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Article

The Development and Teaching of the Postgraduate Course "Engineering System Modeling and Simulation" in Combination with Essentials Taken from Research Projects

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Abstract: This teaching research paper presents a novel idea that combines fundamental scientific problems in practical engineering with the construction of the "Engineering System Modeling and Simulation" course. A large amount of mathematical modeling, numerical simulation, 3D entity modeling, finite element simulation, and analysis used to obtain the research results of our scientific research projects is fed back and integrated into the teaching content of the Engineering System Modeling and Simulation course. The content system of this course is based on the Harbin Institute of Technology (HIT) aerospace engineering course and embodies the values and characteristics of HIT. It is constructed to meet the requirements of the "Ten Special Actions to Accelerate the Training of High-level Talented Person" focused on by the Ministry of Education and the Academic Degree Committee of the State Council. The research results and implementation of the current work are expected to produce pedagogical benefits for the training of postgraduate students in mechanical engineering and promote the understanding and mastery of basic and professional knowledge. At the same time, this course can also enhance students' research ability, engineering ability, thinking ability, and innovative consciousness.

Keywords: postgraduate education; course construction; engineering systems; modeling and simulation; scientific research project

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1. Introduction

System modeling and simulation are essential in engineering [1,2]. The postgraduate course, "Engineering System Modeling and Simulation", is a core degree course for postgraduate students of the School of Mechatronics Engineering at HIT. It aims to teach postgraduate students to comprehensively apply system modeling knowledge and simulation skills. With the complexity of engineering systems, postgraduates must apply advanced problem-solving skills to model complex systems [3] to follow the trend of scientific and technological development and the promotion of the progress of national defense science and technology, which has led to "Engineering System Modeling and Simulation" becoming particularly important. Reference [4] draws on and applies Australian understanding of effective teaching to examine the concept of effective teaching. This paper argues that it is very important for teachers to introduce theoretical concepts by citing practice in the classroom; that is, practice verifies theory. The "Engineering System Modeling and Simulation" course promotes the development of students' modeling practice and systems thinking [5]. College educators have focused on cultivating science and engineering students' scientific thinking for decades [6]. Thus far, this course has trained more than 2100 students for China's academies of aeronautics, astronautics, and national defense. There were 192 students taking this course in 2019. The course covers a wide variety of specializations, including mechanical and electrical engineering, mechanical design and theory, aerospace manufacturing engineering, fluid machinery and engineering, power machinery and engineering, mechanical manufacturing and automation, and control theory and engineering. This Engineering System Modeling and Simulation course has cultivated excellence in students who have gone on to participate in China's aerospace and national defense undertakings.

"Engineering System Modeling and Simulation" is an efficient engineering discipline. System modeling plays a crucial role in representing a complex system and analyzing interactions between its components or with other systems [7,8]. Indeed, building models is a well-recognized way of understanding the world by utilizing system simplification. Simulation is a particular type of modeling wherein we experiment with a model and not with a phenomenon [9]. With the continuous development of scientific and technological progress, educational reform, and discipline construction, there are precise requirements for deepening the reform of this course. With China's emphasis on industrial education, the course team urgently realized that course reform needs to integrate the latest scientific research achievements and technological frontiers into the course teaching system [10–12]. Shenyang University has studied the teaching system of the "system engineering" course from the perspective of system optimization thinking and the promotion of information engineering technology. By analyzing the teaching focus, the difficulties and solutions of the course, and the target determination and knowledge model constitution, a teaching system involving systematic thinking has been formed. By strengthening practical teaching, the system's ability is improved to solve enterprise problems in developing industrial engineering talent [13]. The literature [14] points out that practice teaching is the most important link to cultivate the practical ability of students. Studying on the spot can deepen students' understanding of foundational engineering and help them understand concepts more intuitively. Teachers should combine theoretical knowledge with engineering practice, design teaching content in a targeted manner, and find teaching methods suitable for developing the subject. Sun [15] used virtual reality technology integrated with teaching. This immersive interactive technology was applied to animation teaching so that students could intuitively develop a deeper understanding of their major. Instructor Rahul Dave [16] from Harvard University taught an applications course, highlighting software engineering and computer science use in solving scientific problems in actual engineering situations. Levent Sevgi [17] introduced a course outline for teaching electromagnetic modeling and simulation, and put forward the teaching process. The teacher and the students explore problems in class simultaneously, making it easier for students to understand theoretical knowledge in depth. The University of California, Berkeley, offers a dynamics course that introduces and investigates Lagrange's equations of motion for particles and rigid bodies, as well as a course called MATLAB for Programmers. These two courses cover the establishment of mechanical and mathematical models of real engineering systems and numerical analysis of these models. Each course involves in-depth teaching, but lacks the connection between analysis and real engineering [18]. The University of Cambridge offers a course called Mechanical Vibrations, which teaches how to mathematically describe and analyze the behavior of simple mechanical vibrating systems [19]. In addition, Nanyang University of Technology also offers a course on system simulation and modeling, which covers simulation model-building aspects of discrete systems in detail and demonstrates how computer simulation can be used to successfully model, analyze, and improve systems under study [20]. The current teaching methods demonstrated in postgraduate courses face several challenges: (1) How do we broaden the way of thinking further and integrate theory with practice? (2) How do we promote the development of students' research abilities and engineering thinking? (3) How do we stimulate students' practice and innovation potential? Kember and McNaught [21] proposed ten principles of effective teaching and provided a clear description of the methodology used to determine them. Moreover, based on our many years of experience in the practice of research and talent training, we realized that the implementation process of scientific research projects often includes mathematical modeling, numerical simulation, numerical analysis, 3D solid modeling, and finite element analysis. This content comes directly from vivid cases and materials of scientific research practice. These can provide rich materials for course reform and play an essential role in cultivating postgraduate students' ability to solve complex engineering problems.

Furthermore, the current movement toward instruction focused on "student learning" rather than "teacher teaching" is making headway. It aims to reshape teaching content and reform teaching methods based on the fundamental task of moral education and cultivating people.

