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Research on Ideological and Political Education and Practice in Advanced Fluid Mechanics Course

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Abstract: It is a strategic measure to promote the ideological and political construction of the college curriculum comprehensively. In the traditional teaching atmosphere, students' sense of mission and social responsibility may be weaker. However, by establishing a student-centered approach that is guided by professional and engineering problems, students can strengthen their theoretical foundations, enhance their sense of mission and social responsibility, throughout the learning process. For instance, stimulating students' learning motivation and help them achieve a sustainable state of development by incorporating ideological and political education elements into traditional teaching methods. Using numerical simulation of fluid motion can enrich teaching methods and improve students' interest in learning, while fluid mechanics experiments can develop students' hands-on abilities and cultivate their scientific and rigorous craftsmanship. This comprehensive approach builds a full-scale education pattern for all members that complement each other.

Keywords: Advanced fluid mechanics, Curriculum ideology and politics, Numerical simulation

1. INTRODUCTION

A new era of technological revolution and industrial transformation is rapidly advancing, triggering profound changes in the scientific research paradigm. Cross-disciplinary fusion is continually evolving, with increasing integration of science and technology with economic and social development. High-caliber research-oriented universities must integrate the development of science and technology as a primary productive force, talent as a vital resource, and innovation as the primary driver of growth. Utilizing their strengths in fundamental research and cross-disciplinary fusion, these institutions become the mainstay in basic research and a driving force for major technological breakthroughs [1]. Chinese higher education system boasts the world's largest scale and number of graduates each year. The central questions of education are what kinds of individuals to cultivate, how to nurture them, and for whom to cultivate them. The fundamental criterion for evaluating all work in universities is the effectiveness of moral education. Value-shaping, knowledge transmission, and skill-building should be integrated and inseparable [2].

In the New Era, it is crucial to continuously apply and promote the socialist ideology with Chinese characteristics for educating people. This should be accomplished through the integration of this ideology into textbooks, classrooms, and the minds of the public. The concept of curriculum-based ideological and political education should be implemented across all universities and disciplines nationwide to achieve a widespread consensus, with a clear definition of its tasks and goals. Specific requests for implementing this education in universities should also be proposed. By incorporating ideological and political education into the teaching process, students' scientific thinking and theory can be further developed, and they can be inspired to demonstrate the qualities of a great craftsman, including being hardworking, adventurous, truth-seeking, and eager to climb new heights. Additionally, students' patriotism, sense of responsibility, and mission should be encouraged, preparing them to take on challenges in the future [2, 3]. Furthermore, fluid mechanics should be elevated from "morphological theory" to the level of "mechanical theory" at the university level [4]. Huang Haidong [5] discussed the principles and practices of ideological and political education curriculum design for the "hydrodynamics" course, reflecting on the course's ideological and political education. Sun Yifang [6] proposed integrating ideology and political education into fluid mechanics course by creating a plan based on Guangdong Ocean University's fluid mechanics course, resulting in improved ideological awareness and overall student quality. Cheng Gan [7] integrated ideological and political elements into course design to achieve mutual promotion between "knowledge imparting" and "values guidance" in teaching. Hu Xuan [8] used the "Fluid Mechanics" experiment to discuss the current teaching situation of basic mechanics courses and explores ideology's concept, content, and methods in experiments. Wang Hui [9] focused on knowledge imparting as the foundation and ideological and political education as the guidance. He explored ideological and political elements in the fluid mechanics curriculum from four aspects.

2. CURRENT SITUATION AND EXISTING PROBLEMS IN ADVANCED FLUID MECHANICS COURSES

"Advanced Fluid Mechanics" is a fundamental course not only for the School of Civil Engineering but also for many STEM majors [10]. This course provides students with a strong foundation in theoretical mechanics and enhances their problem recognition, analysis, and solving skills. By taking this course, students can develop their professional competence and establish a solid base for tackling complex engineering problems. Overall, the course is beneficial for students looking to improve their theoretical understanding of fluid mechanics and enhance their practical application skills.

