ISSN 2522-6398 Vol. 7, Issue 7: 141-145, DOI: 10.25236/FER.2024.070721

Reform of Mathematical Physics Equation Teaching Methods Based on Information-based Teaching Platform

Xinxin Jia[a], Xiaofeng Li[b,*], Huibin Yu[c], Qinglin Jiang[d], Jingya Wen[e]

School of Ocean Technology Science, Qilu University of Technology (Shandong Academy of Sciences), Qingdao, China
[a]jiaxx@qlu.edu.cn, [b]cactusimp@163.com, [c]binbinyu@163.com, [d]526901565@qq.com, [e]wjy8110@qlu.edu.cn
**corresponding author*

Abstract: *This paper addresses the issue of students' weak interest in the foundational course "Mathematical Physics Equations" and their lack of basic knowledge during teaching. It proposes an educational reform method based on a student-centered approach and utilizing an informational education platform. The article will suggest specific reform measures from two aspects: teaching content and methods, to explore the teaching of Mathematical Physics Equations. Through preliminary teaching reform practices, it aims to enhance the overall interest of students from various science and engineering majors in this course, thereby more effectively mobilizing their learning initiative, enthusiasm, and inquiry spirit, achieving better teaching results.*

Keywords: *Teaching Reform, Educational Reform, Teaching Mode, Teaching Practice*

1. Introduction

"Mathematical Physics Equations" primarily focuses on the mathematical models of partial differential equations and their systems involved in scientific research and practical engineering applications. It systematically describes the derivation process of mathematical models that describe physical phenomena, the categories of partial differential equations, and the solution methods for various types of boundary value problems. By discussing the basic theory of well-posedness for solutions to three typical types of equations—wave equations, heat conduction equations, and Laplace equations—the course enhances students' mathematical logical thinking skills, further solidifies their foundational theoretical knowledge, and refines the knowledge structure system across all engineering disciplines. As a bridge connecting mathematics with other disciplines, Mathematical Physics Equations organically integrates fundamental mathematical theories, logical thinking methods with actual scientific research and engineering applications. This plays a pivotal role in cultivating the scientific literacy and enhancing the research capabilities of contemporary university students. Therefore, numerous universities' science and engineering programs have chosen this course as a mandatory subject[1-3].

The content of "Mathematical Physics Equations" is abstract, hence students generally find the course monotonous and dull. As a fundamental course in their major, it requires a high level of mathematical foundation from students, making it relatively difficult for beginners. Consequently, student disengagement is quite severe, mainly manifested in unsatisfactory final grades. Based on previous teaching experiences, the reasons are roughly as follows: Firstly, the lax study attitude at the beginning of university leads to a relatively weak foundation in advanced mathematics, directly causing difficulty in subsequent theoretical learning[4]. Secondly, the course aims to study the theoretical solutions of partial differential equations, with most of the solving process being theoretical derivation and results often expressed in complex forms such as integrals, series, special functions, etc., which can easily induce fear of difficulty among students. Thirdly, with the reform of university courses, the class hours of this course have been further reduced, greatly reducing students' classroom learning time. Lastly, there is an inability to timely and effectively obtain information about students' mastery of knowledge, resulting in feedback failure regarding information content.

In this paper, addressing the aforementioned issues in the course, and drawing upon accumulated experience from previous teaching practices, we propose a student-centered teaching method based on

ISSN 2522-6398 Vol. 7, Issue 7: 141-145, DOI: 10.25236/FER.2024.070721

an informational teaching platform. This method, which includes urging students to preview before class, engaging them with interesting teaching during class, consolidating through in-class quizzes, and reinforcing after class, forms a humanized teaching model. The aim is to transform this foundational course into one that is vivid, lively, rich in content, and capable of enhancing students' comprehensive abilities through the reform of its teaching methods.