Given this, this paper proposes to use the "Engineering System Modeling and Simulation" course to explore fundamental scientific problems in practical engineering. It aims to form a unique course teaching method based on the characteristics of HIT. We are dedicated to intuitively and vividly visualizing modeling, simulation, and system theory, all which seem very abstract. The goal of this course is to cultivate students' abilities in mechanical structure design, finite element method (FEM) simulation and analysis, mathematical modeling, experimention, and control system design, while also revealing their creative potential and broadening their thinking and vision. This course aims to cultivate excellent students from HIT by arousing students' interests, improving teaching effects, and stimulating students' potential.

2. Integration of Project Research Results in the Construction of the Course

2.1. Scientific Research and Achievements Related to "Engineering System Modeling and Simulation"

In the past ten years, our teaching team for this course has constantly been thinking, tracking, seeking feedback, and improving the training goals and positioning the course within the process of talent training, making the course system relatively complete and practical. E. K. Wati and N. Widiansyah [22] claim that using instructional media can support the teaching and learning process. Designed system and simulation models can be used as learning media to improve student learning outcomes. Accordingly, we can methodically teach the seven stages of system modeling inquiry: problem recognition, system conceptualization, model representation, model behavior, model evaluation, policy analysis, and model use [23]. After several years of practice and exploration, mathematical modeling, numerical simulation, 3D modeling, finite element simulation, and other technologies have been applied to each scientific research project. Some achievements have been made and several stable scientific research directions have been established, which are described as follows:

(1) We are committed to studying ultrasonic vibration wire drawing, including ultrasonic transducer and transducer array design theory, ultrasonic wire-drawing technology of hard-to-draw materials such as titanium and titanium alloy wire, contact mechanics and tribological applications, and the contact failure mechanism. Figure 1 illustrates 3D models of the ultrasonic vibration wire-drawing system and a finite element simulation and experiment of the wire-drawing process. The oscillator mainly comprises a piezoelectric transducer and a stepped amplitude transformer. The ultrasonic wire-drawing structure of the composite ultrasonic vibrator can improve quality. Students need to consider the staggered angle of the oscillator distribution and the phase difference of the coupling effect of multiple ultrasonic oscillators when establishing a mathematical model of a composite ultrasonic oscillator, which helps in developing their mechanical structure design and mathematical modeling abilities. The influence of structural parameters and input signals on the pull-out force can be analyzed through FEM simulation, and the correctness of the theoretical analysis can be verified.

This study has been supported by the National Natural Science Foundation of China. In the course, we introduce the mechanical structure of the ultrasonic transducer, carry out its mechanical simplification, and conduct mathematical modeling and analysis so that students can understand the modeling and analysis methods of the ultrasonic vibrator. In addition, interested students can also join our research group to assist the doctoral students in conducting physical research.

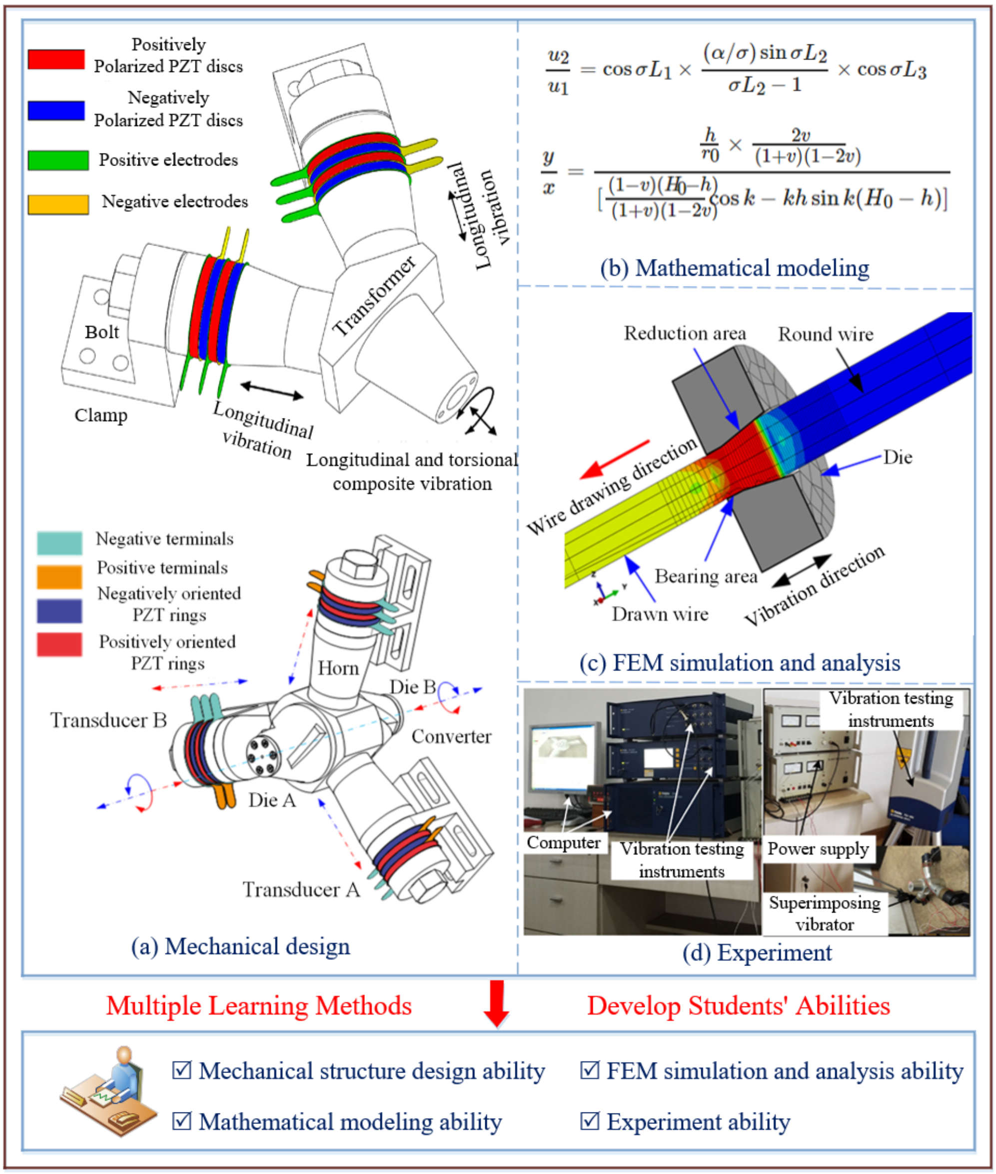

Figure 1. Three-dimensional models of the ultrasonic vibration wire-drawing system and finite element simulation and experiment of the wire-drawing process [24,25].

