

Practices and Explorations on Introducing New Scientific Research Achievements into Electromagnetics Teaching for Undergraduates

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Abstract— In accordance with the “Outline of China’s National Plan for Medium and Long-term Education Reform and Development (2010–2020)”, the raising of education quality is appointed at the heart of task for the present Chinese higher education reform and development. Furthermore, the fostering of young talents or professionals shall command a central position in college work, and no effect shall be spared to produce high-caliber professionals and top-notch innovators with steadfast faith, more integrity, rich knowledge, and superb abilities. Consequently, course teaching, as the most important activity in university, has become the top concerned and hot discussed subject. Actually, since from the beginning of the 20th century, many educational experts and scholars has suggested to introduce the latest scientific research achievement into undergraduate teaching, and then putted it into practice. This paper analyses and sums up these practices coming from some famous Chinese universities, and integrates with our own in the National University of Defense and Technology, during the past nearly 10 years. Based on these, several good ideas and reliable approaches are discussed and concluded, which we think are useful to effectively improve student’s research ability and creative thinking in the courses such as electromagnetic, electromagnetic field and wave, and electrodynamics for undergraduates. At last, some special impediments and outstanding problems are addressed with the expectation to have a deeper discussion with international colleagues.

1. INTRODUCTION

Under the guidance of the “Outline of China’s National Plan for Medium and Long-term Education Reform and Development (2010–2020)” [1], several domestic universities, such as Sun Yat-sen University, Nanjing University, Tsinghua University, Peking University and so on, have actively been involved in the wave of educational reform. Throughout these domestic teaching reform implementations in the past decade [2–10], bilingual education, computer-aided instruction, introducing the latest scientific research achievements into undergraduate curriculums have become the main directions of the reform. Besides, elementary physics curriculums like electromagnetisms, electromagnetic fields and electromagnetic waves, electrodynamics and so on, which are found on the basis of electromagnetic phenomena, always be the first choice of pilot courses.

Focus on introducing the latest scientific research achievements to promote the teaching outcomes, the electromagnetism-relating courses teaching reform has been the practice for many years in many domestic colleges and universities, receiving the widespread recognition and support from most of the educational researchers, managers and coaching staff. In the first part, this paper presents an objective summery and analysis of these practices. We pay more attention onto the ways and the approaches of which they have made use of to introduce the related scientific research achievements, as well as the effects they have achieved. At present, higher educational course reform with improvement of teaching quality at the core, aims to training high-quality talents who would be adapt to the high-speed development of national economy and national defense construction, and be adapt to the information age of science and technology changing with each passing day. For this requirement and combination with the practice of our school in this area, in the second part, this paper discusses the necessity and orientation of introducing the related scientific research achievements into teaching of those electromagnetism-related courses. Furthermore, it points out two outstanding problems encountered in the process of previous reform. One is how to solve the contradiction between the new increased content and the limited class hours, and the other is how to solve the contradiction between the new materials characterized by relativity, variability and exploratory and the textbook exiting knowledge characterized by maturity and logicity. Class discussion teaching methodology, active learning with students as the main body and research teaching, have been the hot-points in overseas education researches and become the content which domestic colleges and universities compete to study in recent years. Therefore, with the help of these new teaching ideas, in the third part, this paper addresses some special impediments and preliminary ideas, with the expectation to have a deeper discussion with international colleagues.

2. THE PRACTICES OF DOMESTIC UNIVERSITIES

Basic physics courses always become the pilot in the education teaching reform by domestic colleges and universities, and courses associated with electromagnetic phenomena, such as electromagnetism, electromagnetic field and electromagnetic wave, and electrodynamics always walk in the forefront of the pilot. On the one hand, this is because the basic status of physics and electromagnetic phenomena is one of important subjects and concepts. There are so much abstract knowledge and experimental content that it is very difficult for students to learn. So we always hope to promote students' learning effect through the teaching reform. On the other hand, this is because of the close connection between the electromagnetic theory to these technologies, such as the microwave engineering, antenna engineering, wave propagation and scattering, electromagnetic exploration, microwave remote sensing, Micro-nano electronics, vacuum electronics, microwave electronics and optics. The basic knowledge of curriculum has been widely applied in industrial applications. Scientific research put forward the realistic demand for college education, in turns, new scientific results easily put important influence on teaching. Therefore, introducing scientific research achievements in electromagnetic theory teaching is in accordance with the characteristics of the course itself.

