The Practice of CDIO-Based Teaching Reform on Postgraduate Major Course—A Case Study of Course "Reliability Theory and Application"

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Abstract. In this paper, course content design and teaching mode exploration based on CDIO concept were discuss on postgraduate major course "Reliability Theory and Application". In order to explore teaching innovation mode with distinctive major characteristics, and to improve students' engineering practice and innovation ability, based on the CDIO engineering education concept, tracking feedback of phased teaching effect is investigated and analyzed, and finally, the further conception of teaching reform is given. The tracking feedback shows that teaching based on CDIO engineering education concept is conductive for students to understand and adapt to work requirements, and also beneficial to stimulate students' interest and initiative.

1. Introduction

Compared with undergraduates, most postgraduates will engage in works with higher professional requirements after graduation, and even be required to become a manager as soon as possible. Therefore, how to train students to put professional knowledge they have learned into practice, and cultivate students' teamwork spirit and ability to discover, analyze and solve practical problems are important directions for reform and innovation on engineering postgraduate education. [1].

CDIO is an abbreviation of four English words (C: Conceive; D: Design; I: Implement; O: Operate), which generalizes the whole life process of industrial products, from conception to implementation and even to the end. CDIO engineering education, an important achievement of international engineering education reform in recent years, received extensive attention from engineering educators around the world, are beneficial to not only high-level but also general engineering major education. The basic idea, having a good inspiration for Chinese higher engineering education, is to closely integrate business needs with engineering education and comprehensively cultivate students' engineering practice and innovation ability [2]. In recent years, the research results of postgraduate course teaching reform based on the CDIO concept have been published continuously [3-5].

Reliability, a basic element of product quality characteristics and the key to improve products quality, plays an increasingly important role in products' whole life cycle, including r&d, design, manufacturing, use and maintenance [6]. With the large-scale construction of rail transit in China, such as high-speed railways and urban rail transit, the reliability of rail transit equipment and facilities is directly related to rail transits safety and life cycle cost. The demand for reliability engineering professionals is increasing from equipment R&D and manufacturing enterprises to railway bureaus, subway companies and other operational units [7]. So institute of Rail Transit of Tongji University has set up "Reliability theory and application" as an elective course for postgraduates since 2006. Considering that reliability engineering is characterized by interdisciplinary, high theoretical requirements and strong practicality, and rail transportation also has its own professional characteristics, the course must focus on the combination of theory and engineering practice, which is different from only-teaching courses and general social practice courses, but consistent with the

CDIO engineering education philosophy. Based on the CDIO engineering education concept, taking “reliability theory and application”, Tongji University's engineering postgraduate course, as research and practice object, this paper explores postgraduate education reform and innovation with strong professional characteristics, and try to provides practical reference for postgraduate courses construction, which are aimed at cultivating high-level and innovative engineering talents.

2. Teaching Challenges

According to teaching situation in the past years, it can be found that the teaching implementation of "reliability theory and application" needs to face two big challenges.

The first challenge is diversity of audience. This course is not only for postgraduates who major in Transportation Engineering and Vehicle and Operation Engineering, but also for students from other institutes. This means that students with different knowledge backgrounds and learning intentions study together. So course content and mode must be carefully considered, designed and timely adjusted. For example, teacher needs to adjust the depth and breadth of course content according to students’ knowledge background; teacher has to create appropriate class atmosphere and stimulate students’ learning interest by design and match course content according to students' learning characteristics and learning intention. All of these require teachers’ teaching experience and classroom control ability.

The second challenge comes from the lack of teaching materials. Teaching materials are the basic elements and important tools and play a fundamental and guiding role in class. However, the existing textbooks or professional books related to reliability engineering on the market are basically applied to aerospace or national defense equipment. This course is oriented to the rail transit industry, and its theoretical focus, practical object and implementation mode are all different from the national defense and military industry. At the same time, the diversity of audience also promoted teaching mode innovation, so that the traditional teaching model, mainly depending on teachers’ explanation, is not suitable for this course. The lack of textbooks brings some difficulties to not only teaching, but also students' preparation and review. At present, the teaching team remedies the defect by printing and distributing part of handouts and listing the reference books. In the meantime, the team is accumulating materials and plans to complete teaching materials construction with the support of subsequent teaching reform projects.

