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Exploration on the Course Reform of "Fundamentals of Material Science" Promoted by Academic Competition in Application-oriented Universities

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Abstract: In the context of the construction of application-oriented undergraduate colleges, this paper proposes some measures to explore reforms in the teaching of "Fundamentals of Material Science" course for the Functional Materials major at Huizhou University. With academic competitions as a starting point, these measures aim to improve students' practical skills and innovation and entrepreneurial abilities, and promote the quality of application-oriented undergraduate teaching.

1. Introduction

Application-based undergraduate universities prioritize the practical application of skills and aim to cultivate highly skilled professionals who possess exceptional social and competitive skills, which are in high demand [1]. To meet the demand of rapidly emerging strategic industries like new materials and electronics technology, Huizhou University established the Functional Materials major, which implements a "strong foundation and wide caliber" training model. This model equips students with fundamental theories and skills in materials science and engineering, professional knowledge and practical abilities in functional materials preparation, structural characterization, and performance analysis, as well as the capacity to design, develop, produce, and manage functional materials and devices, such as electronic information and intelligent sensing. Graduates are expected to be physically and mentally healthy, possess excellent qualities, have an international perspective, and demonstrate an innovative spirit - in other words, highly qualified application-based professionals. "Fundamentals of Materials Science" (or "MatSci Fundamentals" for short) is a core course for the Functional Materials major, serving as an introduction to the field of materials science that emphasizes both theoretical knowledge and practical skills development[2, 3]. To meet the development needs of the university and society, the "MatSci Fundamentals" course has undergone a series of reforms that focus on teaching content, talent development through the teaching mode, practical teaching, and course evaluation[4]. These measures aim to provide students with a solid foundation for engaging in material-related scientific research and technical production in the future.

The "MatSci Fundamentals" course requires students to have a solid foundation in advanced

mathematics, college physics, chemistry, and physical chemistry. However, some students in our program struggle with understanding and deriving mathematical formulas. In fact, some students were even admitted to the program through transfer. These foundational differences cause students to develop a dislike for topics such as formula derivation, and as a result, they lose interest in the course material later on. As an applied undergraduate program, the emphasis is on enhancing students' technical and practical skills, as well as their ability to innovate and start their own businesses. Therefore, in the teaching process of "MatSci Fundamentals", it is important to cater to individual students' needs and implement appropriate changes[5].

To address the issue of the course's current focus on theory over practice and to strengthen the application of the "MatSci Fundamentals", as well as to enhance the integration of theory, practical skills, and innovation and entrepreneurship abilities, the teaching team of this major has taken a two-pronged approach from the perspectives of teaching content and teaching skills. By combining the training objectives of applied undergraduate students, they have explored a modular teaching reform based on "application-driven, project-oriented, and competition-promoting" approaches, and attempted to cultivate students' engineering thinking, innovation, and entrepreneurship abilities. To achieve these goals, the teaching reform of this course will focus on multiple dimensions, such as the reconstruction of teaching content, hybrid teaching methods, diverse assessment and evaluation methods, ideological and political education, and the establishment of excellent teaching teams. The goal is to promote students' initiative and innovative abilities, meet their multi-level and diversified needs, and build a comprehensive teaching system for moral education and talent cultivation[6].

2. The Reform of "MatSci Fundamentals" Teaching by Academic Competition

2.1. The Importance of Academic Competition

Academic competitions are a way to promote a deeper understanding of theoretical knowledge and problem-solving skills through a combination of theoretical teaching and practical application. The innovation and entrepreneurship competition aims to deepen the application-oriented undergraduate education reform, stimulate students' innovation and creativity, and further promote high-quality entrepreneurship and employment among graduates in this field. Academic competitions are an important component of undergraduate practical teaching, and the Ministry of Education and relevant departments at all levels have issued several documents encouraging the use of academic competitions to enhance the innovation ability of university students. Participation in academic competitions requires students to have a solid theoretical foundation, as well as teamwork, professional skills, and innovative capabilities, all of which are essential for achieving outstanding results.