2. Approaches to Teaching Content Reform

Establishing a student-centered teaching approach, in conjunction with the knowledge structure system of the course content, it is necessary to plan the teaching platform, teaching software, teaching aids, ideological and political elements, etc., while organically integrating various teaching elements. The ultimate goal is to cultivate comprehensive innovative talents in science and engineering who possess mathematical and physical logical thinking, noble sentiments and character, strong innovative critical thinking, and the ability to solve practical problems [5].

Based on the educational and teaching concepts set earlier, the new teaching approach for "Mathematical Physics Equations" are as follows:

1) With the goal of new STEM (Science, Technology, Engineering, and Mathematics) teaching philosophies, the content of instruction is designed to reasonably select and organically integrate ideological and political elements based on the different topics and knowledge points covered in each lesson. Considering the professional nature of the content, it is characterized by "basic content + analogical innovation", transforming basic knowledge into specific and vivid case studies through analogical innovation, which facilitates students' understanding of abstract knowledge points.

2) Relying on the teaching platform, the organic combination of online and offline teaching is used. Through the guided release of online knowledge points, it urges the accumulation of preliminary knowledge; during class, the teaching platform is used to grasp the learning situation in real time, and after class, feedback on students' mastery of knowledge is provided through the teaching platform.

3) With teaching knowledge points as the main focus, diverse and personalized teaching methods are adopted. The classroom employs a blended, interactive, case-based, and heuristic teaching approach to stimulate students' interest and enthusiasm in learning.

4) Construct an assessment mechanism for both classroom and extracurricular knowledge structures that can examine both foundational knowledge and comprehensive abilities, and is evaluative.

3. Specific Measures for Teaching Reform

3.1. Improvement of Teaching Modes and Methods

1) Seizing the opportunity of curriculum reform in the blended learning model of schools, actively utilize information resources and platforms, and focus on students to achieve comprehensive integration based on information technology platforms and teaching content. It is necessary to use information technology platforms, push knowledge point information on the platform before class, supervise their learning progress, and realize "online self-study before class". During multimedia teaching in class, use the information platform to achieve "face-to-face interaction" with questions and knowledge points; after class, use the information platform to provide feedback on the mastery of knowledge structure, truly realizing online and offline blended classroom teaching, cultivating students' independent learning while grasping their knowledge learning situation.

2) The method of analogy is used for the characteristics of abstract concepts. By introducing physical models familiar to daily life, we can impart knowledge points in a vivid way and provide personalized teaching for different knowledge points. For instance, when explaining the well-posedness problem of solutions, considering the well-posedness conditions of equation solutions: existence, uniqueness, stability characteristics, we can introduce traditional musical instruments such as "guzheng" and "harmonica" based on the characteristics of wave equations, as shown in Figure 1 and Figure 2. The vibration rules of these musical instrument teaching aids conform to the first type boundary condition (Figure 3) and the second type boundary condition (Figure 4). This not only vividly describes the characteristics of each boundary condition but also stimulates students' interest in learning, enlivens the classroom atmosphere, and reduces the dullness brought by abstract knowledge.

ISSN 2522-6398 Vol. 7, Issue 7: 141-145, DOI: 10.25236/FER.2024.070721

3) The integration of information processing of abstract knowledge into teaching models. When teaching basic knowledge, software technologies such as scientific research and engineering are applied based on their principles. For instance, when describing wave equations, string vibration equations can be used, and computational programs can be written in languages or software like C, Python, Matlab, etc. The results of the wave equation solutions can be presented in graphical form, making it easier to vividly and visually demonstrate the abstract problems to be solved. For example, Figure 5 shows the solution of a two-dimensional wave equation visualized in MATLAB. Through Matlab animations, students can intuitively understand the general rules and characteristics of sound wave propagation in wave equations, thus providing them with a more direct understanding of wave propagation.

