knowledge points such as the generation, propagation and oscillation of neutrinos. We illustrate how Wolfgang Pauli predicted the existence of neutrinos in 1930 to account for the energy deficit in nuclear decay, introduce the two core research breakthroughs made by the Jiangmen Neutrino Experiment team, and integrate scientific research by displaying original research images. We introduce Xing Zhizhong, the chief scientist of the Jiangmen Experiment, and Zhou Shunlong's research team, who have been stationed in remote underground laboratories all year round and spent more than a decade repeatedly improving purification processes. We also talk about older generations of nuclear physicists who worked incognito in Gobi deserts and remote mountains, sticking to their mission of conducting scientific research for the motherland. Through these approaches, we integrate ideological and political education with subject teaching. We adopt differentiated instruction and cultivate a growth mindset, using tiered assignments to reduce frustration and reshape students' perceptions of failure, thus realizing psychological integration in teaching.

Finally, it comes from the tegrated exploration. Why is the Jiangmen Neutrino Experiment built 700 meters underground? A preliminary scientific research exploration on the logic of experimental design based on the principle of particle detection; We conduct ideological and political research on the contemporary value of fundamental physics by integrating it with major scientific facilities in basic physics, as well as energy security and technological competition. Combining the abstract and difficult knowledge of microscopic particles with the evasive mentality when encountering complex physical knowledge in the past, and in connection with the repeated trial-and-error experiences of scientists, this paper explores how to adjust one's own learning mindset and psychological reflection to enter the integration of teaching and psychology.

4. Summary

We conducted a questionnaire survey regarding the implementation and effects of the teaching case themed "Solar Nuclear Fusion and Neutrino Detection", with the survey results presented in **Table 1**. The survey sample consisted of 472 undergraduate students from nine classes. Statistical results show that students who had not looked up information on domestic major scientific facilities such as Jiangmen Underground Neutrino Observatory and Jinping Underground Laboratory accounted for 24.153% of the total respondents, while those who proactively searched for relevant materials made up 75.847%. Within the sample, 33.263% of students felt intimidated by the study content; a large proportion of students, accounting for 54.237%, looked forward to the learning voluntarily; 28.602% regarded the knowledge as abstract and difficult to learn, 23.941% thought it was moderately approachable despite its abstract nature, and 47.458% considered it easy to learn. Besides, 26.695% of students saw no improvement in their confidence in science and technology after the learning activity, whereas 72.881% reported enhanced confidence in this regard.

Table 1. Questionnaire on the teaching case of "Solar Nuclear Fusion and Neutrino Detection".

Class	Number of students	C1	C2	C3	C4	C5	C6	C7	C8	C9
1	55	18	37	20	33	13	10	32	19	36
2	57	11	46	21	28	16	11	30	16	39
3	49	15	34	14	26	14	15	20	12	37
4	52	12	40	17	35	18	12	22	13	39
5	45	13	32	15	27	12	11	22	11	34
6	48	14	34	18	28	13	15	20	10	38
7	58	17	41	19	23	16	13	29	17	41
8	55	16	39	17	27	15	14	26	15	40
9	53	13	40	16	29	18	12	23	13	40
Total	472	114	358	157	256	135	113	224	126	344
Percentage	100%	24.153%	75.847%	33.263%	54.237%	28.602%	23.941%	47.458%	26.695%	72.881%

Note: C1 represents the number of students who have not consulted the data of domestic major scientific facilities such as Jiangmen and Jinping, while C2 represents the number of students who have actively consulted the data of domestic major scientific facilities such as Jiangmen and Jinping. C3 is afraid of the number of students studying. C4 represents the number of students who actively look forward to learning. The number of students who think abstractions are difficult to learn in C5; The number of students who think that abstraction is easier to learn in C6; The number of students who think it is easy to learn is C7, and the number of students whose confidence in technology has not increased after learning is C8. C9 represents the number of students whose confidence in technology has increased after learning.

To sum up the above content, through relevant learning, students are able to independently explain the basic principles of energy production via solar fusion and neutrino detection, as well as distinguish between the research approaches of theoretical physics and experimental physics. Integrating scientific research into teaching has motivated most students to take the initiative to look up information on major domestic scientific facilities such as the Jiangmen Underground Neutrino Observatory and the Jinping Underground Laboratory, greatly increasing their willingness to participate in innovative physics research projects. Furthermore, ideological and political education has remarkably boosted students' confidence in domestic science and technology.