2.2. The Form of Academic Competitions

The metallographic skill is fundamental to the study and analysis of materials, making it an essential practical skill for students in materials science. The National Undergraduate Metallographic Skills Competition is a highly respected professional competition for undergraduate students in materials science across the country. Similarly, the China International "Internet +" Innovation and Entrepreneurship Competition is the most influential national competition for undergraduate students, which aims to promote innovation and entrepreneurship education, cultivate talent in these areas, and encourage mass entrepreneurship and innovation. Both competitions are excellent opportunities for students to enhance their practical and innovative abilities, and to demonstrate their expertise in their fields of study.

2.3. The Direction/Purpose of the Reform

The reform is designed around "learning", with different levels based on the course content. Modern information technology is fully utilized to carry out diverse teaching activities, promoting active learning and cultivating students' high-level learning abilities. Project-based teaching supports course teaching, creating a practical teaching model and improving students' practical skills and innovation and entrepreneurship abilities. Advanced engineering cases in the field of materials from both domestic and international sources are introduced, and values are integrated into the curriculum in a subtle and unobtrusive manner, achieving value guidance[7].

2.4. Reform Scheme

2.4.1. The Reform of Teaching Content

To address the needs of students in applied undergraduate universities, who tend to have weaker foundations in mathematics and physics, it is necessary to increase the amount of practical training during the teaching process. This inevitably requires some reduction in theoretical course content, which in turn demands that instructors have a strong grasp of the essentials of the "MatSci Fundamentals" course. They should be able to select the most essential aspects of the course material and reduce mathematical derivations while emphasizing the students' understanding of the principles. By integrating textbook knowledge with relevant micrographs, instructors can explain the phenomena of material preparation and phase transition, which can increase students' interest in learning and help them appreciate the application of course knowledge in actual industry. At the same time, the taught knowledge should be able to be cross-disciplinary and help develop students' independent innovation ability, laying a solid foundation for future innovation and entrepreneurship. Therefore, the selection of theoretical teaching content places a high demand on the instructor's abilities[8].

Applied undergraduate colleges should focus on local business needs, combining the characteristics of this course with the actual situation of the local materials industry. With this in mind, the teaching content of this course can be reformed in several ways[9]. Firstly, instructors can create several projects based on the course content, and combine classroom teaching with the instructor's research direction. Students can form research teams according to their interests and participate in scientific research, greatly improving their learning interest and practical abilities during project development. Secondly, while emphasizing practicality, abstract content such as formula derivations and logical operations in the course content can be simplified, leaving homework assignments for students who have extra time or are preparing for postgraduate exams to engage in self-directed and exploratory learning. Thirdly, for "typical knowledge points" that are difficult to understand or where individual students have questions, instructors can establish a micro-lecture video library to provide students with refined learning guidance outside of limited classroom time.

2.4.2. The Reform of Teaching Mode

Since positioning itself as an application-oriented undergraduate university, Huizhou University has been continuously exploring and reforming teaching modes in various majors. Although many achievements have emerged, there are still areas that need improvement. For instance, due to the rigid requirement of research achievements in the evaluation of professional titles, some instructors have put more emphasis on research and thus lack sufficient attention to teaching. This has led to repetitive and monotonous teaching content and methods over the years. Teaching has focused more on completing teaching tasks rather than on students' practical skills, application of theoretical knowledge, and innovation and entrepreneurship abilities, which are highly valued in the training of applied undergraduate talents in this major. Therefore, the teaching mode of "MatSci Fundamentals" currently conflicts with the requirements of applied undergraduate talent cultivation[10]. The

following are the ways in which this course will be reformed and explored:

2.4.2.1. Creating a New Mode of Practical Teaching

The research advantages of the Guangdong Provincial Key Laboratory of Electronic Functional Materials and Devices will be leveraged to create educational advantages, with the strong research conditions of our team being utilized to support course instruction and develop an innovative model for practical teaching. Students' ability to analyze and solve engineering problems will be cultivated, and their practical innovation skills will be enhanced, laying a solid foundation for addressing real-world engineering challenges in the future.