(2) We are committed to carrying out research on aerospace simulation and inertial test equipment, multi-degree-of-freedom simulation turntables, structural optimization design based on dynamic characteristics, space motion trajectory analysis, and virtual simulation technology. We have developed a variety of pieces of aerospace simulation equipment, including load torque simulators, two-axis turntables, vertical three-axis turntables, high–low-temperature three-axis turntables, three-axis servo turntables, six-DOF systems, and nine-DOF motion simulation systems. These developments have significantly contributed to the national scientific and technological progress.

Figure 2 shows a 3D model of a three-axis simulation turntable for aircraft attitude simulation. In the course, students design the overall scheme of the motion control system based on the performance indicators of the turntable control system, and select and design the system's controller, motor, motor driver, high-precision encoder, and communication methods. They also continuously analyze the feedback signal through adaptive control technology, and adjust the turntable to work in the optimal state according to the set threshold. From design to processing, sufficient documents and learning processes on these turntables are available for interested students to reference. Some students have completed their master's projects based on this subject, demonstrating that they can skillfully complete the modeling and analysis of the turntable.

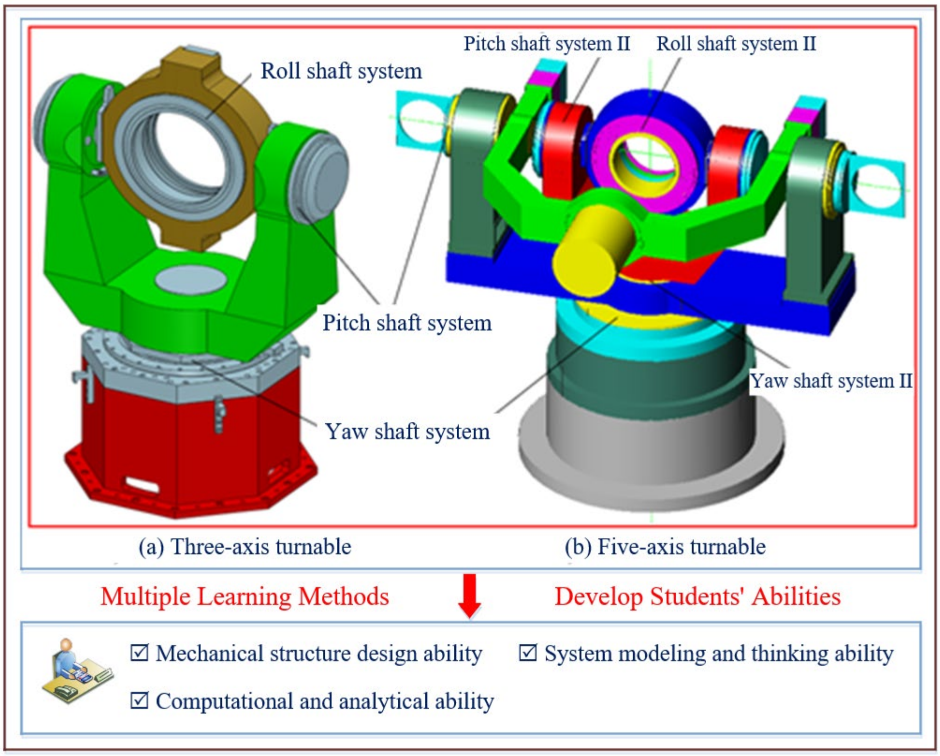

Figure 2. Three-dimensional modeling of multi-axis simulation turntable for aircraft attitude simulation.

(3) In the field of intelligent robot technology, in view of the goal of "larger size, thinner thickness" proposed by the LCD panel industry and the higher demand for the performance of handling robots, we study the critical technologies of intelligent handling robots that deal with large glass substrates in clean environments, as shown in Figure 3. The project has been supported by The National Key R&D Program of China under grant No. 2018YFB1308500.

The students establish the dynamic model of the six-degree-of-freedom handling robot and optimize the system's structural design with the help of finite element simulation analysis. It is necessary to suppress the vibration of the cantilever beam in its hand for the robot actuator to transport the LCD panel smoothly. The students use different vibration suppression methods to design and complete their vibration suppression control system.

(4) In the field of energy-harvesting technology, we are committed to studying piezoelectric control theory, fluid-induced vibration energy harvesting theory and technology, the optimization design of energy harvesting systems, and the application and development of energy-harvesting technology. Figure 4 shows a schematic diagram of the 3D modeling and multi-physical field coupling mathematical modeling and numerical analysis of a fluid-induced vibration energy-harvesting system. This research has been funded by the National Natural Science Foundation of China under grant No. 51677043. The piezoelectric energy-harvesting structure is a common beam vibration model; thus, it is explained to students as a primary example in the course. The course contents are explained in detail by combining mechanical models, mathematical models, experimental research videos, and some physical displays. With these methods, students' abilities in structural design, FEM analysis, mathematical modeling, and experimental operationare cultivated.

