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Research on Teaching of "Mechanical Design Methodology" on Account of Outcome-Based Education

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***Abstract*—Outcome-based education is regarded as a very successful educational reform at domestic and overseas. Teaching reform of "mechanical design methodology" was carried out according to outcome-based theory. It is conducive to talent training and promoting higher education in line with international standards. The course syllabus has been revised and improved, and the teaching content has been adjusted to satisfy the outcome based education. The teaching method has been innovated and reformed based on the student-centered and orientated by "student development, student learning and learning effect". The new teaching method was formed with the student-centered, teacher-led and social environment as the practical background. In the aspect of course assessment, we pay attention to the whole teaching process, including classroom attendance, classroom discussion, extracurricular design homework, final exam, etc. The practice showed that a good teaching effect was achieved.**

Keywords—Outcome based education; Engineering education; Mechanical design methodology; Knowledge construction; Learning transfer

I. INTRODUCTION

Outcome Based Education (OBE) was first proposed by Spady et al., in 1981, it soon gained people's attention and recognition, and became the mainstream concept of education reform in the United States, The United Kingdom, Canada and other countries, which was considered as a very successful education reform [1, 2]. The American Association for Accreditation of Engineering Education (A-BET) fully accepts the CONCEPT of OBE and carries it through the certification standards of engineering education. In June 2013, China was accepted as a signatory member of the Washington Agreement. On June 2, 2016, At the International Engineering Union Conference held in Kuala Lumpur, China signed on as a full member of the Agreement on mutual Recognition of International Undergraduate Engineering Degrees. It is of great significance to guide the reform of engineering education with THE OBE educational concept to establish a world-class university and a first-class major.

Traditional methods of evaluating students, which focus on choosing the right answer from several given answers, often test memory rather than show what students have learned. OBE emphasizes that students should achieve Learning outcomes through teaching design and implementation [1]. The OBE evaluates what students can do, not what they know. The OBE requires students to demonstrate their competence through challenging tasks, such as making project proposals, completing project planning, conducting case studies, and giving oral presentations. Such tasks enable students to show their abilities of thinking, questioning, researching, deciding and presenting [4]. Therefore, the OBE places students in an environment where they can develop their design skills to complete a complete process. The OBE focuses more on higher-order abilities such as creative thinking, analyzing and synthesizing information, planning and organizing. This ability can be gained by working as a team on some of the more complex tasks. Based on constructivism and student-centered education philosophy, OBE advocates taking students' learning outcomes as the core, designing the teaching process, expanding students' learning opportunities and making them reach the academic peak step by step [5, 6]. Therefore, the definition of learning outcomes, the teaching methods to achieve learning outcomes, and the assessment of learning outcomes become the key issues.

Mechanical Design Methodology is an optional course set up by our college to improve the product design ability of students majoring in machinery. At present, there are plenty of mechanical product in different area, such as in industry or in life. In the commercial society, all kinds of mechanical products are available for people to obtain, and these products can meet all kinds of basic needs. Therefore, it is required that trained talents can design "products with competitive advantages", and students should take the initiative to build knowledge systems to meet the needs of innovation and creation. The teaching under the guidance of OBE education philosophy can better cultivate such talents.

