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Cultivation of Higher-Order Thinking under the Background of New Engineering

-- A Case Study of Electromagnetic Field Fundamentals

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Abstract

The New Engineering focuses on cultivating compound talented person with global vision, innovative spirit and practical ability and newcomers of the times who can take on the great responsibility of national rejuvenation. The electromagnetic field fundamentals are basic courses for multiple engineering majors such as electrical, electronics, and communication. Its theory supports many major equipment technologies, such as wireless charging, DC transmission, radar, communication, navigation, aerospace, electronic countermeasures, electromagnetic interference and so on. Therefore, it is helpful to cultivate students ' higher-order thinking ability and challenging spirit to meet the needs of new engineering by learning the electromagnetic field basics. This paper has discussed how to cultivate students' higher-order thinking ability in the teaching of electromagnetic field fundamentals course by using teaching strategies and practical methods such as ideological and political guidance, problem orientation, engineering practice guidance and students' mutual learning. In this way, it could help the cultivation of top-notch innovative talents and the construction of new engineering.

Keywords

Electromagnetic field; New Engineering; Higher-order thinking; challenging spirit.

1. Introduction

Since February, 2017, the Ministry of Education has actively promoted the construction of new engineering disciplines with the formation of " Fudan Consensus ", " Tianda Action " and " Beijing Guide " successively. It issued " Notice on the Development of New Engineering Research and Practice, "and " Notice on Recommending New Engineering Research and Practice Projects ". Plenty of ways and methods of leading global engineering education have been explored to help build a powerful higher education country. With the rapid development of information technology, the future emerging industries and new economy need high-quality compound " new engineering " talents with strong engineering practice ability, strong innovation ability and international competitiveness compared with the traditional engineering talents. Therefore, under the background of "new engineering", cultivating learners with higher-order thinking is the development direction of future education [1-2].

Higher-order thinking refers to the advanced cognitive ability beyond the basic cognitive process, including critical thinking, creative thinking, systematic thinking and so on [3]. Most of the classroom settings were based on Bloom's primary educational goals of knowing, understanding and application. It emphasized the mastery of knowledge and the cultivation of basic memory, understanding and application ability. Less work was done in analysis, synthesis and evaluation, which was not conducive to the cultivation of students' higher order thinking.

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Therefore, it is not conducive to the cultivation of students' higher order thinking. As a result, they lack the ability to mine prior knowledge related to new information according to existing knowledge. Especially, with the rapid development of science and technology, students with higher-order thinking ability can better adapt to the needs of future scientific and technological development, and have stronger competitiveness and innovation ability.

As a compulsory course for science and engineering students, the course of electromagnetic field fundamentals is difficult and highly dependent on mathematics and physics. Its theories has supported the development of many cutting-edge technologies, such as wireless charging, DC power transmission, radar, communication, navigation, aerospace, electronic countermeasures, electromagnetic interference and so on [4]. Therefore, it is helpful to cultivate students ' higher-order thinking ability and lay a solid foundation for their future work. Therefore, this paper focuses on how to cultivate students' higher order thinking ability in the teaching of electromagnetic field fundamentals, so as to help cultivate top-notch innovative talents. In teaching, students are trained to learn higher-order thinking modes such as critical thinking, creative thinking, and systematic thinking through teaching strategies and practical methods such as ideological and political guidance, "constructivism" theoretical teaching design, engineering practice guidance, and students' group mutual learning. Furthermore, it cultivates students to innovate and have the ability to solve practical engineering problems, and eventually grow into future "New Engineering" talents that are needed for future emerging industries and new economies.

2. Ideological and Political Guidance the Formation of Critical Thinking

The electromagnetic field fundamentals takes the electric field and the magnetic field as the research phenomenon, and discusses the relationship and the laws contained in them. These theories, such as Coulomb's law, Faraday's law of electromagnetic induction, Ampere's law of force, Ampere's loop theorem, Biot Savart's Law, and the law of full current, are all products of synthesis, extension, breakthrough and innovation by scientists based on previous research and using rich association, critical thinking and creative thinking. It contains rich thoughts of historical materialism and dialectics [5].

For example, the electromagnetic field is a kind of material, but invisible, which reflects the principle of objective reality of matter. The wave-particle duality of light reflects that contradiction is the unity of opposites. The correlation between the law of electromagnetic induction and Kirchhoff's voltage law in the circuit reveals the dialectical relationship between field and road, which is helpful to improve students' dialectical thinking and cultivate students' sense of innovation, but it also requires students to pay attention to the application conditions of the law. Although the discovery of the magnetic effect of electric current is accidental, it has devoted many years of Oster's research process, which not only reflects the philosophical thought of contingency and necessity, but also further reveals that things are universally related. This discovery was also inspired by Kant's unified philosophical idea that various natural forces are transformed into each other and that the universe has universal natural forces, which also proves that philosophy plays an important role in the development of natural science. Faraday believed that electromagnetism is a kind of proximity action, and for this reason he proposed the idea of lines of force and the concept of field, which at that time was a new concept and a pioneering insight in electromagnetism, and a challenge to the action at a distance. In order to uncover the laws of electromagnetic phenomena, Maxwell turned his attention to the application of models (electromagnetic ether models) and engaged in painstaking theoretical research with extensive reference to the ideas and mathematical methods of fluid mechanics. He published the article "On the Physical Lines of Force", which put forward two new concepts of induced (vortex) electric field and displacement current, and made a key breakthrough in

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the theoretical research of electromagnetism. Therefore, in the teaching of electromagnetic field, students are guided to gradually understand critical thinking and dialectical thinking, and understand the important role they play in the process of establishing the theoretical foundation of electromagnetic field through curriculum ideological and political education..

