Analysis of the Teaching Reform of the "Fundamentals of Materials Science" Course under the Background of New Quality Productive Forces

Xiangwei Meng[1], Yanqing Guo[2], Yuan Yuan[2], Shiquan Lyu[1*]

[1] School of Chemistry and Enviromental Engineering, Hanshan Normal University, Chaozhou 521041, Guangdong, China

[2] School of Physics and Electronic Engineering, Hanshan Normal University, Chaozhou 521041, Guangdong, China

Corresponding author: shiquan_lv@hstc.edu.cn

Abstracts: Under the background of New Quality Productive Forces, the innovation of materials technology has significantly promoted the development of strategic emerging industries, such as new materials, new energy, and civil aviation. "Fundamentals of Materials Science", as a core course in the materials discipline, aims to cultivate materials professionals with ideals and beliefs, moral qualities, cultural literacy, and a sense of discipline. This paper, in response to the requirements of New Quality Productive Forces for the teaching of "Fundamentals of Materials Science", based on the OBE educational concept and oriented towards "learning outcome production", analyzes the characteristics of the course content and the requirements for postgraduate entrance examination, emphasizes practice and application, closely aligns with industrial demands, and implements a teaching design that meets the "two highs and one degree" standards. It integrates the latest research achievements and engineering application examples into the teaching process. It discusses the deficiencies in content setting, teaching methods, and assessment methods in the current course teaching, and proposes improvement measures such as optimizing teaching content, methods, and assessment methods, and further constructing a characteristic teaching system to enhance teaching quality, cultivate materials applied technical talents needed in the new era, and assist the development of New Quality Productive Forces.

Keywords: new quality productive forces; fundamentals of materials science; teaching reform; applied technical talents

1. Introduction

Materials are the foundation for human survival and development, playing a crucial role in the course of human history. Driven by modern science and technology, the variety of materials has been increasing, and new materials with different functions keep emerging. The performance of existing materials has also been improved and enhanced to meet various usage requirements. Human beings' ability to control and transform nature has reached a new level, bringing about significant changes to social productivity and human life, and promoting the advancement of human material and spiritual civilization by a step. Therefore, materials science has become the foundation of scientific and technological development and a pillar of industrial production[1]. Chinese universities have deeply felt the various aspects of the impact of materials on society and have a clear understanding of the demand for materials science in modern society. As a result, the course "Fundamentals of Materials Science" has emerged as a basic course for students majoring in materials to understand materials. In recent years, although important breakthroughs have been made in related research fields of materials science such as nanomaterials and information materials, these major developments in the field of materials science have brought many new problems, new situations, and new challenges to the teaching of the "Fundamentals of Materials Science" course in the context of new productive forces[2]. This makes the reform and innovation of the course teaching of "Fundamentals of Materials Science" imperative.

2. Problems Faced by the "Fundamentals of Materials Science" Course in the Context of New Quality Productive Forces

"Fundamentals of Materials Science" is an ancient yet modern course. It is a theoretical, rich and rather difficult course to master. The teaching content of "Fundamentals of Materials Science" not only has obvious characteristics of fundamentality, interdisciplinarity and practicality, but also features numerous knowledge points, complex content, abstractness and difficulty in memorization, as well as prominent teaching difficulties. With the continuous development of materials science and technology, various new materials, new processes, new technologies and new theories have been fully integrated into the current teaching materials, thus making the teaching content no longer a simple combination of dull concepts, hard-to-understand principles, monotonous methods and rules, but a complete system formed by the mutual

penetration of knowledge imparting and skills training[3,4].

With the increasing demand for materials science talents in modern society, the knowledge content covered in "Fundamentals of Materials Science" has gradually become part of the teaching curriculum for senior undergraduate students in major engineering colleges across the country, and has also become a mandatory subject for the postgraduate entrance examination in materials-related fields. During the teaching process for undergraduate students, the extensive learning content leads to a relatively insufficient teaching time for "Fundamentals of Materials Science", resulting in students' insufficient mastery of the basic knowledge of materials science and difficulty in understanding its essence. Moreover, they lack relevant materials in science experiments, and their problem-solving abilities are not improved. Therefore, Liu Ruiping et al. proposed the necessity of simplifying the teaching content, transforming traditional teaching methods and assessment approaches, selecting and organizing teaching content, and conducting discussion-based teaching using modern teaching methods [5]. Du Xueli et al. further carried out teaching reforms by integrating online and offline resources, connecting classroom and extracurricular activities, and incorporating engineering cases, cutting-edge scientific and technological achievements, and ideological elements, changing the teaching approach from "teaching-oriented" to "learning-oriented" [6]. In recent years, under the promotion of the "Double Ten Thousand Project", many scholars have begun to explore new teaching models and deepen teaching reforms [7, 8]. For instance, Zhang Jin et al. from Southwest Petroleum University analyzed the problems and solutions regarding the OBE and "course ideological education" concepts faced by blended teaching based on MOOC classrooms. However, most of the research has mainly focused on the exploration and practice of course content, teaching methods, and teaching means. There are few reports on teaching reforms for the materials science foundation course based on the concept of postgraduate entrance examination. Therefore, in light of the requirements of the Materials Science and Engineering College of our university for the materials science foundation course, it is imperative to explore teaching reforms for this postgraduate course in materials science.