2.1 Unclear teaching objectives

The "Advanced Fluid Mechanics" course primarily covers topics such as fluid statics, fluid kinetics, ideal fluid dynamics, steady plane potential flow, fundamentals of actual fluid dynamics, dimensional analysis, and the principle of flow similarity. However, it comes with significant difficulties [11], such as the application of Newton's law of internal friction, Bernoulli's equation, Stokes' equation, and Euler's equilibrium differential equations. To excel in the course, students need to have a solid mathematical and mechanical foundation. The coursework entails a shift from rigid body mechanics to fluid mechanics, increasing the complexity of calculations. Sadly, the traditional teaching method still involves lecturing with PowerPoint presentations and formula derivation. This approach creates a single teaching style, making it challenging for students to overcome the course's inherent difficulties. Students may become passive in class and only devote significant time to solving practice problems ahead of the final exam. Additionally, when they encounter difficulties, they lack the courage to face the challenges. Most advanced fluid mechanics theories are contingent on certain hypotheses, which often serve as a bridge between theory and practice. Therefore, a solid foundation in advanced fluid mechanics is a must for students.

2.2 Students have a low sense of responsibility

During the advanced fluid mechanics learning process, students often lack perseverance as they tend to solely focus on passing the final exam rather than fully engaging with the course content. The syllabus is insufficient to develop industry-related talent, and there is a lack of coordinated teaching plans for professional education and its corresponding industries. Additionally, there is little connection between the subject and scientific research, and a bridge has yet to be established between students' theoretical foundations and social responsibilities. There is a lack of synergy between ideological and educational aspects in the cultivation of applied talents, and the mechanism for talent cultivation and industry integration is not adequate. Currently, various principles and requirements have not been fully implemented in talent cultivation and classroom teaching.

3. KEY ASPECTS AND METHODS OF COURSE-BASED IDEOLOGICAL AND POLITICAL EDUCATION

3.1 Establishing a new teaching system

The current traditional teaching approach in higher fluid mechanics relies heavily on teacher-led lectures and the use of formulas as an aid. However, to enhance students' proactivity in learning, it is necessary to introduce innovative teaching methods that include ideological and political education within the curriculum. Such an approach can help students to establish a noble outlook on life and values, enhance their humanistic literacy, and promote their sustainable development. It can develop an educational model that combines moral education with ideological and political education. This model aims to strengthen students' sense of responsibility towards society, the country, the Communist Party and the people, thereby increasing their political, ideological, and emotional identification with the innovative theories of the Party and the country. This approach also aims to bolster their confidence in China's unique path of socialism, theoretical self-confidence, institutional self-confidence, and cultural self-confidence, while cultivating their qualities of innovation and perseverance.

The key teaching methods in the teaching system is shown in Figure 1. The objective is to enable students to clarify their life goals, establish lofty ideals, and stimulate their motivation for learning. Ultimately, it is expected that students can reach a state of sustainable intrinsic motivation. Moreover, students' sense of social responsibility is expected to be improved, which is crucial in achieving the goal of moral education in higher education.