3. Teaching Reform and Practice

The "reliability theory and application" teaching team has carried out a continuous reform attempt since 2010. In this process, the teaching team, on the one hand, grasps students’ learning characteristics firmly, and adjusts teaching practice according to students’ actual situation in each class; On the other hand, attaches great importance to multi-party communication with industrial departments and timely feedbacks the acquired information. After several years of unremitting efforts, the teaching team has gradually clarified the teaching objective and content, and improved teaching mode and evaluation.

3.1 Teaching Objectives: Based on CDIO Engineering Education Concept

Based on CDIO engineering education concept, the following teaching objectives have been established: this course ,involving reliability engineering practice of rail transit equipment’s whole life cycle, can guide students apply reliability theory and technology through the model "case guidance, project driven, teamwork", train students' ability to discover, analyze and solve practical engineering problems, and improve students' abilities in team organization, task allocation, member communication and other aspects, and cultivate positive and cooperative spirit.

3.2 Teaching Content: Keeping Close to Engineering Practice

In order to contact theory with practice, the whole life cycle reliability project of rail transit products becomes the course's main line. The organizational structure is shown in figure 1.

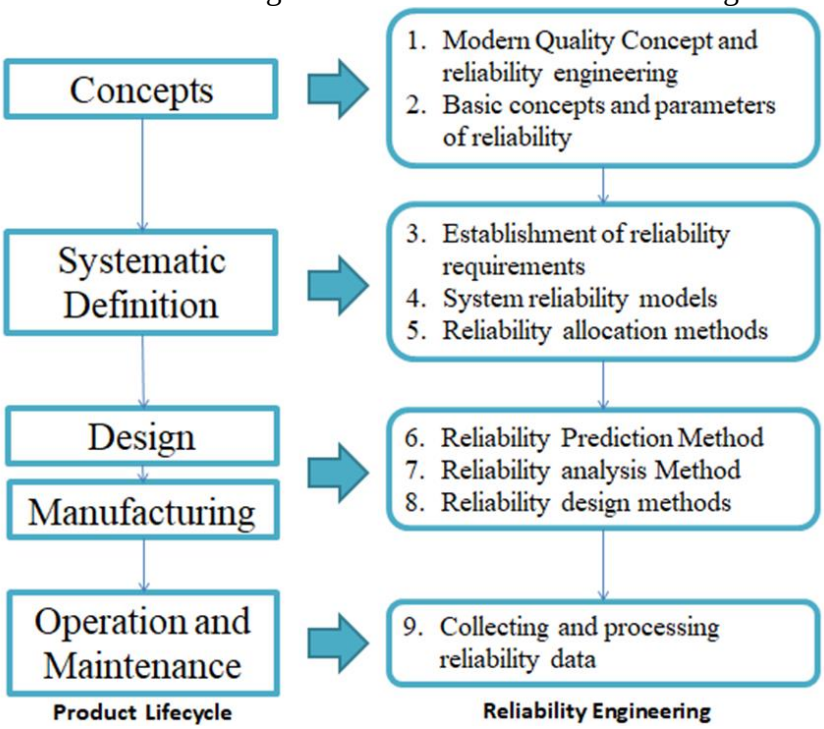

Fig.1. Organization chart of teaching content

The course content includes basic concepts of reliability, common mathematical models and technical methods involved in reliability work projects, etc. The organizational structure is closest to reliability engineering practice in rail transit field. According to 9 basic topics divided by course content, the 54-hour course is divided into 36 hours of theoretical study and 18 hours of practice. It can also be expanded or tailored according to how much course hours are and whether students understand. For example, the introduction of reliability parameters can be appropriately added or reduced, or the content about reliability design can be expanded.

3.3 Teaching Model: Student-Centered

The curriculum repositioned the two roles, teaching and learning, and changed from teacher-led to student-centered. Students become the protagonists, while teachers are the classroom atmosphere builders, course guiders and the helpers. On this basis, teachers and students can learn to do and do to learn. Under this role setting, teaching team introduced the seminar teaching paradigm, which core is "teacher-student discussion and interaction". Many educators in Chinese colleges and universities are also focus on implementing this paradigm in recent years [8-11], due to the paradigm's good effect in arousing students' interest in active learning, cultivating the students' research thinking, exercising students' ability to collect and process information, and improving students' comprehensive ability to grasp new concepts, interactive communication, teamwork, speech expression and so on. Finally, the course "reliability theory and application" established the basic teaching mode of "Lecture + Seminar". The following methods are specifically carried out:

(1) Theme-based Seminar

Theme-based Seminar is mainly used for theoretical learning in this course. In general, the theoretical learning is taught by teachers, supplemented by students' topic sharing in groups. Except basic concepts and important mathematical formulas or models, other knowledge's teaching process is "firstly self-study, then exhibition, sharing and teachers' Q&A". For example, reliability design method is suitable for self-learning, due to the flexible and diversiform contents, involving electronics,

machinery, software and environmental protection, have clear themes but few connections among them.

