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Teaching Reform Practice and Ideological and Political Design of Engineering Electromagnetic Field

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Abstract: As a critical foundational course in electrical engineering, "Engineering Electromagnetics" is often perceived as obscure due to its complex formulas, which pose challenges for student comprehension. Moreover, traditional teaching methods frequently result in inefficiencies. With the development of new media technologies, integrating various online and offline teaching methods across pre-class, in-class, and post-class stages has been explored to reform the entire teaching process. This approach aims to enhance the effectiveness of "Engineering Electromagnetics" instruction and incorporate ideological and political considerations into the curriculum. Bold explorations are undertaken by integrating anecdotes of prominent figures and significant technological engineering cases. The goal is to construct a comprehensive knowledge framework for students by combining offline classroom sessions with online audiovisual materials, fostering long-term effective understanding and memory retention, thereby achieving reform in "Engineering Electromagnetics" education.

1. Introduction

"Engineering Electromagnetics Field" is one of the three most important compulsory foundational courses in the field of Electrical Engineering and Automation. It holds a crucial position in the curriculum for electrical engineering students, integrating knowledge acquired from earlier courses such as "Advanced Mathematics", "University Physics" and "Circuit Theory", while serving as the theoretical basis for subsequent courses like "Electric Machines" and "High/Low Voltage Electrical Appliances"[1]. Consequently, this course involves numerous abstract concepts and intricate formulas, which often lead to difficulties in comprehension, reduced interest in learning, and lack of initiative among students. Therefore, it's often humorously referred to by students in the electrical engineering field as one of the "Four Great Scriptures of Electrical Engineering"[2-4].

Nevertheless, the content covered in this course holds vast application prospects in cutting-edge fields such as mobile communications, radar, electronic warfare, and the Internet of Things. Building a conceptual framework for engineering electromagnetics and solidifying its theoretical

foundations aims to cultivate contemporary university students equipped with robust knowledge in this domain, crucial for seizing technological peaks and leading scientific and technological developments in related fields. As a result, teaching and learning of engineering electromagnetics are increasingly emphasized by relevant experts. Many instructors actively integrate various teaching methods both online and offline during lectures, introducing electromagnetic field computation methods, software, and research instruments to visualize abstract concepts. Enhancing the efficiency and quality of teaching engineering electromagnetics has thus become an important issue in contemporary educational reform and practical exploration. Particularly in recent years, the significance of integrating ideological and political education into course design has become increasingly prominent. The focus is now on how to integrate ideological content with course knowledge, thereby not only imparting expertise in engineering electromagnetics but also promoting correct values among students.

2. Course content of engineering electromagnetic field

To facilitate students' understanding and mastery of "Engineering Electromagnetics," the course typically begins with an introduction to vector analysis and field theory. Reviewing relevant mathematical concepts aids students in efficiently grasping the course content. Building on this foundation, the formal teaching of the course usually comprises five chapters categorized by different types of electromagnetic fields: static electric fields, steady electric fields, steady magnetic fields, time-varying electromagnetic fields, and the propagation of plane electromagnetic waves. In the section on static electric fields, fundamental concepts such as charge, electric field intensity, potential, and electric field lines are introduced to establish students' basic understanding. Building upon this, topics such as Gauss's theorem, continuity conditions, uniqueness theorem, and boundary value problems are progressively taught. Consideration of the influence of dielectric polarization introduces the concept of electric displacement vector and expands into steady electric fields. The section on steady magnetic fields primarily covers physical quantities like magnetic induction intensity and magnetic vector potential, alongside principles such as Ampère's circuital law and magnetic field energy. While these three types of electromagnetic fields are often treated separately, in reality, electric and magnetic fields are interdependent and convertible. Therefore, the concept of time-varying electromagnetic fields is introduced, focusing on electromagnetic induction laws, the law of total currents, and an overview of Maxwell's equations, including the concept of Poynting vector. This structured approach introduces students to the fundamental knowledge of the four types of engineering electromagnetic fields, concluding with an application-oriented discussion on plane electromagnetic waves. Through this curriculum, the aim is to enable students to develop a profound understanding of electromagnetic field theory and its applications, equipping them with the ability to analyze and solve practical engineering problems. Moreover, integrating both offline and online methods to enhance students' intuitive understanding of these concepts, while incorporating ideological and political education, remains pivotal in achieving educational reform and ideological integration within the course structure.