Case 2. Teaching Case Analysis of "MATLAB Simulation of White Light Young's Double-Slit Interference" Integrating Information Technology and Innovative Physics Experiments in College Physics

I) Key points of knowledge and teaching objectives

Taking physical theory as the core and MATLAB information technology as the tool, an innovative experimental system is constructed that "from theoretical derivation to numerical modeling, from simulation visualization to parameter exploration, and finally to virtual-real comparison". Digitizing the uncontrollable and hard-to-observe white light double-slit interference process enables continuous parameter adjustment, high-definition visualization of phenomena, and quantitative verification of patterns, making up for the shortcomings of traditional physical experiments and achieving a deep integration of physical principles and information technology.

Our core integration point is mainly manifested in the utilization of MATLAB's numerical calculation function to superimpose and simulate the light intensity of the red, green, and blue visible light bands of the three primary colors, to simulate the interference and dispersion effect of polychromatic white light, and to transform the abstract principle of polychromatic light interference and dispersion into intuitive color images and data curves.

II) Teaching links and processes

Firstly, during the preparation stage, we relied on the smart teaching platform to push micro-lessons on the principle of double-slit interference and formula derivation courseware, and assigned preview tasks. Master the formula for interference light intensity, distinguish the interference differences between monochromatic light and polychromatic light, familiarize yourself with the basic operation of MATLAB in advance, and clarify the core issues of experimental exploration.

Secondly, during the experimental stage, we adopt a hierarchical teaching approach that integrates information technology with experimental operations. First, for students at the basic level, we require them to complete the physical experiment of traditional laser double-slit interference, measure the spacing of monochromatic light fringes, record experimental data, and master basic experimental operations. Secondly, for the students in the advanced level, we require them to run the MATLAB code, independently modify the parameters (double slit spacing d, slit width a, screen pitch L), observe the changes in the density, color and brightness of the fringes, quantitatively verify the physical formulas, and explore the influence of the parameters on the interference phenomenon. Finally, for the students in the extension layer, we require them to respectively simulate the monochromatic laser interference and white light interference spectra, compare the differences between the two, deeply understand the physical essence of white light dispersion, and solve the key and difficult points in the class.

Thirdly, we innovate and expand students' thinking to deepen the cultivation of their digital literacy. We mainly assign inquiry tasks to students, such as modifying codes to simulate the interference effects of white light with different color temperatures and narrow-band polychromatic light. Students are required to compare physical experimental data with simulation data and analyze systematic errors. In the end, they need to complete digital experimental reports covering simulation graphs, data fitting, law summaries and other contents.

Finally, we conducted an online quiz with 8 classes of students as samples. For the convenience of comparison, students from classes 1 to 4 participated in the deep integration innovation experiment, while those from classes 5 to 8 carried out the general traditional ordinary experiment. We mainly consist of 25 multiple-choice questions, requiring students to answer them, with a total score of 100 points. The main contents of multiple-choice questions are the three primary colors of red, green and blue, as well as the light intensity and frequency in the visible light band, the principle and rule of interference and dispersion effect of polychromatic white light, the formula of double-slit interference, the formula of interference light intensity, how to distinguish the interference differences between monochromatic light and polychromatic light, and how the density of stripes, color and brightness change when the parameters (double-slit spacing d, slit width a, screen distance L) are modified? How to explore the influence of parameters on interference phenomena, and MATLAB code writing and common commands etc. We have obtained the students' online test scores, as shown in **Table 2** and **Table 3**.

Table 2. Student Test Scores after the innovative experiment of white light Young's double-slit interference simulated by deeply integrated information technology MATLAB.

Class	Number of students	D1	D2	D3	D4	D5
1	56	6	10	15	13	12
2	58	10	12	9	11	16
3	50	8	9	12	8	13
4	51	6	10	11	9	15
Total	215	30	41	47	41	56
Percentage	100%	13.953%	19.070%	21.860%	19.070%	26.047%

Table 3. Students' Test Scores after the traditional white light Young's double-slit interference experiment.

Class	Number of students	D1	D2	D3	D4	D5
5	53	18	17	7	6	5
6	52	20	12	9	5	6
7	59	26	11	11	8	3
8	46	14	13	8	7	4
Total	210	78	53	35	26	18
Percentage	100%	37.143%	25.238%	16.667%	12.381%	8.571%

Note: D1 represents the number of students scoring less than 60 points, and D2 represents the number of students scoring between 61 and 70 points. D3 represents the number of students with scores ranging from 71 to 80. D4 represents the number of students with scores ranging from 81 to 90. D5 represents the number of students with scores ranging from 91 to 100.

