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Practical Measures and Exploratory Thoughts on the Teaching of "Fundamentals of Materials Science" Course

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Abstract: The "Fundamentals of Materials Science" course is an important professional basic course for materials science majors. Based on the current difficulties and problems in teaching and combined with the actual situation of the curriculum setting of the materials science major in our university, this article explores the teaching mode of this course from aspects such as the optimization of teaching content, the comprehensive application of teaching methods, and the mutual assistance between after-class learning and classroom instruction. It emphasizes students' conscious and active learning and cultivates students' interest in materials science research and exploration, so as to achieve the goals of improving teaching quality and students' comprehensive learning ability.
Keywords: Fundamentals of Materials Science; Teaching Reform; Teaching Mode

The "Fundamentals of Materials Science" course is an important professional basic theoretical course for materials majors. It comprehensively and systematically elaborates the relationships and variation laws among the composition, structure and properties of different materials such as metallic materials, inorganic non-metallic materials and polymers, covering contents such as the solid-state structure, crystal defects, diffusion, deformation, recrystallization and phase diagrams of materials. It contains a large number of abstract concepts and definitions, complex principles and laws, and also involves many engineering practical applications, with a very complex knowledge system. Students have great difficulties in grasping the key points of learning and mastering the correct learning methods during the learning process. Therefore, students have low enthusiasm in learning this course, lack active thinking and even develop a weariness of learning. To effectively solve these problems and improve the teaching quality, it is necessary to reform the teaching content and methods, optimize the teaching means, enhance students' interest in learning and stimulate their enthusiasm for materials science research.

1. Problems Arising in Teaching

The "Fundamentals of Materials Science" is the first professional basic theoretical course that undergraduate students encounter when they shift from basic theoretical courses to professional courses. It contains a large amount of professional knowledge and concepts, covering a very wide range of professional knowledge, and almost all chapters and contents are key points of learning. As a professional basic theoretical course that links the preceding and the following, the quality of learning this course is related to students' understanding and mastering in the subsequent professional course learning. However, in the process of communicating with students, it is found that many students think that the course content is dull and boring, and it is difficult to thoroughly understand the abstract concepts and

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principles in a short time; there are too many key contents to handle. When they are still digesting the previously learned contents, new knowledge points come one after another, and sometimes it is inevitable to attend to one thing and lose sight of another.; when grasping the key points of knowledge, they only pay attention to the specific contents without thinking about why these problems are raised and what problems can be solved. Mechanical learning and memory lead to many negative consequences, such as low learning interest, distraction in class and low learning efficiency. It can be seen that this is a difficult course to teach and learn. To improve the teaching efficiency, more efforts must be made in both teaching and learning.

2. Optimizing Teaching Content around the Teaching Purpose

The existing teaching content elaborates in detail the combination and change of the composition, structure and phase state of materials from the microscopic structure to the macroscopic properties. It is difficult to cover all aspects of materials science and ensure a certain depth within the limited class hours. The teaching of "Fundamentals of Materials Science" aims to enable students to master the basic concepts, principles and theoretical knowledge of materials science and establish a thinking mode of the relationship among composition, structure and performance. On the other hand, with the continuous development of science and technology, new materials, new technologies and new processes emerge continuously, making many traditional contents of "Fundamentals of Materials Science" backward and inappropriate in teaching, and appropriate adjustments need to be made in teaching. Optimize the teaching content from the above two aspects.

2.1. Adjusting the Teaching Content According to the Professional Curriculum Setting

The reference textbook used in our university is "Fundamentals of Materials Science" edited by Hu Gengxiang, Cai Xun, Rong Yonghua, etc. published by Shanghai Jiao Tong University Press. This textbook covers polymer materials in many chapters. There is a lot of repetitive content with the "Polymer Chemistry" and "Polymer Physics" courses offered in the same period. Therefore, when teaching, polymer materials are not specially introduced, but relevant contents are reviewed and discussed with students when introducing the commonalities and differences of the three major materials.