3. Teaching reform and ideological and political design ideas

To address the aforementioned teaching content of "Engineering Electromagnetics," identify potential ideological focal points for each chapter, corresponding ideological elements, and implementation methods. Further plan the instructional segments for each chapter of "Engineering Electromagnetics," integrating both offline and online methods for educational reform and practice. Specific details are outlined in Table 1.

Table 1: The corresponding relationship between curriculum content and ideological and political elements

Course chapter	Ideological and political point	Ideological and political elements	Teaching link
introduction	Brief history of the development of electromagnetism	Scientific spirit	Online case preview before class
Electrostatic field	Coulomb's law, Gauss's theorem	Positive spirit	Offline classroom case discussion
Constant electric field	Current continuity equation	Skepticism	Online case preview before class
Constant magnetic field	Principle of flux continuity, Ampere's loop theorem	Innovative spirit	Offline case inspiration
Time-varying electromagnetic field	Faraday's law of electromagnetic induction, Full current law, Maxwell's equations	Spirit of exploration	Online case preview before class
Planar electromagnetic wave propagation	Electric power industry development status	Craftsmanship spirit	Offline classroom case discussion

4. The whole process of teaching combining online and offline

The traditional teaching form of Engineering Electromagnetic Field is mainly lecture-based teaching based on teachers' blackboard writing. The advantage of this teaching method is that it can clearly lead students to construct knowledge framework. However, due to the large number of formula deduction, the process is often boring and boring, which is easy to cause students' drowsiness. After that, with the development of new media technology[5], teachers combined blackboard writing and PPT to teach formula derivation, and tried to show the process of formula derivation to students more clearly by drawing and other means, but this often accelerated the teaching progress, resulting in students unable to digest theoretical knowledge in time. Therefore, a combination of online and offline teaching methods, such as pre-class case guide, classroom video interaction and case teaching, and after-class knowledge framework summary, should be considered to reform the whole teaching process to improve students' learning interest and learning effect, as shown in Fig.1. At the same time, considering that the traditional teaching content of engineering electromagnetic field is mainly derived from formulas, it pays more attention to the explanation of theoretical knowledge and the training of application skills, ignoring the cultivation of students' humanistic quality. Therefore, in the course teaching process, when introducing the theoretical formulas proposed by relevant scientists, some social and humanistic ideological and political elements can be added to enhance students' interest and cultivate students' correct outlook on life, values and world outlook. The specific design of teaching links can be seen below.