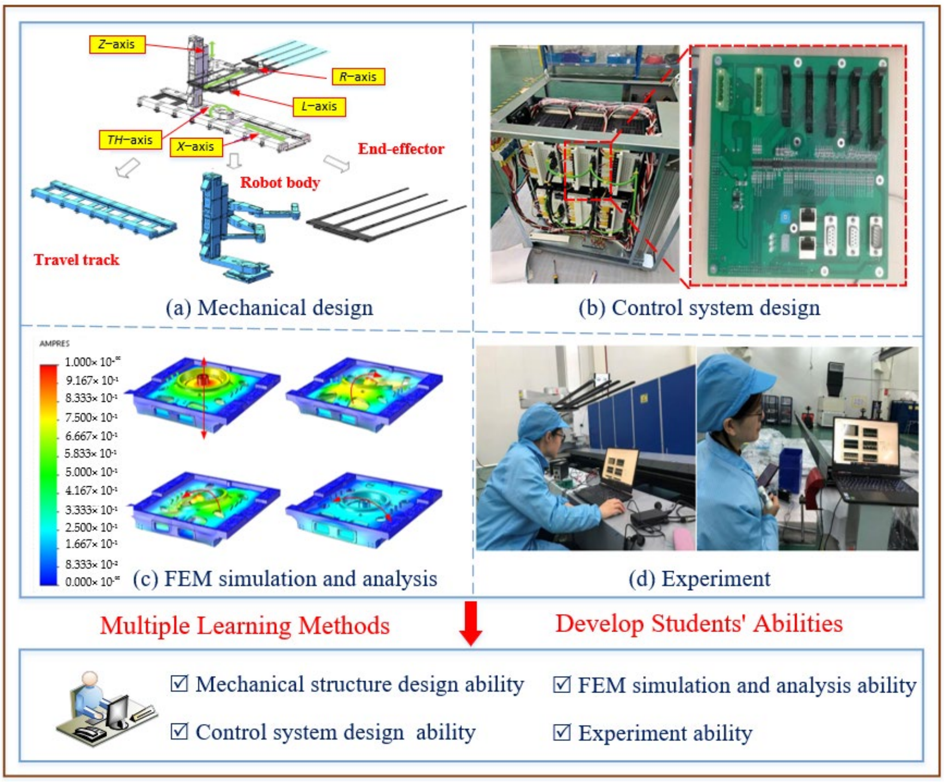

Figure 3. Three-dimensional modeling for structure design of a high-speed intelligent handling robot [26].

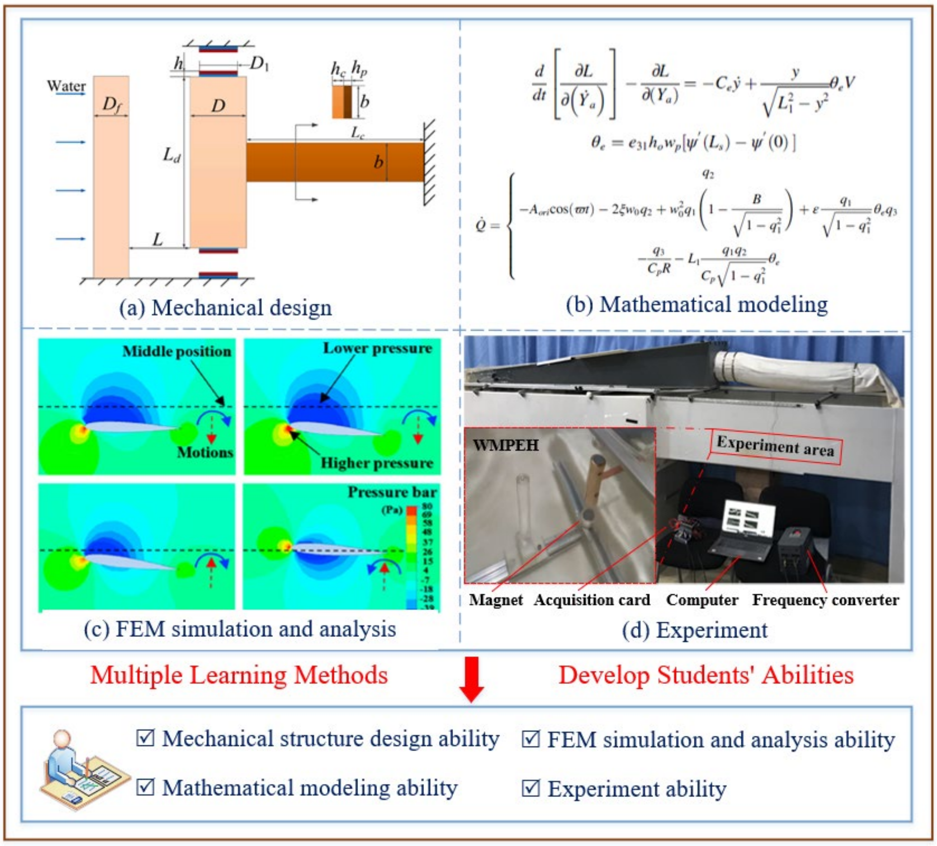

Figure 4. Three-dimensional modeling, multi-physical field coupling mathematical modeling, and numerical analysis of vibration-induced energy-harvesting system [27,28].

The research process of each project mentioned above includes mathematical modeling, numerical simulation, 3D modeling, and finite element simulation. Thus, modeling and simulation have been effectively integrated into the classroom teaching of the Engineering System Modeling and Simulation course as engineering examples. These examples cover simple to complex practical engineering structures. By simplifying the mechanical model of these structures, students can clearly and intuitively experience the simplification process of the model. The results from building and analyzing the mathematical model can also be compared with the results of the experiment, allowing students to more clearly understand how to complete the modeling and analysis and recognize the problems and ideas of the modeling process, which will help improve students' modeling ability. At the same time, through these relatively new research directions, students can understand the direction of current scientific research developments and learn how to complete scientific research earlier and more intuitively, which is very helpful for students' subsequent development. Over the course of teaching for many years, the authors have found that in this way, the completion of students' after-class experiments and course assignments is also far better than that under previous teaching methods. Therefore, these examples can enrich classroom content and broaden the thinking and vision of postgraduate students [29], improve professional skills, and lay a solid foundation for talent training. In the teaching process, we adopt the 5E teaching model. The 5E teaching model, as described by Rita Tavares et al. [30], is related to each phase of the model: engagement, exploration, explanation, elaboration, and evaluation.