3. ' Constructivism ' Theory Promoting the Cultivation of Creative Thinking

Constructivism theory advocates student-centered approach, which emphasizes students' active exploration, discovery, and construction of the meaning of knowledge learned. Teachers always play the roles of organizers, guides, helpers, and facilitators in this process. Therefore, this paper adopts "scaffolding instruction" teaching method to carry out teaching design based on constructivism theory. The design includes elements such as creating scenarios, collaboration, and conversation, which may contribute to fully unleash students' initiative, enthusiasm, and creative spirit, and finally enables students to realize the construction of knowledge and cultivate their creative thinking [6].

This paper takes the teaching of " magnetization " as an example to illustrate the application of scaffolding instruction design. As shown in figure 1, the classroom teaching process is divided into five stages: "building scaffolding - entering the scene - independent exploration - collaborative learning - effectiveness evaluation".

Firstly, the concept of magnetization is introduced through the duality relationship based on the students' existing knowledge of dielectric polarization, and a scaffold is set up for the interaction between the dielectric and the field.

Secondly, in the classroom, a scene of "magnetization application" is created through the example of "magnetic separator" application, and students are guided to think about the application of magnetization in industrial production, medical care, daily life, etc., so that they can have a preliminary understanding of the application of magnetization.

Then, the teacher provides the knowledge outline and task list for this lesson. Students actively consult materials based on the outline and task list, clarify basic concepts such as magnetic medium, magnetic dipole model, and magnetization current, deeply analyze the magnetization mechanism, and understand the correction of Ampere's loop theorem after magnetization. Through this process, students' learning initiative is stimulated and their ability to actively explore knowledge is exercised.

Next, the classroom enters the stage of collaborative learning. Group members can share their personal understanding of knowledge, discuss existing issues, and achieve a more comprehensive understanding of magnetization related content so as to complete the construction of magnetization knowledge.

Finally, it is the stage of effectiveness evaluation. Under the guidance of the teacher, objectively evaluate students' self-learning ability and contributions to group collaborative learning, and test whether they have completed the construction of meaning for the knowledge they have learned. Building an integrated system of learning, thinking, application, creation, and evaluation to effectively enhance students' creative thinking and innovation abilities.

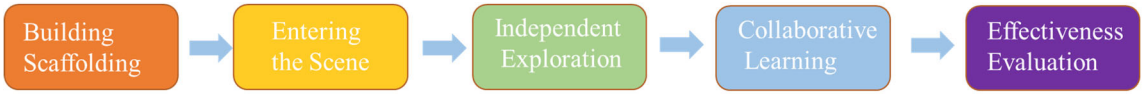

Figure 1. Scaffolding instruction design

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4. Engineering Applications Assist in The Formation of Systematic Thinking

Electromagnetic field theory comes from engineering practice, which in turn guides engineering practice. It is the theoretical foundation of modern technological theories and techniques, such as wireless charging, direct current transmission, radar, communication, navigation, aerospace, electronic countermeasures, electromagnetic interference, etc. The electromagnetic field theory, centered around Maxwell's equations, deeply elaborates on the interactions and connections between charges, media, electromagnetic fields, and electromagnetic waves, promotes the unified development of electricity and magnetism, and also embodies the application of systematic thinking.

Therefore, in the teaching of electromagnetic field, the practical application of electromagnetic field is introduced to stimulate students ' curiosity and curiosity, promote their active thinking and exploration, and help the formation of systematic thinking.

This article takes Faraday law of electromagnetic induction as an example. First, it is viewed as an overall system. The system consists of two basic units, the magnetic circuit and the electric circuit, and contains a number of components such as magnets, conductors, measuring devices and so on. Students are guided to an initial understanding of the roles and effects of these components on each other. Second, in order to gain a deeper understanding of the phenomenon of electromagnetic induction, the study is categorized according to the factors that affect the magnitude of the electric potential. For example, you can analyze the influence of the way the conductor moves in the magnetic field (such as uniform motion, variable speed motion, etc.), the strength and direction of the magnetic field, the connection of the circuit (such as series, parallel, etc.) on the magnitude and direction of the induced electromotive force, and so on. By decomposing and refining, students can proficiently master the law of electromagnetic induction and its applications. Then, the article takes the design of a generator as an example to further analyze apply the law of electromagnetic induction in engineering. Generators have a wide range of applications in industrial and agricultural production and daily life. Their working principle is Faraday law of electromagnetic induction, which can convert other forms of energy such as thermal energy, chemical energy, wind energy, etc. into mechanical energy and then into electrical energy. To ensure the normal operation and efficient output of the generator, it is not only necessary to optimize the magnetic field design, improve the material and shape of the conductor, and change the connection method of the circuit, but also to comprehensively consider multiple factors such as energy conversion efficiency, user demand, and cost. These optimization measures must rely on systematic thinking to play a role.

Therefore, through the analysis and exercise of overall analysis-decomposition and refinement-comprehensive application-optimization system thinking, it can not only deepen students' understanding of electromagnetic induction, but also cultivate their systematic thinking.

5. Conclusion

Cultivating students' higher-order thinking ability is the focus of electromagnetic field course teaching reform. This article effectively cultivates students' higher-order thinking abilities through measures such as ideological and political guidance, constructivist teaching design, engineering problem oriented teaching methods, the combination of theory and practice, group discussions and cooperative learning, and modern technology assisted teaching. However, these strategies still require teachers to constantly explore and improve during the teaching process.

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In the future, for the comprehensive and high-quality development of students, we will continue to focus on the research and practice of high-order thinking training in the teaching of electromagnetic field basic courses, and continuously improve and perfect the teaching process.

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