As can be seen from the comparison of **Table 2** and **Table 3**, the proportion of failing students who did not participate in the innovation integration experiment (37.143%) is much higher than that of students who participated in the experiment (13.953%). We can also see that the proportion of outstanding students participating in the integrated innovation experiment reached 26.047%, which is much higher than that of outstanding students in the traditional experiment (8.571%). For students in the D3 grade range, the proportion of those participating in the integrated innovation experiment reached 21.860%, while the proportion of students in the traditional experiment was only 16.667%. From the above, we can see that students who participate in the deep integration of information technology and innovation experiments have significantly improved their mastery of optical knowledge.

III) Summary

Firstly, from the perspective of knowledge, students have accurately mastered the core principles of polychromatic light interference, dispersion, and diffraction modulation interference, thoroughly clarified the differences between monochromatic light and white light interference, and significantly improved their mastery rate of optical knowledge points. Secondly, from the ability level analysis, the students master basic MATLAB simulation modeling, data visualization methods, digital physical experiment exploration ability, adaptation of new engineering compound talent training requirements. Finally, from the perspective of cultivating students' qualities, we have achieved the cultivation of students' scientific modeling thinking, quantitative analysis thinking, and innovative exploration awareness, effectively breaking the drawback of traditional physics experiments that "emphasize operation but neglect thinking".

5. Conclusions

In this paper, we have studied the teaching model of college physics that organically integrates the "five dual drives" of courses and scientific research, ideological and political education, psychology, information technology, and innovative experiments. We have found that the college physics teaching model that organically integrates courses and scientific research has broken through the inherent barriers of long-term separation between basic course teaching and scientific research, and has established an integrated education system that "imparts scientific research thinking into theoretical classrooms, replicates scientific research processes through physical experiments, extends scientific research practice through extracurricular channels, matches scientific research literacy with multiple evaluations, and provides mutual support from teaching and research staff". This model can effectively address the pain points of traditional college physics teaching, which emphasizes knowledge over ability and exam-oriented over innovation, and achieve mutual empowerment and collaborative education between basic teaching and scientific research.

We have found that the college physics teaching model that deeply integrates courses with ideological and political education adheres to the core idea of "unifying knowledge imparting and value guidance". It relies on the natural philosophical, historical and technological educational resources of the physics discipline, and has constructed a complete teaching implementation system integrating classroom, experiment, extracurricular, assessment and teaching staff. This model discards the shallow integration approach of mechanically implanting ideological and political content, achieving seamless, endogenous and full-process penetration of ideological and political elements and physics professional knowledge. It not only fulfills the teaching task of consolidating the natural science foundation of science and engineering students in university physics, but also simultaneously achieves the moral education and talent cultivation goals of patriotic education, scientific spirit cultivation, dialectical thinking shaping, and scientific and technological responsibility assumption. It is a feasible teaching model for implementing ideological and political education reform in public basic courses in colleges and universities in the new era and comprehensively improving the quality of talent cultivation.

We have found that the teaching model of college physics, which integrates courses with psychology based on theories such as cognitive psychology, positive psychology, and motivational psychology, has broken through the limitations of traditional teaching that only focuses on knowledge output and neglects the psychological acceptance laws of students. This model addresses the common problems among college students, such as fear of physics, aversion to learning, and anxiety, from the root. While imparting basic physics theories and experimental skills, it also cultivates students' rational, tenacious, and confident healthy learning psychology. This model is an effective teaching paradigm for enhancing the quality of university physics classroom teaching and implementing all-round education in the new era.

We have found that the teaching model of college physics, which deeply integrates courses with information technology, breaks through the limitations of shallow application of multimedia. It uses information technology to solve the traditional teaching pain points of college physics, such as the difficulty in abstract teaching, the limitation of experiments, and the difficulty in teaching students in accordance with their aptitudes, and realizes the blended and collaborative teaching of online and offline. This model of deep integration that takes into account the teaching of basic disciplines and the demand for digital talent cultivation in the new era is the mainstream and novel reform of the digital reform of college physics teaching in current universities.

We have found that the teaching model of college physics that integrates courses with innovative experiments breaks the disconnection between theoretical teaching and standardized verification experiments. It runs through the entire teaching process with innovative design and independent exploration. This not only adheres to the core teaching task of college physics to consolidate the foundation of natural science, but also gradually cultivates students' practical innovation and problem-solving abilities. It is an important, feasible and novel model for the reform of practical teaching of college physics in universities and the implementation of the goal of cultivating students through innovation and entrepreneurship.

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Author Contributions

Liu had overall control over the entire paper, wrote all the content of the paper and was responsible for submitting it. Cheng conducted the research and wrote some of the text. Hao reviewed the data and edited the manuscript for publication.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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