2.2. The Implementation Approach for Course Construction

For the course system construction process, we propose the concept in which the HIT's unique Engineering System Modeling and Simulation course uses teaching objectives that integrate scientific research projects into the course's education content. Theoretical research and practical application are combined in parallel. By constructing the course as the main line, we can improve the course objectives, teaching system, teaching content, teaching model, and comprehensive innovation experiments. Figure 5 shows the implementation approach for constructing the unique Engineering System Modeling and Simulation course system of HIT.

As shown in Figure 5, after an analysis of the policy that drives the cultivation of high-level graduate talents in China, the Engineering System Modeling and Simulation course can be constructed to create distinctive course content and achieve the goal of teaching content that is a combination of theoretical and practical teaching. Specifically, a new curriculum content system can be formed through the design and integration of comprehensive innovation experiments. If the teaching content is approved, it will be combined with scientific research to develop the teaching content and the innovative design of comprehensive innovation experiments. Students' logical thinking ability is trained through the establishment of mechanical and mathematical modeling, and the ability to use scientific research software is improved through 3D solid modeling, finite element simulation, and analysis of engineering systems. If the teaching content is not approved, new theoretical knowledge will be added, some old theoretical knowledge will be cut out, and the curriculum teaching model will continue to be improved from the selected teaching content as a breakthrough point. When the teaching content is approved, the research and practice of the teaching method will be carried out, and the course content will be further improved and optimized through the evaluation of the teaching operation effect. If the teaching evaluation shows that it is not satisfactory, the construction of the Engineering System Modeling and Simulation course content will continue to be improved by studying measures to improve satisfaction. However, if the teaching evaluation shows that it is satisfactory, then the new course system and teaching methods of the Engineering System Modeling and Simulation course may be implemented, and the goal of collecting Engineering System Modeling and Simulation course content feedback and the integration of science and education will be achieved. Additionally, the teaching objectives of the

Engineering System Modeling and Simulation course with HIT characteristics will be met, effective teaching models and methods will be proposed, and a complete teaching content construction theory and method will be formed, which will improve the teaching theory of the course. This will have a positive significance in improving teaching methods.

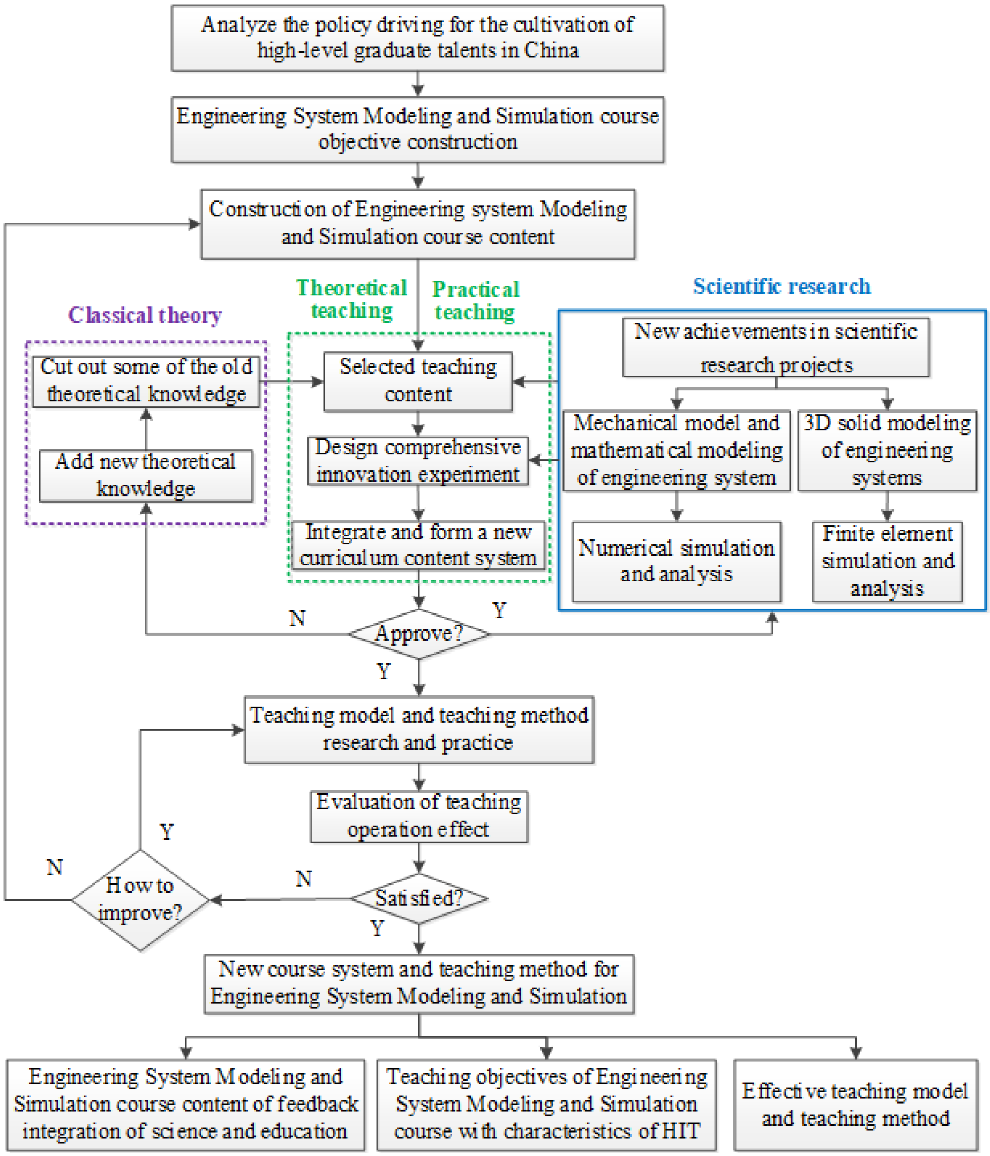

Figure 5. Implementation approach for course construction.