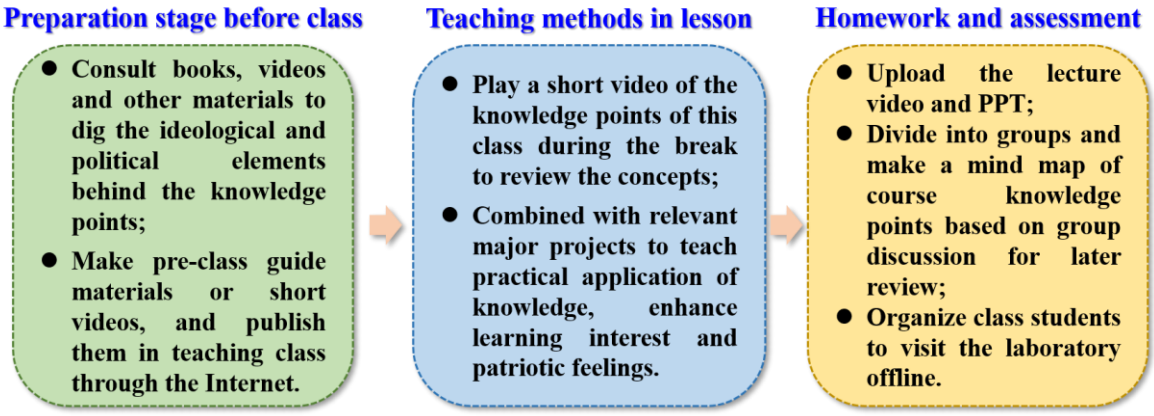

Figure 1: Whole course teaching design

4.1 Preparation stage before class

The design of the pre-class preparation stage can be carried out from the following aspects. First of all, according to the contents of each chapter of the course "Engineering Electromagnetic Field" (see Table 1), the knowledge points that need to be mastered by students are clarified. Further explore and excavate the humanistic ideological and political elements behind the knowledge points by consulting books, videos and other materials, and make pre-class preview materials to guide students to think before class and stimulate their interest in learning. On the one hand, for example, in chapter 1, students are required to master the relevant knowledge of Coulomb's law. Then, based on the historical background and establishment process of Coulomb's law and its contribution to the development of electromagnetic field theory, relevant pre-class guide materials or short videos of cases can be made and released in the teaching class through the Internet before the formal class. Through the above measures, students are guided to establish the basic knowledge framework of electrostatic field, understand the basic physical quantities of electrostatic field, understand the relevant theoretical concepts, and "warm up" for formal learning of electrostatic field related knowledge; On the other hand, for example, the part of time-varying electromagnetic field in Chapter 5 requires students to master Faraday's law of electromagnetic induction, total current law and Maxwell's equations. Through consulting relevant information, we can see that in the face of the phenomenon of magnetic electricity, Faraday and Maxwell two great scientists have different ways of understanding. In the face of the views put forward by Faraday, Maxwell did not back down, through constant exploration of truth, put forward and improved Maxwell's equations, laying the cornerstone of electromagnetic field theory. Based on this, by making relevant introductory videos before class, students can stimulate their enthusiasm for learning, and convey the scientific spirit of seeking truth and being pragmatic and never giving up. To sum up, by realizing online interaction with students before class based on data survey results, the knowledge points and ideological and political points contained in each chapter of the course can be shown to students in advance, stimulating students' learning interest and helping them build the knowledge framework of this course.

4.2 Teaching methods in lesson

The design of the formal classroom teaching stage can be approached from the following aspects. Firstly, it should strictly adhere to the systematic teaching requirements of the "Engineering Electromagnetics" course outline, avoiding adjustments that may affect students' effectiveness in pre-class preparation. Considering the extensive hours typically allocated to "Engineering

Electromagnetics," often spanning 3-4 consecutive sessions, careful planning of the teaching process is necessary to prevent student apprehension and fatigue from prolonged exposure to complex formula derivations. For this purpose, on one hand, utilizing break times to play pre-recorded short videos summarizing and reviewing the knowledge already taught in the current class can be beneficial. Leveraging the characteristics of short videos can quickly engage students' interest and enhance classroom atmosphere, facilitating concurrent review and revision of course content. On the other hand, integrating discussions of significant engineering or technological achievements into theoretical knowledge during classroom teaching can enhance students' learning interests and cultivate a sense of national pride. For instance, when introducing Chapter 6 on plane electromagnetic wave propagation, relating it to the basic theory of electromagnetic wave propagation and reception by China's Five-hundred-meter Aperture Spherical radio Telescope (FAST) can be effective. Narrating stories of scientists' diligent efforts during FAST's construction and reporting scientific achievements since its completion can inspire students' pride and identification with their professional studies. Additionally, considering each student's unique thinking process and different perspectives in understanding things, organizing students into groups for pre-class preparation and requiring them to describe the course content in their own simple and understandable language, making and uploading videos, can encourage active thinking. During class, selecting and playing videos from some groups can provide the entire class with various perspectives of understanding and encourage proactive thinking among students.