II. INNOVATION OF TEACHING SYLLABUS AND TEACHING CONTENT BASED ON OBE CONCEPT

According to the OBE concept, the formulation of the syllabus and the selection of teaching content should be determined according to the requirements of the current society for graduates. Therefore, aiming at the strategic upgrading requirements of intelligent manufacturing and Industry 4.0, we conducted in-depth enterprise research, and further adjusted and improved the teaching syllabus according to the first-hand data collected and the general background of national innovation and entrepreneurship. After the adjustment, the course targets are as follows: to enable students to establish the design idea of mechanical products with customer demand as the target and function as the guide, and to establish the design consciousness of developing new products by using the method of functional analysis. Cultivate students' ability to apply new functional principles to practical product design and enhance students' awareness and ability of commercial design. Enable students to further understand the whole design process of mechanical products and have the ability to "put forward creative ideas and convert them into competitive products as soon as possible", thus laying a good foundation for engaging in mechanical design and manufacturing work in the future. The course aims to cultivate students' design ability by comprehensively applying the theoretical and professional basic knowledge they have learned, which is the learning outcome pursued by this course. To the achievement of learning results, we made three aspects of subdivision: (1) in the grasp of the degree of knowledge, we pay attention to train students to distinguish the various types of mechanical design problems, to transfer design demand into design required constraints, goals and design decisions. The students should master the method of function decomposition and analysis of mechanical products, the design method of motion function and process function, master the key technical function and comprehensive technical function characteristics and solution ideas and methods, and learn to design the method of mechanical motion system that meets the functional principle. They should understand the core and peripheral problems of mechanical product design, grasp the task and main content of practical design, master the key points of mechanical structure design, and learn to carry out practical design of functional principle prototype. Also, they should master the five measures of mechanical product commercial design, learn to the overall design ideas and methods of the functional principle design, practical design, and product commercial design. (2) In the aspect of ability training, we focus on training students' ability to transform design requirements into constraints, goals and design decisions required by the design, and cultivate they ability to have different types of design ideas. The students' design ability oriented by functional requirements was emphasized and their ability of functional principle design was cultivated. The students' ability of practical product design based on functional principles and commercial design ability of improving product market competitiveness were cultivated. Finally, the student should be cultivated to have the overall design ability of functional principle design - practical design - commodity and design. (3) As the quality training, the student was expected to have the design philosophy of improve the product competitiveness as the design goal, have the consciousness of design the quality into the product, and formed a good design quality.

Centering on the three elements of competitive product design, namely, functional principle design, practical design and commercial design, we revise the teaching content to grasps a main line and three basic points. The main line refers to cultivate students have the competitive advantage of product design. The three basis points, respectively is: physical fields for the integrated use of mechanism as the core function of principle innovation design, based on the structure design, the integrated use of modern design theory and technology of practical product design, as well as value optimization design as the core of commercial design. In the teaching process, attention should be paid to the cultivation of students' awareness and skills of mechanical design and innovative design ability, and the positive transfer of knowledge.

III. TEACHING METHOD INNOVATION BASED ON OBE CONCEPT

According to the OBE concept, student-centered teaching method is also the inevitable trend of the reform and development of higher education in the world, and is the key to improve the teaching quality of higher education. On the basis of adopting modern educational technology, it sets up the student-centered teaching concept, adjusts the center of "teacher, textbook and classroom". The teaching process was divided to classroom lectures and discussions, as well as the process of complex homework and practice after class, and organically combines the teaching process after class. The complex homework will be arranged from the first class, with a main line running through the three knowledge points of functional principle design, practical design and commercial design, and three reports and discussions according to the schedule of the lecture. As a professional course, "mechanical design" is a course offered on the premise that students have basic theoretical knowledge and basic professional knowledge, so it is necessary to comprehensively use the content of the advanced course. However, many students find it difficult to apply what they have learned to the new scene. The so-called gourd boiled dumplings could not be poured out. For example, the basic thermal effect and piezoelectric effect are known to students, but it is difficult to relate them to the functional principle design of products. Through some examples of product design, the course aims to open up the path of knowledge transfer for students. There are two technical routes for inkjet printers. One is the use of thermal effect. The other utilize the piezoelectric effect, in which an expanding piezoelectric crystal pushes an ink drop out of a nozzle, and the two effects are identical, with no discernible difference from the user's point of view. Each company owns its own patents and intellectual property. For another example, as to magnetic effect, students are not strange, they also know hard disks, magnetic tapes, and disks work based on the near-field magnetic record information technology. But they do not understand why storage density can be increased in exponential in the decades with the same technique system, and whether the storage density can increase unlimited, if there is a limit, how to break through and so on. To this end, the course introduces the influence of surface roughness, surface ultra-

precision machining technology, domain arrangement, and paramagnetic effect and so on, and then spreads to lithography storage, IBM millipede technology and all that. IBM millipede technology of hard disk can breakthrough on the order of magnitude of magnetic hard disk, the prototype has launched more than ten years, but never put on the market, to organize the students to discuss, content involves many aspects such as material, advanced manufacturing, market demand, make the students will have the knowledge as much as possible out of, and rebuilding, used for innovative design. As stated in the transfer theory, it is difficult for knowledge to automatically and spontaneously migrate forward due to implicit and inert reasons, so it needs to be stimulated [7, 9]. Just as what constructivism says, fragmented knowledge needs to be reconstructed in the brain to form a knowledge system suitable for individuals before it can be used in practice and innovation [7, 8]. While stimulating students to use various physical effects, the application of "material field analysis method" in functional principle design should be timely taught. In terms of product design ideas, we taught and trained students to extract design boundaries from vague market demands, transform them into design requirements, form specific products, and then conduct market verification.