The specific implementation paths and methods of course construction are as follows:

(1) Teaching objective planning of the Engineering System Modeling and Simulation course with HIT characteristics.

(a) Emphasize the close connection between the Engineering System Modeling and Simulation course and the current national education and training objectives for postgraduate students.

(b) Identify the characteristics of postgraduate students, the needs of society, the development direction of the discipline, etc.

(c) Clarify the teaching purpose of each knowledge point in the course, and establish the goals of knowledge-building, gaining skills and abilities, and practical application experience that postgraduate students need to achieve.

(d) Combine teaching about the background of aerospace and high-end equipment industry needs and theory with practice to cultivate students' ability to analyze and solve practical problems, as well as to develop their innovation ability.

(e) Enforce the relationship between theoretical and practical teaching, attaching importance to cultivating postgraduates' practical ability and innovation ability through practical teaching. Enhance the ability of postgraduates to adapt to social competition. Finally, combine the characteristics of HIT with the practical course objectives. Figure 6 shows the course teaching objective planning. The details are as follows:

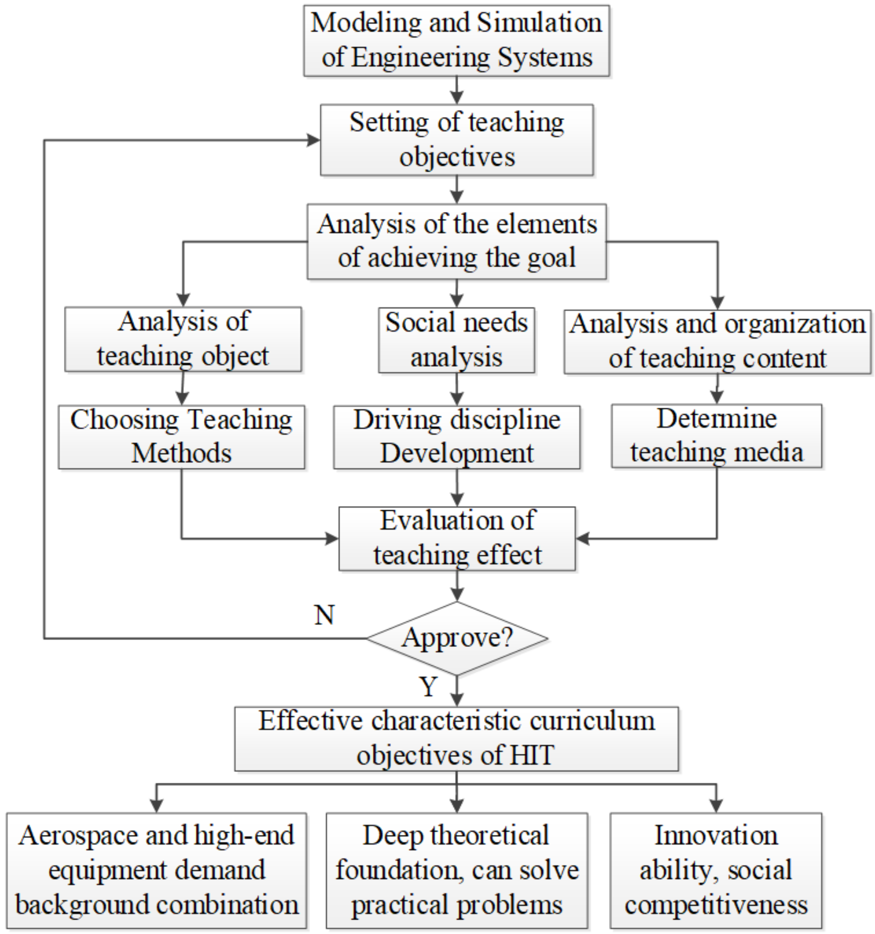

Figure 6. Course teaching objective planning.

(2) Teaching content construction of the Engineering System Modeling and Simulation course is based on science and education integration.

Figure 6 is a planning diagram of the teaching objectives of the course. We can select the teaching method by analyzing the course subjects and determining the subject development and teaching media that combines social needs and teaching content. A curriculum with HIT characteristics is formed by perfecting the formulation of teaching objectives. Combined with a background in aerospace and defense needs, the program aims to develop outstanding students who can solve real problems and be innovative.

According to the course teaching objectives established above, research and teaching resources should be established through the specific process described as follows:

(a) Refine the latest research results of scientific research engineering projects, including mathematical modeling, numerical simulation, 3D solid modeling, and finite element simulation. Figures 7 and 8 show the practical operation training and teaching diagrams of engineering system mathematical modeling and numerical simulation, 3D solid modeling, and finite element simulation.

(b) Select the teaching content and construct the knowledge point frame.
(c) Refine the classroom teaching points.
(d) Clarify critical points and difficulties.
(e) Define how students learn in and after class.

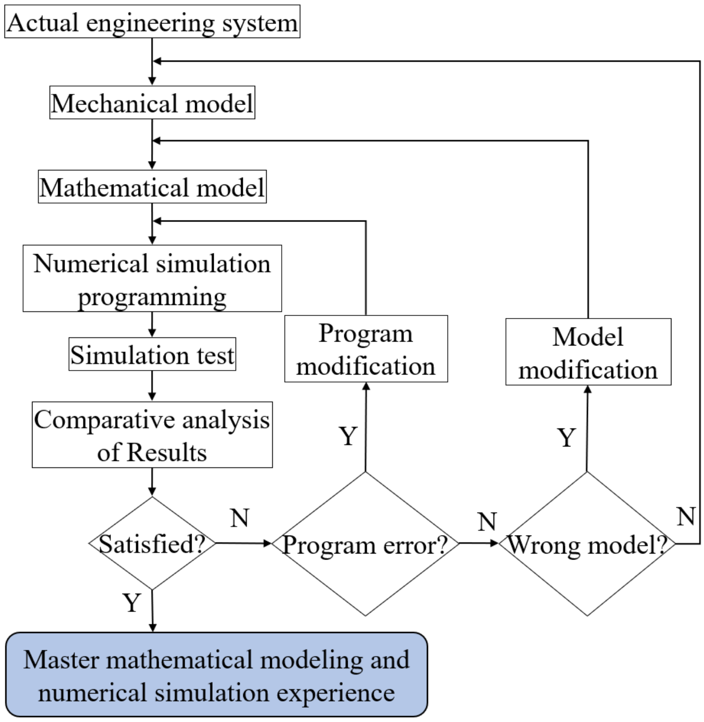

Figure 7. Schematic diagram of practical operation of teaching an engineering system with mathematical modeling and numerical simulation.