4.3 Homework and assessment

In the post-class design phase, to further consolidate the course knowledge points, several steps can be taken. Firstly, teachers should promptly upload class recordings and the corresponding PowerPoint presentations to the internet for students to review and revise. Secondly, dividing the class into small groups of 5 to 6 students each, instructors should instruct each group to create concept maps based on their understanding of the course material covered in the session. This approach not only enhances comprehension of the course material but also allows for the formation of concept maps through group discussions, which can better stimulate memory recall of related knowledge for later review purposes. Finally, integrating with the teaching content, organizing timely offline visits to laboratories and field trips for the class can deepen students' understanding of practical applications of electromagnetic fields.

Through a comprehensive course reform design spanning pre-class, in-class, and post-class phases, the aim is to fully engage students' interest in the otherwise dry subject of "Engineering Electromagnetics" and actively integrate ideological and political elements into the curriculum. To evaluate the effectiveness of the curriculum reform and the integration of ideological and political elements[6], the following measures and methods can be employed to assess the courses before and after reform:

1) Academic Performance Improvement: Compare the average grades and pass rates of students before and after the reform.

2) Interest Survey: Conduct surveys or interviews to understand students' interest in and engagement with the new course design.

3) Teaching Evaluation and Reflection: Evaluate teachers' performance and reflections on the implementation of the new curriculum through self-assessment and peer review.

4) Enhancement of Practical Skills: Assess improvements in students' practical skills through internships, project assignments, and other practical activities.

5) Social Responsibility and Civic Awareness: Evaluate whether students demonstrate increased social responsibility and civic awareness through the redesigned curriculum.

6) Long-Term Impact Tracking: Evaluate the long-term sustainability of the reform's effects and analyze its impact on students' career development post-graduation.

5. Conclusions

With the advancement of new media technologies, the challenge lies in effectively integrating online and offline teaching methods throughout the entire instructional process, ensuring students navigate a complex and challenging course with both efficacy and enjoyment. This paper explores key ideological and educational aspects within the "Engineering Electromagnetics" curriculum, incorporating scientist narratives and significant engineering examples. It aims to design initiatives across the pre-class, in-class, and post-class phases to fully engage students, addressing issues like dull offline classroom atmospheres and difficulties in grasping intricate theoretical concepts. These efforts are aimed at offering insights into reforming the teaching of Engineering Electromagnetics.

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References

[1] Zhai Menglin, Jia Fengde, Yang Yunlong, et al. Exploration of ideological and political education reform in the "Engineering Electromagnetics" course [J]. Journal of Textile and Apparel Education, 2023, 38(6): 74-78.
[2] Yuandong Wei, Li Huiqi, Zhao Xiaojun, Liu Gang. Efficient Teaching and Ideological Practice in the "Engineering Electromagnetics" Course [J]. Education and Teaching Forum, 2021, 35: 21-24.
[3] Lin Hong, Tu Songjiang. Exploration of Teaching Reform in "Engineering Electromagnetics" Under New Conditions [J]. China Electric Power Education, 2019(07): 73-75.
[4] Liao Miao, Huang Meiming. The Application of Short Video Production in the Teaching of Marxist Principles[J]. Communication and Copyright, 2023(05): 98-100.
[5] Lv Dianli, Wang Zhihua, Zhang Huijuan. Construction and Practice Research of "Engineering Electromagnetics" Digital Courses in the New Era Context [J]. Education and Teaching Forum, 2021, (26): 9-12.
[6] Jiang Tao, Li Rui, Cao Xiaoling. Teaching Research on "Engineering Electromagnetics" Under the Background of Engineering Education Accreditation [J]. China Electric Power Education, 2021, (09): 61-62.