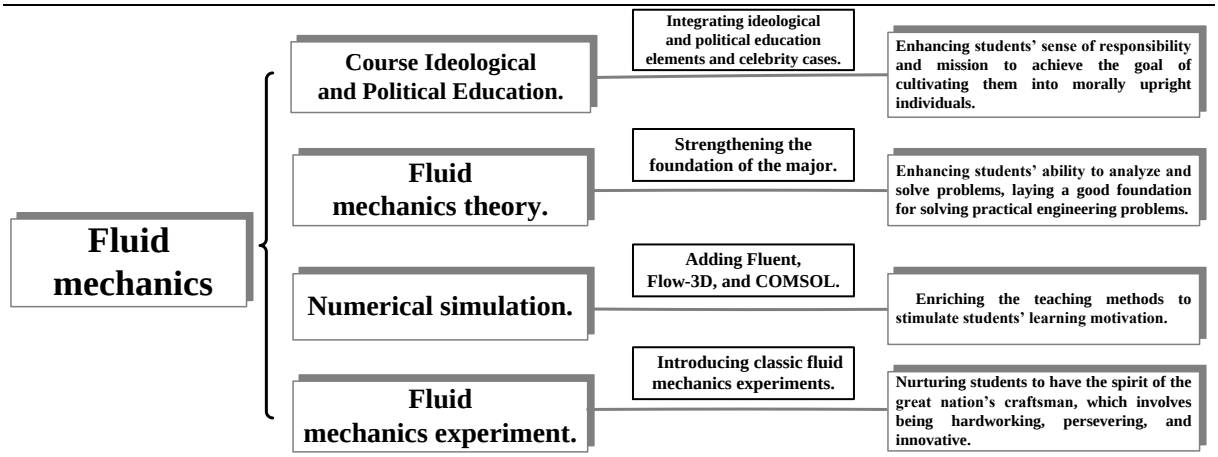

Fig. 1 Key Teaching Methods in the Teaching System

3.2 Enrich the teaching methods

To supplement traditional teaching methods centered around teaching and textbooks, numerical simulation and fluid experiments are introduced. In recent years, Computational Fluid Dynamics (CFD) has been developed, which combines advanced fluid mechanics, numerical mathematics, and computer science [12]. CFD software can be used to present fluid state diagrams and obtain fluid-related data such as velocity, fluid pressure, volume fraction, angular velocity, etc. In advanced fluid mechanics courses, students are given the opportunity to choose their preferred direction and perform numerical simulations. This provides them with a better understanding of the complexity of fluid motion, and the impact of variations in numerical simulation parameters which require mathematical and physical models. The goal is to deepen students' understanding of advanced fluid mechanics and bring them closer to the essence and core concepts of the subject. Through diverse teaching methods, we aim to unleash students' potential and ignite their motivation to allow for a multidimensional and varied appreciation of the beauty of fluid motion.

Universities have various types of experimental equipment available for students to use. By combining theory and experiments, students gain firsthand experience of the impact of various factors and errors in the experimental process, which deepens their understanding of the complexity of the causes behind engineering problems. Scientific research aims to combine theory and practice, tap into students' potential for scientific and technological innovation, enhance their sense of social responsibility and mission, cultivate their spirit of hard-working and, innovation, as the national craftsmanship, who contributes to building a great nation.

3.3 Strengthen professional expertise

Strengthening students' professional expertise is an essential aspect, considering the remarkable history of advanced fluid mechanics. For instance, during the management of the Sui and Tang Grand Canal, the ancient practice of using wooden banks to narrow the river was proposed to aid the dredging process. In 1316 AD, the "copper kettle drip" was invented, which utilized the flow from a hole to measure the change in the water level in a copper kettle to calculate the time. Archimedes' principle, explains the fundamental principle of buoyancy for objects in a fluid medium. Newton studied the laws of motion for objects in a damped medium and proposed the law of fluid friction. Additionally, Bernoulli equation provides the systematic description of the mutual conversion between potential energy, pressure energy, and kinetic energy of fluid. Moreover, Euler's continuous medium model for fluid provides a general analytical method for incompressible fluid motion. Lagrange enriched the analytical methods for fluid motion by proposing a differential equation for advanced fluid mechanics, which differs from Euler's. Incompressible viscous fluid motion's differential equation was initially proposed by Navier, and later, Stokes derived this set of equations more rigorously, later known as the N-S equations. The existence of laminar and turbulent flow states in viscous fluids was experimentally verified by the British physicist Reynolds, who proposed the critical Reynolds number as the criterion for distinguishing between these two flow states.

The goal is to enhance students' awareness of social responsibility and achieve comprehensive, full-process, and all-round education. According to statistics from the Yellow River Conservancy Commission, the downstream of the Yellow River has experienced approximately 1,500 flood breaches in the past 3,000 years [13]. The breach of the Yellow River in 1642 and the tragic sight of the soil layer at the Bianhe river site bears witness to the devastating effects of such events. Incidents in coal mines resulting in loss of life and property damage caused by water inrush or seepage also serve as constant reminders. By exploring historical and modern

engineering cases in China and the history of advanced fluid mechanics, it is expected to inspire students' reverence for the scientific spirit, cultivate their rigorous scientific research and craftsmanship, enhance their sense of responsibility, and improve their cultural and national confidence. Using negative examples to promote engineering theory education which is useful, to inspire students' sense of social responsibility and mission, as well as to cultivate their strong professional ethics. The subject class time allocation is shown in Figure 2.