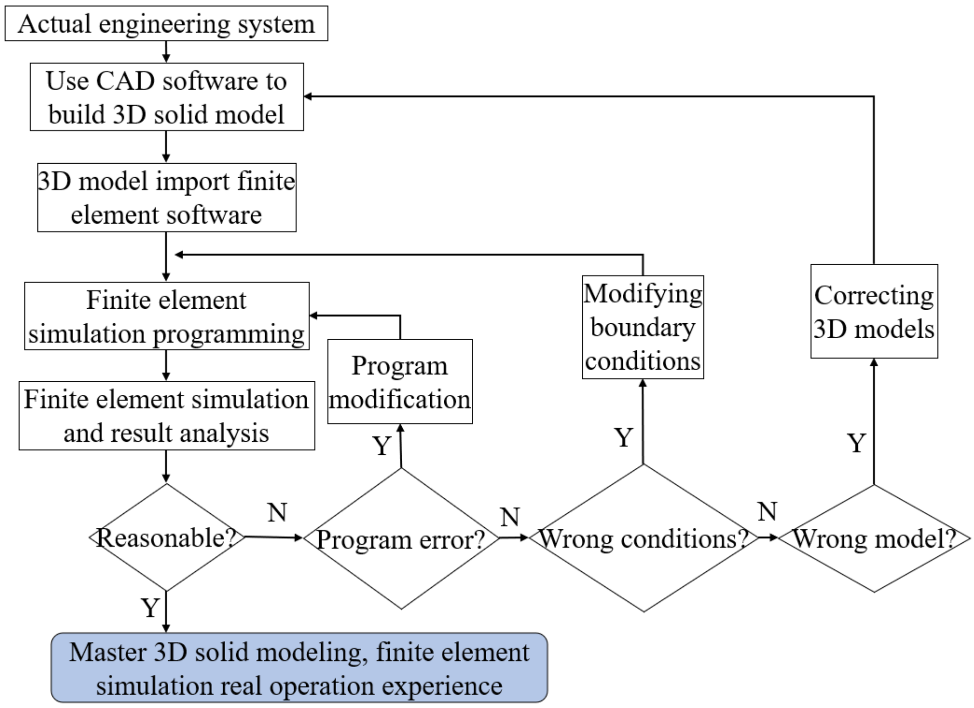

Figure 8. Schematic diagram of practical operation of teaching an engineering system with 3D entity modeling and finite element simulation.

Figure 7 shows a schematic diagram of the practical operation of teaching an engineering system with mathematical modeling and numerical simulation. Students first build a mechanical model of a specific actual engineering system. The direct relationship between mechanical models is described using mathematical modeling. The numerical calculation method is used to analyze the influence of each parameter variable of the mathematical model on the system. If it conforms to the changing law of the actual engineering system, it means that the establishment of the mechanical and mathematical models is correct. If the numerical simulation results are very different from those of the actual problem, it is necessary to check the mathematical programming and the mechanical model and carefully modify them until they are correct.

Figure 8 shows a schematic diagram of the practical operation of teaching an engineering system with 3D entity modeling and finite element simulation. Students first build a 3D model of their actual engineering system using CAD software and carry out finite element simulation analysis on the model according to different simulation requirements, different solvers, or if they need to write finite element simulation programs. If the finite element simulation analysis results conform to those of the actual engineering system, it means that the finite element simulation settings are correct. If the result is not correct, the finite element simulation program or the boundary condition setting needs to be checked, and what is incorrect needs to be carefully modified until it is accurate.

3. Comparison, Analysis, and Discussion

System modeling and simulation technology has been widely used in aerospace, information, biology, materials, energy, advanced manufacturing, high-tech and industrial, agriculture, commerce, education, military, transportation, social, economic, medical, entertainment, and life services fields, among others. Engineering System Modeling and Simulation is an essential course for postgraduate students majoring in mechanical and electronic engineering, mechanical design and theory, and mechanical manufacturing and automation. Through the study of this course, students can further understand and master the advanced theoretical methods of mechanical engineering and improve their ability to solve practical engineering problems. It also enables students to broaden their scientific horizons, exercise new ways of thinking, and enhance their understanding of the laws of the objective world and their ability to innovate.

Its advanced theories and methods are powerful tools for analyzing problems in complex mechanical systems. The subject also provides favorable guidance and theoretical support for studying mechanical design theory, mechanics, measurement and control technology theory, 3D modeling technology, finite element analysis, experiments, etc. For education in the field of dynamics of mechanical systems, courses such as Mechanical Vibrations, Mechanical System Dynamics, Mechanical and Electrical System Dynamics, Finite Element Theory, and System Identification have developed quite mature theories and a variety of teaching materials. As for Engineering System Modeling and Simulation, there are few books and studies and no content systems suitable for this course. Owing to the fact that most theories and methods in this course relating to mechanics theory, control theory, computational theory, and experimental technology were developed in the 1960s, their theories and research methods are scattered across the literature, which is not convenient for teaching. In addition, we checked the postgraduate courses related to Engineering System Modeling and Simulation offered by the top nine universities, with the results of the fourth round of the mechanical engineering discipline evaluation being A and A+ (see Table 1). Disciplinary evaluation is the overall evaluation of the first-level disciplines with the right to confer doctoral or master's degrees nationwide in accordance with the Academic Degree Committee of the State Council and the Ministry of Education's "Catalogue of Disciplines for Degree Granting and Talent Training", which is issued by the Academic Degrees and Postgraduate Education Development Center of the Ministry of Education.