2.4.2.2. Results-Oriented Case Teaching

The teaching format of this course adopts a group project-based approach, with a focus on real-world engineering application problems and case studies. The aim is to cultivate students' problem-solving abilities and innovation mindset, guide their research interests, and integrate ideological and political elements into the curriculum to lead values. The course also includes project-based practical exploration tasks to enhance students' professional skills, and encourages them to participate in the National Metallographic Competition to further improve their practical skills. After 1-2 years of team-based project implementation, students are encouraged to participate in the "China International Internet+ Innovation and Entrepreneurship Competition" to gain a sense of satisfaction and joy, and to develop a strong interest in materials science and innovation entrepreneurship.

2.4.2.3. A blended Online and Offline Teaching Method

The course teaching reform under the new engineering education program requires interdisciplinary, timely, and engineering thinking. Correspondingly, the teaching format of this course also faces challenges. The traditional teaching model, in which the instructor is the main lecturer and students are passive listeners, is changed to a more interactive and inspiring teaching style. Students are encouraged to search for information based on their project progress, and the instructor guides their learning accordingly. With the help of related projects, students can apply and practice their engineering knowledge, which can greatly improve their learning outcomes. After implementing the project-based teaching method, students are expected to explore and learn further on their own if they are interested in related projects. Based on their achievements, they are encouraged to participate in various academic competitions such as the National College Student Metallographic Skills Competition, China International Internet + Innovation and Entrepreneurship Competition, and Challenge Cup, which can enable students to apply their knowledge and deepen their passion for the combination of market demand and engineering knowledge.

2.4.3. The Reform of Assessment Method

Assessing students is an important means of evaluating teaching effectiveness and a crucial component of the teaching process. Therefore, it is essential to have a scientific assessment method. Researching how to design assessment and evaluation mechanisms, reforming the traditional evaluation method of "final exam + regular grades", and reflecting process evaluation and competency evaluation, integrating project participation, teamwork, ideological and political performance, and academic competition results into the assessment system can stimulate students' learning enthusiasm and innovative ability at different levels, help students transition from "passive learning" to active exploration, and improve their comprehensive qualities and abilities.

3. Result Analysis

Currently, the mentorship teaching system has been implemented in our major since 2021, and the "project-driven teaching method" has been carried out on a small scale for two consecutive years. Through the projects, students have gained valuable experience and have even won national and provincial innovation and entrepreneurship projects for two consecutive years. Based on their progress in the projects, teams of students have participated in the "China International Internet+" innovation and entrepreneurship competition in both 2021 and 2022, achieving excellent results with silver medals at the provincial level. Furthermore, the overall professional skill level of students has greatly improved due to the promotion of the "project-driven teaching method". Students who participated in the metallographic skill competition won three first prizes, five second prizes, and two third prizes at the provincial level, as well as one first prize, two second prizes, and four third prizes at the national level. It is the result of the previous course reform that has provided an opportunity to establish a flexible and open learning ecology for this course. Through project-based teaching, we hope to not only solidify the teaching content but also stimulate students' interest in learning, expand their horizons, and gradually cultivate and develop their comprehensive innovation and self-learning abilities from the perspectives of interest, practice, and development.

4. Conclusions

Teaching this course can be quite challenging due to the wide range of topics covered and the fast pace of material updates. As our goal is to cultivate applied talents, we've undertaken systematic reforms to the course content, extracurricular activities, and assessment methods of the "MatSci Fundamentals" course over the past few years. These efforts have yielded tangible results, with improvements in student interest, necessary skills, and innovative practice abilities. Our teaching team has also honed our own practical and innovative skills to better meet the needs of applied undergraduate education.

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