3. Teaching Reform Strategies for the "Fundamentals of Materials Science" Course in the Context of New Quality Productivity

3.1 Content of Curriculum Teaching Reform

Based on the OBE educational concept and oriented towards "learning outcome output", in accordance with the characteristics of the "Fundamentals of Materials Science" course content and the requirements for postgraduate entrance examinations, a "two-dimensional, two-sex, one-degree" standard teaching design was implemented. Through the "high-levelness" of the teaching design, the basic knowledge of materials science, engineering practical ability and scientific literacy were organically integrated. The course ideological education concept was integrated into the entire classroom process, cultivating students' confidence and ability to solve complex problems. Practical engineering case-based advanced thinking was introduced, guiding students to apply knowledge to solve practical problems. The "innovativeness" of the teaching design is reflected in three aspects: First, the cutting-edge and contemporary nature of the course content, constantly integrating the latest progress in materials science as cases into the course teaching. In response to the complexity and diversity of the course content and the different assessment requirements of different schools for this course, the teaching content was optimized, updated and selected, focusing on explaining key and difficult knowledge, and gradually increasing the proportion of professional postgraduate entrance examination questions in the question bank. Second, the advanced and interactive nature of the teaching form, adopting a hybrid online and offline teaching method in the classroom. Students can easily obtain the latest learning materials through platforms such as WeChat Learning through mobile phones and other online methods, starting the accumulation of knowledge at any time and anywhere. The theoretical explanation process, comprehensive experimental process and university student competitions are organically integrated to cultivate students' cognitive ability of the unity of theory and practice. Third, the inquiry and individualization of the learning process, organizing students to conduct flipped classroom teaching in offline groups in the form of group discussions. Students form teamwork and scientific expression abilities during the learning process. From the three levels of attitude, ability and knowledge, students recognize the challenge of the assessment requirements. Through the study of this course, students master the basic theoretical knowledge and principles related to materials science, such as crystallography, crystal defects, deformation, material strengthening, phase diagram - phase change, solidification, diffusion, etc., and have the ability to analyze and solve complex problems in materials science and engineering, achieving the goal of autonomous learning and lifelong learning.

3.2 The objective of curriculum teaching reform

Based on the OBE educational concept, efforts are made to enhance students' learning and thinking abilities. Centered on the students, various aspects such as the reconfiguration of teaching content, innovation of teaching methods, and process

evaluation of learning are emphasized, with particular attention paid to the sense of achievement in the students' learning process. On the basis of imparting basic knowledge, materials science issues from scientific research achievements and engineering cases are integrated into the teaching content. Group-based project research learning strategies are adopted, and practice of questions and simulation of the interview process in professional problem scenarios are strengthened to promote the improvement of students' learning and thinking abilities, reflecting the high-level, innovation, and certain challenge of the course. We further explored the ways and methods to integrate the educational philosophy of the course into the course content design, teaching method development, assessment and evaluation, as well as other aspects of course management and teaching. We also analyzed how to use "soft influence" approaches to reflect emotional and value guidance, guiding students to view things, analyze problems, understand society, and plan their career paths from a correct perspective, viewpoint, and method.

3.3 Course teaching reform measures

Based on the Postgraduate examinations needs of students in the School of Materials Science and Engineering, and considering the complex content of the "Fundamentals of Materials Science" postgraduate course, with the aim of enhancing students' theoretical foundation and improving their research innovation ability and practical skills, the concept of course ideological education was integrated into the entire teaching process. The teaching reform was carried out in terms of teaching content, teaching methods and teaching means. The specific steps are as follows:

(1) Utilizing the existing relevant research and teaching platforms of the school, a blended online and offline teaching mode was adopted, with a time ratio of 1:1. Multiple people were assigned to jointly undertake the course, and each person was responsible for independent content.