Figure 1. Musical instrument Guzheng

Figure 2. Harmonica structure diagram

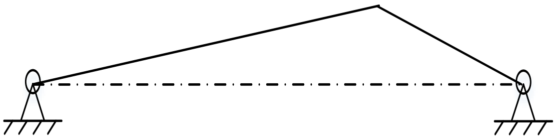

Figure 3. Physical Model of Guzheng

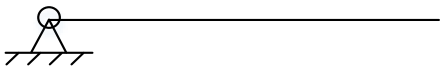

Figure 4. Physical Model of Harmonica

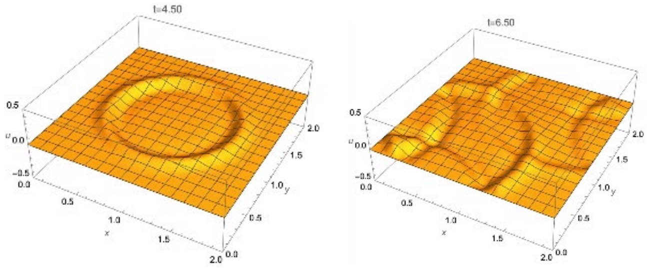

Figure 5: Illustrative Diagram of the Solution to the Two-Dimensional Wave Equation

3.2. Rational Planning of Teaching Content

Focusing on the needs of various science and engineering majors, and combining the goal of cultivating students' innovative abilities and good character traits, elements such as ideological and political elements, traditional culture, and the latest research trends are organically integrated into part of the teaching content.

1) The explanation of teaching content closely revolves around the major studied. The specific teaching content is set according to the students of each major, and different examples and problem-solving are selected from the actual problems of the students' majors. For instance, the wave equation applied in the basic "underwater acoustic principle" of underwater acoustic detectors, Fourier transform and Laplace transform used in processing underwater acoustic signals, Fourier optical transform applied in optical calculations, etc. The teaching content all selects applications directly related to the major. Meanwhile, during teaching, case studies from scientific research projects of various majors are combined for discussion and research.

2) The teaching content reasonably integrates ideological and political elements. Ideological and moral qualities, craftsmanship spirit, and national sentiment are always the professional sentiments that science and technology workers in the field of engineering must possess. In teaching, integrating ideological and political elements according to the knowledge content being explained can help cultivate students' patriotism, engineering ethics, and subtly influence their ideological and moral qualities.

3) The integration of our country's excellent traditional culture is reasonable. Our country's outstanding traditional culture has a long history, and its philosophical connotations answer many engineering technical problems from a higher philosophical level. For instance, the philosophical idea

ISSN 2522-6398 Vol. 7, Issue 7: 141-145, DOI: 10.25236/FER.2024.070721

proposed in "Zhuangzi" of our country that "the Tao is an objective existence and the origin of the universe", holds significant reference value when solving the instability issues of such solutions, such as the "dynamic stability" of numerical solutions.

4) The teaching content introduces applications from different fields and the latest scientific research achievements. The application of teaching knowledge across disciplinary fields varies greatly. Incorporating the latest applications from different fields and the latest research findings in this field into the teaching design can better stimulate students' interest in the scientific research applications within this course.

3.3. Innovative Assessment Model

The assessment of a course is an important link in evaluating students' knowledge mastery and the quality of teaching. This aspect has always been a crucial part of reform. The rational establishment of an assessment mechanism can not only accurately detect the learning and mastery of knowledge, but also enable teachers to have targeted teaching in subsequent work. Therefore, constructing a reasonable, efficient, and objective assessment model is an important part of the reform of the teaching assessment model. Course assessments should minimize "one final exam at the end of the semester", while emphasizing the examination of teaching and learning processes throughout the course. The assessment process should not only focus on knowledge mastery and learning attitude, but also pay more attention to comprehensive ability evaluation. Relying on information platforms, such as Yangtze River Rain Classroom, a comprehensive quantitative assessment model is constructed, which includes quantified supervision of daily learning process, recording of classroom learning process, tracking of after-class assignments and regular quizzes, and final exams.