2.2. Keeping Pace with the Times and Adding Contents Closely Related to the Course

With the continuous development of new materials and new technologies, some elementary contents are no longer in line with the development of science and technology and need to be supplemented. For example, when introducing the crystal defects in Chapter 3, only a small part of the surface and interface is introduced, while many new materials are based on this. Quantum dots are an emerging functional material with prominent surface effects and characteristics different from general nanomaterials and bulk materials. Surface defects will seriously affect the optical properties of this material. Composite materials have always been an effective means of preparing high-performance and multi-functional materials, and the performance is closely related to the interface situation among different phase states in the microscopic structure. It can be seen that the surface and interface cannot be underestimated in the research and development process of modern materials. Therefore, relevant theories and research trends are added when explaining this part of the content.

2.3. Combining Fast and Slow and Highlighting the Key Points of Teaching

The content of "Fundamentals of Materials Science" is very rich. In the early stage of teaching, slow down the pace appropriately to let students accept the fact that it is different from previous basic theoretical courses when they first come into contact with this course, correct their attitudes and take this course seriously. At the same time, give students sufficient time to master some basic concepts and theories of materials science and lay a good foundation for the subsequent learning. Especially, the crystal defects in Chapter 3 are a completely new theory for students. The teaching content of this part links the preceding and the following, that is, it is related to the solid structure and is the theoretical basis for the deformation and recrystallization of materials. Only by understanding and learning this part of the content well can students better learn the contents of the subsequent chapters. However, in this part of the content, there are many abstract concepts (such as edge dislocation, screw dislocation, perfect dislocation, partial dislocation, etc.) and

complex theories (Burgers vector reaction, jog dislocation, etc.), which are very easy to make students feel confused and bored. Therefore, when explaining this part of the content, it is necessary to explain it repeatedly and patiently guide students to learn and master this part of the content.

3. Comprehensively Applying Teaching Means to Improve the Quality of Classroom Teaching

The teaching task of "Fundamentals of Materials Science" is heavy and the class hours are tight, so the teaching method of "cramming" is inevitable. Students are relatively passive in learning and are prone to negative and slack emotions and lack the motivation to learn. How to improve students' attention and stimulate students' interest in materials science learning and research in the teaching process is a question that must be considered. In teaching, it is found through observing students' behaviors that whenever the teacher mentions some related events, interesting anecdotes, scientific research trends, or shows pictures and videos, it will attract students' attention to varying degrees. During this period of time, students can quickly understand and master the key points of learning and actively ask questions and think about problems.

3.1. Using Multimedia Flexibly

In materials science, from the microscopic to the macroscopic, much knowledge is related to the spatial structure and requires rich spatial imagination ability. It is difficult for students to understand only by relying on the plane drawings in books. Multimedia teaching can use computer technology to make courseware and introduce three-dimensional animation into the classroom to vividly and intuitively show various spatial structures for students and help them learn and understand. For example, when explaining the crystal structure of metals, using three-dimensional graphics can help students intuitively analyze the crystallographic characteristics such as atomic radius, number of atoms in the unit cell, coordination number and interstitial; when explaining dislocations, it can help students understand how dislocations move, multiply and react; when explaining ternary phase diagrams, three-dimensionally analyzing the phase diagrams can help students quickly master the boundaries of single-phase, two-phase, three-phase and four-phase regions and the true meanings of points, lines and surfaces in the phase diagrams. This vivid teaching means has a significant visual impact effect, can immediately attract students' attention, help students overcome obstacles in the learning process, make obscure concept theories vivid and interesting and stimulate students' interest in learning. At the same time, it solves the deficiencies of teachers in language and blackboard writing and improves the classroom teaching efficiency.