Based on the comprehensive analysis of the domestic university reforms in the past decade, the approaches and ways of introducing new scientific research achievements to promote the teaching quality mainly reflect in the following respects.

The first measure is the textbook revision, which opens some window for the front of modern science and technology related to the course.

For example, Sun Yat-Sen University, that was chosen as the first domestic electrodynamics national fine course, rewritten the electromagnetic properties of superconductors in the new third edition teaching material of electrodynamics [8]. It duly increased the superconducting current in London theory and the theory of vector potential local relations, said London local area was given in the superconducting magnetic field penetration depth and the experimental results of deviation, increased Pippa non local modification, increased such as photonic crystal optical spatial soliton and atomic optical trap, the new research hotspot, and explained by classical electrodynamics to a certain degree of content.

Tsinghua university, focusing on cultivating students' scientific quality and from physical principle on the consciousness and ability of technology innovation. It opened Subsequent course for students with higher requirements for the physical basis, after the college course of basic physics theories. The course named as Modern physics and the physical basis of new and high technology. It focuses on the foundation and as far as possible reflect the frontier. It focuses on the physical, but appropriate contact technology. For example, except for atomic molecular nuclear and particle physics, it also talks about the general relativity and chaos. Besides, it includes the physical contents, such as solid state physics and new materials, modern optics and information processing, new energy, which are closely related to high and new technology.

Peking University writes an electrodynamics introductory tutorial. It selects material refined and pays attention to teaching skills, or artistic. It maintains the systemic of the theory and the clarity of basic concept, and at the same time it absorbs the new research results as far as possible.

Nanjing Normal University proposes to take new findings, new invention and subject forefront information into the textbook, to make it keep pace with the times. Adopt the way of the teaching material combination. As for the mature knowledge, it highlights the key part of the teaching material content. And for forefront information, it makes up as the matched reading materials.

In addition, Inner Mongolia University of Science and Technology and some other universities also stand for cut off some old content and introduce the latest scientific research achievements into the textbook, as references for students to read after class.

The second measure is redesign the experiments and practice programs, which let the students near to the real and present scientific researches.

Quite a few domestic Universities, like the Jilin University, the Taiyuan University of Technology, the Capital Normal University and the Nanjing University of Aeronautics and Astronautics University, have actively explored the methods and measures to using scientific research to improve the experiment teaching. They pay attention to transfer the professional laboratory science frontier and the scientific and technological development projects to the demonstration and practice experiments, open to the students. Comparison of representative including optical bi-stable, non steady, chaos and control, power generation using high temperature solid oxide fuel cell, the preparation of high temperature superconducting ceramics and magnetic levitation, dot matrix display based on single chip microcomputer control magnetic field distribution and the semiconductor refrigeration

demonstrations and practice experiments.

Sun Yat-Sen University designed the new ideas of new theory and new technology, in the latest scientific research achievements, as the extracurricular reading and discussion topic or in the form of lectures in the knowledge module. In addition, they encourage and guide the efficient junior students to participate in various early scientific research training, science and technology competition.

The undergraduate students' academic achievements in quality and quantity are demonstrated by the students' published academic papers.

The third measure is to establish a course online learning platform, with the new scientific achievements plentiful and easy reachable for students.

Qiqihar University and Hebei University advocates the establishment of a library or online courses for students, with learning resources, which is much less likely to involve through class but shows relation to the technology development and scientific progress. It plays the role of an auxiliary supplement classroom teaching.