1) Supervision of regular learning process. Regular learning includes the full supervision and feedback on pre-class preparation, mainly reflected in the form of pushing related learning videos through the platform before class, answering questions about pre-class courses, and platform learning time. This is done in a supervisory manner to encourage students to focus on regular learning. In this way, it can timely grasp the students' knowledge preparation before class.

2) Classroom learning process recording. Using an informational teaching platform as a tool, multimedia explanations of classroom teaching content are completed; at the same time, relying on the multimedia platform, real-time in-class interactive testing of knowledge points is conducted, and the mastery of knowledge is promptly understood based on feedback information. Meanwhile, the platform randomly asks questions and calls roll to ensure students maintain efficient learning. Through the method of recording real-time classroom processes, assessment indicators are set to effectively supervise and evaluate learning in real time.

3) Homework and regular quizzes for assessment. The knowledge learned is consolidated through homework, which includes forms such as literature research reports, answers to after-class exercises, and discussions on after-class exercises. The quantity of after-class exercises is not emphasized, but their specificity and generality are required. For the entire semester's course, 1~2 periodic quizzes are conducted to timely record and grasp the learning situation of the knowledge. The scores of homework and quizzes are recorded in a platform format, such as submitting them in the form of Rain Classroom and forming regular assessment scores.

4) The format of the final exam. The final exam is in the form of a test paper, focusing on discursive questions and comprehensive application questions, thereby examining students' learning status of the entire course.

3.4. Enhancing Teaching Levels and the Application of Information Resources

By regularly convening teaching content, methods, and instructional design seminars, the level of teaching can be improved. At the same time, within the teaching team, regular teaching seminars and observation classes are held to further enhance the teaching level. By utilizing modern network resources, a wide range of teaching cases are collected and organized as a case library. Computer languages such as C and Python are used for numerical calculations of differential equations; at the same time, various teaching software like Matlab, Fluent, Comsol etc. are used for describing and depicting physical phenomena, making abstract physical formulas more intuitive.

ISSN 2522-6398 Vol. 7, Issue 7: 141-145, DOI: 10.25236/FER.2024.070721

4. Conclusions

For undergraduate students majoring in science and engineering, relying on information technology platforms to effectively learn the course of Mathematical Physics Equations can not only enhance their foundational theoretical knowledge but also maximize the cultivation of their innovative application abilities. Under a student-centered teaching reform model that reasonably utilizes information technology platforms, the author conducted preliminary experimental teaching. Through early practical experiments, it was found that under an educational reform model based on information technology platforms and centered on students, there was a significant increase in students' enthusiasm and interest in learning "Mathematical Physics Equations". At the same time, a refined assessment mechanism encouraged higher student participation in learning, resulting in noticeable teaching effectiveness.

Acknowledgements

The work was supported by the The Qilu University of Technology First-Class Undergraduate Course: Mathematical Physics Equations; Shandong Province Undergraduate Teaching Reform Research Project (Project Number: M2020151).

References

[1] Mou Haining. Exploration of Teaching Reform for the Course "Mathematical Physics Equations" in the Context of New Engineering Education [J]. Science, Education and Culture Review (Mid-month Issue), 2020(10): 65-66+72.

[2] Xu Chao, Ding Yong. Construction of Mathematical Physics Methods Course Integrated with Professional Education [J]. Physics Bulletin, 2020, 39(1): 17-20.

[3] Zhang Chunling, Hu Song. Reflections on the "Mathematical Physics Methods" Course for Marine-related Majors [J]. Education and Teaching Forum, 2019(03): 132-134.

[4] Liang Kunmiao. Mathematical Physics Methods, Fourth Edition [M]. Beijing: Higher Education Press, 2010.

[5] Jiang Xiaokun, Zhu Hong, Li Zhiyi. New Model of Engineering Talent Training [J]. Higher Education Development and Evaluation, 2018(34):17-24.