3.2. Introducing Interesting Anecdotes

The history of materials development is the history of human civilization development. Introducing well-known interesting anecdotes in the classroom shortens the distance between students and profound materials theories, makes students more deeply realize that materials science is around us, deepens the impression and sense of intimacy of materials science and thus improves learning interest. For example, when talking about alloys, show the picture of the Sword of Goujian. The story of Goujian is familiar to students, and they have a certain sense of intimacy and curiosity about the sword he wore. When students are asked "Why does this sword still look gorgeous and sharp after thousands of years", it can naturally arouse their active thinking. With confusion, they will seek answers. When students study with questions, their attention is greatly improved. At this time, through appropriate guidance and cooperate with the explanation of alloy strengthening related to alloys, the role of solute elements and other contents, students listen with great interest and also understand the scientific meaning of this part of the content more deeply.

3.3. Combining with Scientific Research Practice

In the basic knowledge of crystallography in Chapter 1, a small part of the content introduces the knowledge of reciprocal lattice to students. This part of the content involves mathematical derivation. The difference between the lattice derived from mathematics and the real lattice is easy to make students confused and it is difficult for them to understand what this part of the content is about and what it can do. At this time, introduce X-ray diffraction technology

to students. When students understand the magic of the reciprocal lattice and admire the intelligence of scientists, their learning enthusiasm is stimulated. When introducing the Kirkendall effect in Chapter 4, introduce to students how Kirkendall designed the experimental scheme to prove the non-reciprocal diffusion in solids when studying the diffusion law of atoms in solids. At the same time, although this experimental technique was invented earlier, it is still used to prepare functional hollow nanospheres and has new vitality. Let students understand that even early theoretical knowledge can be "used today". They should not think it is "outdated and useless" and not study it carefully just because the theory was formed a long time ago.

3.4. Making Full Use of Network Resources

Up to now, the development of information technology has greatly broadened people's horizons and also provided a platform for many enterprises and factories to show themselves. Through network videos, many industrial information technologies can reach the vision of ordinary people. Especially some video resources related to materials processing are more precious for colleges and universities that cannot offer experimental courses of metallic materials. By finding suitable resources, the production practice far from the campus is presented in front of students at a close distance, making students more truly and vividly understand the guiding significance of the principles and laws in materials science in the actual production process. Materials science that can be "seen, thought and used" can stimulate students' learning enthusiasm and improve learning effects. For example, many video resources about the processing of "shafts" can be found on the Internet, ranging from bicycle shafts to generator shafts. The processing processes of different shafts are very different, but the principles of melting, casting, forging, tempering, annealing and surface treatment of iron and steel materials involved are the same. By watching videos, students can better understand these knowledge and have some preliminary understanding of the application of materials science in production practice.

4. Combining Classroom Teaching with After-Class Self-Study

"Fundamentals of Materials Science" is difficult to teach and learn and the teaching hours are limited. To enable students to learn more materials science knowledge within the limited time, in addition to working on the teaching content and teaching means, it is also necessary to give full play to students' subjective initiative as much as possible. Assigning after-class exercises is an effective means to help students with self-study. Students must have a certain mastery of relevant knowledge to successfully complete the after-class exercises. At the same time, teachers can also understand students' mastery of knowledge points from the completion of after-class exercises and re-explain the contents with more errors and greater misunderstandings. In addition to assigning after-class exercises, small papers can also be set according to the course content. Excellent scientific research and degree papers are good supplementary teaching materials. Let students strengthen their understanding of the learned content and understand what scientific research in materials discipline is in the process of researching papers. Use advanced science and technology to stimulate students' enthusiasm for learning "Fundamentals of Materials Science" and engaging in materials science research.

5. Conclusion

With the development of human civilization and science and technology, more and more requirements are put forward for materials. As students majoring in materials, they must adapt to such new requirements. Therefore, it is necessary to reform the existing teaching content of "Fundamentals of Materials Science", improve the teaching methods, stimulate students' interest and desire to learn this course, improve their learning enthusiasm and fully mobilize students' initiative to participate in learning. Lay a solid foundation for the subsequent learning of various professional courses, cultivate qualified R & D talents for the materials industry and promote the rapid development of the materials industry.

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