The complex homework after class can exercise students' practical ability, the ability to consult materials, and the ability to know the society and understand the needs. The industry-University-Research practice base of our college is a good practice platform, which is a high-quality practice base of our college and is open to teachers and students of our college without reservation. However, the product categories of an industry-University-Research practice base cannot cover all design types, so generalized practice is another feature of this course [10]. Students can actively participate in the display, work, repair, maintenance and other scenes of products from the open environment of the society to accumulate the knowledge needed for design. Cars, for example, is a kind of complex mechanical and electrical products, spare parts more than ten thousand, a lot of structure design is clever, to ensure safety, energy saving, comfortable, environmental protection, a lot of advanced technology, the application of widely auto repair shop can help students understand the car structure, growth design knowledge, improve the design interest, stimulate inspiration. China's infrastructure is in the ascendant, construction machinery can be seen everywhere, so that students can understand the structure and working principle of construction machinery. For example, how the tower crane on a building site grows with the height of the house, how the cement pump truck makes the pipe stretch and stretch, and so on. Others, such as hardware and electrical equipment shop and various industrial product exhibitions, are platforms for understanding mechanical and electrical products and accumulating design experience. The complex homework after class groups, each group is a research and development team, students are required to explore the market demand, customer needs analysis, and then to carry out the function principle of the design (to make the function principle diagram and function structure diagram), according to design principle, structural design and manufacturing process analysis, the final analysis related to design marketing strategy and marketing. In order to help students better finish homework, we also set up a discussion group, convenient between teachers and students, student exchanges, in addition to the targeted students, teachers can also use some advanced design technology of the latest information to students, students can also make you interested in the course contents posted sharing, these are beneficial to provide a good learning atmosphere, the growing interest in the design and capability.

IV. Evaluation and Assessment Innovation Based on OBE Concept

Based on OBE concept, the teaching process is divided into multi-stage teaching objectives. According to the teaching method of "student development, student learning and learning effect" of the new three center, the evaluation and assessment of the whole teaching process are strengthened to make the students have clear learning objectives, be busy with learning and focus on learning. The examination is divided into several links, such as course attendance, class discussion, extracurricular design homework, final examination, etc. Attendance checks students' discipline and learning initiative to ensure that students make the most of their time in class. Class discussions include discussions on design assignments, as well as in-class interactions and pre-emptive responses, aimed at assessing and imposing students' basic knowledge, learning initiative, and problem-solving abilities, as well as team communication skills. The purpose of designing large homework is to cultivate and inspect the students' ability to consult literature materials, make use of public resources, self-study ability and quality, teamwork ability, innovation and problem-solving ability, etc. Homework assignments begin at the beginning of the course and unfold as the course progresses. The work should be submitted in three times for the convenience of mastering the design progress and giving timely guidance. The final work should include complete product design drawing and specification. In the functional principle design stage, the practical structure design stage, and the final commercial design stage, students are required to make PPT, defense, and the whole class participate in the evaluation and discussion. The content of the submission also includes the division of labor and collaboration arrangement of team members, group discussion videos, etc., aiming to cultivate the teamwork ability. The evaluation and discussion of other group work will help improve students' ability to analyze and solve problems. At the same time, the discussion and evaluation in stages are convenient for students to find the gap. During the learning process, students can know how much they have mastered the knowledge in each stage at any time and adjust their learning status timely.

The score of the final exam accounts for 50%. It aims to test the students' mastery of the course knowledge and their ability to analyze and solve problems with the knowledge they have learned. Under the promotion of assessment and evaluation by stages, the foundation of students has been strengthened, and the ability of students to attach importance to classroom learning, listening carefully and thinking independently has been cultivated, which has avoided the bad habit of "brushing" during the examination and put an end to the practice of students asking about "examination points". According to the characteristics of the course, the final exam of

this course is open to the public. Students can bring books, homework, notes, and collected materials and so on. But they must complete the test independently, they can only use the materials they brought themselves and were not permitted to exchange the materials. Because it is an open-book exam, the questions are flexible and the answers are open. For example, the students were asked to imagine the functional principle solution of a product, or design the realization method of a functional principle, etc., there are many different solutions to the same problem. The feature of the examination questions is that they need to use comprehensive knowledge, examine the ability of knowledge transfer of students, and also help students to build their own knowledge system.