According to our analysis of Table 1, we found that colleges and universities with a discipline evaluation of A or A+ are the top universities in China's machinery specialty.

These colleges and universities all offer relevant courses, but their course names and content systems are different, and each has its own style. Through consulting the relevant teaching plans and watching the open courses, we can see that many courses are mainly based on abstract theoretical knowledge teaching and supplemented by a small amount of experimental teaching.

In addition, we also summarized and analyzed the Top 10 universities in the 2022 QS World University Rankings for Mechanical Engineering and their content-related postgraduate courses, as listed in Table 2.

Table 1. The universities that received A and A+ results in the fourth round of national mechanical engineering discipline evaluation and the content-related postgraduate courses offered [31].

No.	University in China	Assessment Results	Relevant Postgraduate Courses
1	Tsinghua University	A+	Dynamic Testing and Analysis of Mechanical Systems; Vibration Theory
2	HIT	A+	Engineering System Modeling and Simulation
3	Shanghai Jiao Tong University	A+	System Modeling and Simulation
4	Huazhong University of Science and Technology	A+	Dynamics Analysis and Control of Electromechanical Systems; Mechanical Vibrations
5	Beijing Institute of Technology	A	Analysis and Test of Dynamic Characteristics of Mechanical Systems
6	Tianjin University	A	Mechanical Dynamics
7	Dalian University of Technology	A	Mechanical Dynamics
8	Zhejiang University	A	Modern Testing Techniques
9	Xi 'an Jiaotong University	A	Modern Testing Techniques; Analysis Theory and Control Technology of Mechanical Vibration Engineering

Table 2. The top 10 universities in the QS World University Rankings for Mechanical Engineering 2022 and their content-related postgraduate programs [32].

No.	University	Country	Relevant Postgraduate Courses
1	Massachusetts Institute of Technology	United States	Modeling and Simulation of Dynamic Systems
2	Stanford University	United States	Dynamic Systems, Vibrations and Control; Advanced Dynamics, Controls, and System Identification
3	University of Cambridge	United Kingdom	Mechanical Vibrations
4	Harvard University	United States	Mechanical Systems
5	Delft University of Technology	Netherlands	Dynamics of Structures; Dynamics and Introduction Continuum Mechanics
6	University of California, Berkeley	United States	Nonlinear Dynamics of Continuous Systems; Advanced Dynamics
7	Nanyang Technological University	Singapore	Systems Simulation and Modeling
8	Swiss Federal Institute of Technology Zurich	Switzerland	System Modeling; Multiscale Modeling; Multiphysics Modeling and Simulation
9	National University of Singapore	Singapore	Computation and Modeling; Advanced Computational Fluid Dynamics
10	Imperial College London	United Kingdom	Modeling and Control of Multi-body Mechanical Systems

The results in Table 2 come from the public courses and public materials of various universities, as well as the contribution materials obtained through exchange. It can be concluded from Table 2 that famous universities across the world are also offering related courses. However, there is a signification difference in the teaching of relevant content on this subject, each with its own system and style. At MIT, for example, the mechanical engineering program offers a "Modeling and Simulation of Dynamic Systems" course, which is about modeling multi-domain engineering systems, covering the state space model, nonlinear mechanical dynamics system, multi-port energy storage and dissipation, Legendre transformation, nonlinear mechanics, transformation theory, Lagrange equation, Hamilton equation, and other theories. The application examples of the course consist of eight experimental projects, including electromechanical transducers, mechanical devices, electronics, fluid and thermal systems, compressible flow, chemical processes, diffusion, and wave propagation [33]. It can be seen that this course also contains much abstract theoretical knowledge, but pays relatively more attention to experimental teaching. In this case, it contrasts sharply with our course and teaching content. Our course can absorb and draw on different world-class universities' specific teaching content. It can provide a reference for our teaching content, make our education training objectives more suitable for actual research, and provide a strong guidance for students when they conduct high-quality scientific research work in the future.

Therefore, this course's timing and improved teaching content and methods fits well with the required postgraduate stage's training objectives and course learning characteristics. By drawing on the features of the world's top-ranked universities that focus on application, we integrated the course content's construction with the teachers' scientific research projects, breaking the law that old theoretical modeling knowledge is too abstract and difficult to understand. Establishing techniques and methods that "see a lot, know a lot, and can be copied when confronted with problems" is more effective. This aligns with the requirements of the "Ten Special Actions to Accelerate the Cultivation of High-level Talented Person", which is the focus of the Ministry of Education of China and the State Council of the China Academic Degree Committee. It embodies the characteristics of HIT's aerospace- and national-defense-integrated course content system and teaching method. The authors have accumulated decades of teaching experience in teaching this course. With the introduction of the research group's new research content and practical engineering examples, the proportion of time spent focusing on experimental and field analysis has increased compared with that spent at other universities at the same level. This course evaluates the student's ability and verifies the effectiveness of the course through the course's performance, experimental design, and completion, as well as the tutor's evaluation of the graduation design. From the perspective of the teaching effect, we can find that the students' autonomous learning ability has been effectively improved, and their system modeling, thinking, and experimental abilities have been improved.

4. Conclusions

This paper presents an innovative idea of constructing an Engineering System Modeling and Simulation course system based on the fusion of science and education. Centering on the three levels of "teaching, learning, and doing", the feedback integration of science and education forms a three-dimensional system of teaching quality, learning quality, and professional skill development quality. The course demonstrates the abstract complex concepts of modeling, simulation, and system theory in engineering systems visually and vividly. By combining a number of scientific research projects with the course content, this course system broadens the thinking and vision of graduate students, enables students to understand the directions of current scientific research developments more intuitively, and cultivates students' skills and abilities in mechanical structure design, FEM simulation and analysis, mathematical modeling, experimentation, and control system design. This work draws on the application-oriented characteristics of the world's top-ranked universities to continuously improve teaching content in response to social needs and teaching evaluation. The present work provides a new method for cultivating highly talented individuals with the characteristic research skills that are valued at HIT.

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