The above reform proposals and initiatives does play a certain effect in the promotion of the teaching quality, but whether the textbook, website content or the practice in the experimental, need students to occupy their spare time to carry out. It failed to solve the existing difficulty that integrating the lessons with scientific research in class. Therefore, how to solve the contradiction between the increased new content and limited hours is currently a problem when we hope to take advantage of the scientific research to promote the quality of teaching. Secondly, the new results usually character with exploratory and existing classic textbook content is systematic and mature. It is difficult for students to develop their scientific discernment, and is more difficult to ensure that students are able to correctly understand and the new problem, just only be provided with lots of materials after class.

3. REFLECTIONS ON THE REFORM OBJECTIVES

Form the above analysis of the past domestic higher education reform in physics courses related to electromagnetism, we can find that the objectives of introducing new scientific research achievements are to wide students' visual field, to promote and encourage students to apply the knowledge learning in the class. However, just only through providing many materials for students to get to know, to read and to practice in their spare time, and in the classroom still making use of the traditional lecture teaching, or infusion teaching, it's difficult to get as many as students to get involved and it is almost impossible to train most of the students with the scientific way of thinking. Therefore, introducing the new scientific research achievements should be tied in closely with the innovation of teaching method. It is important to cultivate the scientific literacy and scientific spirit of students and to stimulate the interest in scientific exploration of students during the class and within the limited hours.

4. EXPLORATIONS FOR PRACTICE

Making use of the idea of discussion-based teaching, we can transfer the new thoughts, new ideas, new methods and novel application coming with new scientific research achievements to the learning materials. We need to unify the process of learning knowledge and applying knowledge with the process of thinking the research behavior coming out with new achievements repeatedly.

Around scientific research hotspot and frontier content, it is necessary to redesign the classroom examples and exercises after class. These new problems should pay attention on the raise of ability to analyzing the problem and solving the problem in the real scientific research. Besides, it is better to add some open questions for thinking, which focus on the capability of digesting the knowledge and the build of scientific thinking as well as the scientific values. Theses demand the teachers to improve their own scientific appreciation that they can grab and keep with the mainstream and frontiers in the development of science and effectively. Furthermore, teachers also need to be able to summarizes the successful application in the actual research and rise it up to the theory of education.

For students to discuss organizational issues and explore solutions to the problem together, it is better to get use of the seminars teaching style to explain examples. During the course, teacher work as guiders. Exercises explain reported by the students, and then for teachers to compare the answers between different teams, like organizers and evaluators. Open thinking questions are for voluntary students to answer freely, which can be the way of select potential researchers for the scientific program and other practice activity. Theses require teachers to improve their own seminar organizational skills. For the chosen topic, teachers need to can develop a careful plan

(includes seminar outline, discuss plans and content evaluation methods, etc.). The discussion can be arranged to start with the curriculum related knowledge, and the end result can be a return to the basics of the curriculum.

Course knowledge and concept map summary should be worked out by the students, according to their own understanding and mastery. We can image that these knowledge structures formed by the students will be Hundred Flowers picture. These knowledge structures will provide a rich learning feedback to teachers. For instance, the course difficulty and the threshold concepts from the point of students, as well as how their understanding of the knowledge is progressing.

5. SUMMARY

This paper analyses and sums up these practices coming from some famous Chinese universities during the past nearly 10 years. The approaches and ways of introducing new scientific research achievements to promote the teaching quality mainly reflect in the three respects. These are the revision of the textbook, the experiments and practice programs designed according to the achievements, and to establish a course online learning platform. Whereas, it is hard to embrace the new material within the limited class time and it is hard for students to indentify the exploratory and changeability of the new achievements. In order to solve these two problems faced by the past reform, we recommend combining the new achievements presentation with the seminar teaching method. Though redesigning the classroom examples, exercises after class, and open thinking questions, recognizing discussions on the solutions by students, and studying the course knowledge and concept maps summarized by students, we can achieve the teaching improvement benefiting from introducing new scientific achievements during the class time.

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