Since the educational reform activities based on OBE have been carried out, students' learning enthusiasm has increased a lot, and the class is active. Some students can gradually apply the knowledge they have learned or come into contact with to the design of products, so that the products have a competitive advantage in terms of functional principle, practical structure or commodity characteristics. In the discussion sessions of the phased evaluation of the assignments, the sparks of ideas were often met, and the resulting large assignments produced many excellent works, and the final exam scores were better than ever.

V. SUMMARY

OBE has become the mainstream concept of education reform in the United States, The United Kingdom, Canada and other countries, and is regarded as a very successful education reform. In recent years, China has also carried out a wide range of related research. This paper introduces the teaching reform practice of mechanical design based on OBE educational concept. According to the characteristics of OBE teaching philosophy, we have carried out all-round reform and exploration in teaching outline, teaching content, teaching method, examination and evaluation, etc. The teaching syllabus is revised and perfected, and the teaching content is adjusted to meet the requirements of the current society for graduates. The teaching method is innovated and reformed, highlighting the transformation from the old three centers of "teacher, teaching material and classroom" to the new three centers of "student development, student learning and learning effect", and forming a teaching method with students as the main body, teachers as the leader and social environment as the practical background. In terms of course assessment, it pays attention to the evaluation and assessment of the whole process, so as to make students clear their learning objectives and achieve the purpose of being busy with learning and focusing on learning. The evaluation and examination of the whole teaching process, including class attendance, class discussion, extracurricular design, and final examination and so on, has achieved good teaching effect.

REFERENCES

[1] Li Zhiyi. Analytical engineering education professional certification results oriented concept [J]. China's higher education, 2014 (17): 7-10. (*In Chinese*).

[2] Li Zhiyi, Zhu Hong, Liu Zhijun, Xia Yuanjing., with results oriented education concept to guide teaching reform of higher engineering education [J]. Journal of higher engineering education research, 2014 (02): 39-34 + 70. (*In Chinese*).

[3] He Jingjing. All China to win the Washington agreement formal membership - engineering education in China to realize international multilateral mutual recognition [EB/OL], http://ceeaa.org.cn/main!newsView.action?menuID=01010101&ID=1000011619, 2016-06-04/2019-11-20. (*In Chinese*).

[4] Pei-hua Gu, Hu Wenlong, Lin Peng, Bao Nengsheng, Lu Xiaohua,Xiong Guanggjing, et al., based on "learning outcomes" (OBE) engineering education mode --, the practice and exploration of Shantou university [J]. Journal of higher engineering education research, 2014 (1): 27- 37. (*In Chinese*).

[5] Tian-en shen, ShenLiRan. Results oriented education concept learning outcomes of the definition, measurement and assessment, the year of America's exploration and practice [J]. Journal of higher education to explore, 2018, 54 + 188 (12): 49-85. (*In Chinese*).

[6] Zhu Mei-hua, XiYing, Lu Jiawei, Wang Guohua, Yang Yujuan. Results oriented education ideas in the teaching of "mechanical engineering material" practice [J]. Journal of mechanical design, 2018, 35 (S2): 51-53. (*In Chinese*).

[7] Compile a Hunan province department of education. Psychology of higher education [M]. Changsha: Hunan University Press, 2007. (*In Chinese*).

[8] Feng Zhongliang, Wu Xinchun, Yao Meilin, Wang Jianmin. Educational psychology [M]. Beijing: People's Education Press, 2000. (*In Chinese*).

[9] Shen Rulin. Discussion on the application of learning transfer theory in tribology teaching [J]. Journal of Changsha Railway Institute (Social Science Edition), 2009, 10(1):94-95. (*In Chinese*).

[10] Shen Rulin, GONG Y L. Teaching Model based on generalized Practical Environment -- Discussion on teaching Model of Mechanical Design [J]. Journal of Changsha Railway University (Social Science Edition), 2012, 13(1):136-137. (*In Chinese*).