(2) The online course content selected was the national-level excellent course. The offline course was taught by the instructor. Discussion and teaching interaction were carried out through communication tools such as WeChat, QQ and Weibo. Micro-videos were recorded at different levels and modules based on the characteristics of the course to stimulate students' interest in learning and improve their autonomous learning ability.

(3) By using emerging technologies such as artificial intelligence and virtual reality, materials science issues related to research achievements and engineering cases were integrated into the teaching content. Students carried out group project research learning strategies, reported solutions to problems, and cultivated students' innovative thinking.

(4) Strengthening the practice of questions, answering professional question scenarios in the form of professional interviews, to stimulate students' interest, and enrich students' theoretical foundation.

(5) Combining theoretical courses, comprehensive experimental courses and university student competitions, such as through competition forms like Internet and metallographic skills competitions, to achieve "promoting teaching through competitions, promoting improvement through competitions, and promoting learning through competitions". Stimulate students' interest, initiative and competitive awareness.

(6) Based on the final training situation of students and their future employment and development, feedback on the course setting.

3.4 The characteristics of teaching reform

The distinctive feature of the teaching reform lies in not only reorganizing the teaching content, innovating teaching methods, and conducting process-based evaluations of learning, but also strengthening the cultivation of students' learning and thinking abilities. At the same time, starting from the practical aspects of the postgraduate entrance examination interviews, a learning strategy of group-based project research is carried out, intensifying the practice of postgraduate entrance examination questions, and simulating the professional problem-scenario questioning in the postgraduate entrance examination process. The innovations mainly come from the following two aspects:

(1) Integrating the process of theoretical explanation, comprehensive experiments, university competitions, and postgraduate entrance examinations organically, achieving the promotion of teaching content focus through competitions and postgraduate entrance examinations, promoting changes in teaching methods and approaches, and enhancing students' ability to understand knowledge and solve problems.

(2) Incorporating the latest research achievements of teachers, actual engineering case materials on material science issues into the teaching content, cultivating students' innovative thinking and practical abilities.

4. Conclusion

"Fundamentals of Materials Science" is a foundational course for the materials discipline. Under the requirements of the new quality productive forces, it is facing greater challenges. Guided by the OBE educational concept and oriented towards

"learning outcome output", this course analyzes its characteristics and the demands of postgraduate entrance examinations, emphasizing practical application, closely connecting with the industry, achieving "two natures and one degree" teaching design, and integrating the latest research results and engineering application cases into the course teaching. By leveraging emerging technologies such as artificial intelligence and virtual reality, the teaching methods and assessment models are innovated, creating a more flexible and open teaching system. Through continuous promotion of reform and innovation measures, the "Fundamentals of Materials Science" course will further exert its influence, contribute to cultivating internationally competitive materials science talents, and effectively promote the new quality productive forces to reach new heights.

Acknowledgments

This paper was supported by the Education Research Project of Hanshan Normal University (E22065, E23054, E24108, E23167, E24146).

References

[1] Guojun Zhao, Xingwu Li, Ling Deng, et al. Research on the standardization of green development of natural resources from the perspective of new productivity [J]. Standard science, 2024 (12): 26-30.
[2] Jiliang Zhou, Fan Xia. The practical logic of the two-way empowerment of modern universities and new productivity [J]. Beijing Education (Higher Education), 2024 (12): 4-12.
[3] Liqun Xu, Zhigang Xu, Qing Li, et al. Exploration and Practice of Innovative Talents Training Mode for Materials Specialty from the Perspective of New Engineering [J]. Journal of Southwest Normal University: Natural Science Edition, 2022,47 (2): 124-128.
[4] Wen Luo, Wenguang Wang,Pengcheng Lin, et al. Exploration of teaching reform of “Fundamentals of Materials Science” based on new energy needs [J]. Education and Teaching Forum, 2025,15: 65-68.
[5] Ruiping Liu, Chenyang Xu, Xiao Huang. First-class course construction of material science foundation [J]. China Metallurgy Education, 2022, 05: 56-58.
[6] Xueli Du, Zhizhong Dong, Wei Li, et al. Mixed first-class curriculum construction of basic materials science [J]. China Metallurgy Education, 2024,03: 39-41.
[7] Jin Zhang, Songxia Li, Jing Zhang, et al. Exploration and Practice of Materials Course Construction in Local Colleges and Universities under the Background of New Engineering Taking the basic course of material science as an example [J]. Research and practice of innovation and entrepreneurship theory, 2025,8: 95-97.
[8] Zhenjiang Li, Huaying Li, Jinhua Zhao, et al. The construction and reform of the basic course of materials science under the background of new engineering [J]. Chinese modern educational equipment, 2025,07: 58-60.