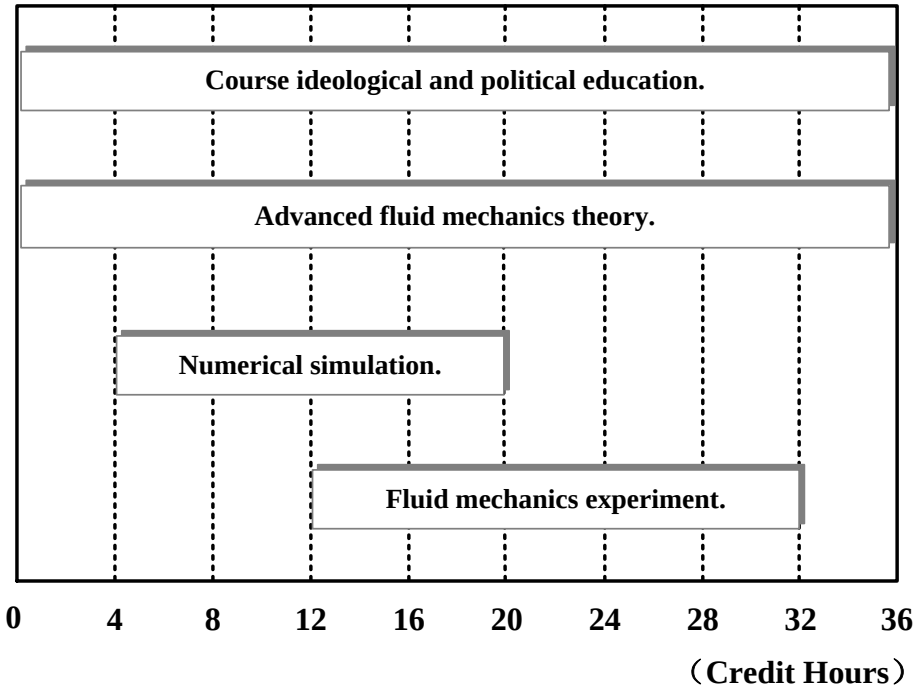

Fig. 2 Subject Class Time Allocation

4. CONCLUSION

This proposal aims to combine advanced fluid mechanics education with ideological education in innovative ways, resulting in outstanding results. The course design naturally integrates ideological elements into advanced fluid mechanics theory, cultivating graduate students' dialectical and unified thinking. This approach aims to achieve both teaching and educating, guiding students to understand global situations, national conditions, Party's concerns, and people's aspirations. Students are instilled with the great ideals of "taking the world as one's own duty" and "ordaining conscience for Heaven and Earth; securing life and fortune for the people; continuing lost teachings for past sages; establishing peace for all future generations." This approach ultimately leads to sustainable development of oneself. By introducing engineering problems and combining numerical simulation with advanced fluid mechanics education, students can personally experience the wonders of fluid motion during the learning process. The presentation of fluid states through numerical simulation parameter settings closer to the ideal state provides students with a more intuitive experience, and increases interest in the classroom. The proposal suggests introducing advanced fluid mechanics experiments, adopting a student-centered and problem-oriented teaching model and, emphasizing the teaching focus and difficulties. This allows students to select research topics, analyze and independently collect relevant information, and analyze and solve problems related to the topic.

The proposed approach aims to build a solid theoretical foundation, improve students' ability to discover, analyze, and solve problems. It also aims to enhance students' innovative ability, to realize the combination of theoretical derivation and experimental verification. and cultivate their spirit of connecting theory with practice and pursuing the truth. By exploring the life and achievements of renowned pioneers in fluid mechanics, it is expected to inspire our students to cultivate a patriotic and great country craftsman spirit. Through negative examples, the author urges students to uphold a scientific and rigorous approach to engineering projects while fostering their admiration for the scientific spirit. The ultimate aim is to kindle their passion for learning that empowers them to take charge of their education and enjoy the process.

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