(2) Case-based Seminar

Case-based seminar is the main teaching method in this course. "Building a real engineering background and aiming at a specific theory" is the key to develop case-based seminar. These cases, accumulated by the teaching team, come from the product design and development companies (such as the rail transit equipment manufacturer), as well as the product use and maintenance companies (such as the rail transit operation company), all of which reflect actual problems and demands. After introducing the theoretical methods of a certain topic, the teacher provides corresponding case background and assign tasks, then students discuss in groups according to the actual situation, give solutions, form the class work report, display and accept questions. The teacher participates in discussions, answers questions, comments on solutions and helps organize conclusions, etc.

(3) Round-table Seminar

In order to shorten the distance between course and engineering practice and improve students' ability of professional research and communication, the teaching team started the "round-table dialogue" seminar teaching module since 2015. The teaching team invites senior reliability experts, working in the first line of engineering, so as to deepen students' understanding of course content by means of topic lecture and free question.

(4) Research-based Seminar

In view of the on-site investigation activities, which often involved in engineering practice, the course also carries out research-based seminar teaching module, so as to help students improve engineering innovation and teamwork ability, and obtain the first-hand experience of Engineering practice. Teachers put forward research topics, then students discuss research objectives in groups, design questionnaires and carry out practical professional investigation.

3.4 Grade Assessment: Reward-oriented

Teaching model innovation leads to the reform of course grade evaluation method. In this course, students' theoretical test and practical learning are comprehensively considered. Besides, team performance, personal questions and answers, and other classroom performances are emphasized, so as to stimulate students' enthusiasm to participate in discussion and teamwork. The participation degree is a basic evaluation factor that cannot be ignored, and students' learning experience and cognitive growth through participation are also the important aspects. In view of these, the course establishes a reward-oriented approach to grade assessment:

(1) Raise the ratio of the ordinary grades. The ordinary grades account for 60% of the total grades, and the final grades account for 40%.

(2) Assess attendance. Students can get one point for every time they show up, and students who leave more than three times cannot get A.

(3) Assess participation in class. During review, with which every class begins, students who answer more than one question actively and correctly will be awarded bonus points. Extra points will be given to those who actively participate in seminars (dare to express opinions) and perform well in teamwork (actively participate in the proposal and formation of case solutions, and dare to respond to others' questions together with groupmates).

(4) The final exam is an open-book examination. Students can bring their notes to the exam.

4. Teaching Effect Tracking

"It takes ten years to grow a tree, but a hundred to rear a man". How to appraise the teaching effect is an important part of the teaching reform. In author's opinion, teaching effect evaluation should not be limited to short-term behavior (for example, midterm or final term teaching supervision, and students' evaluation of teaching). This kind of evaluation is timely, and not complete! After students finish the course, although they leave the class, teaching influence will continue. It is very necessary for us to

extend the teaching effect evaluation. In view of this, the teaching effect evaluation requires us to observe and obtain the teaching results' real presentation for a long period. In order to find reliable results, the team has to establish a long-term teaching effect tracking system consciously and gradually in the process of teaching. The adopted methods include selecting student contacts by enthusiastic volunteers or classmates, and using social platforms such as QQ or WeChat. Moreover, the teaching team should establish the long-term relations with students.

So far, five of the seven grade students have been working. From October 2015 to November 2015 and August 2018 to September 2018, the teaching team has carried out twice previous students questionnaires, expecting to make periodic feedback analysis on the teaching effect and provide support for the subsequent course construction.

4.1 Students' Teaching Recognition

The teaching has received most students' recognition. Some of them mentioned "the class atmosphere is great! I like these practice links", "this class is very interesting and useful", "It's the most impressive, relaxed and happy class atmosphere", "the diversification of teaching methods is most impressive for me, including learning through multimedia video, project examples and students' sharing, from which I learned a lot" and so on.

4.2 Relevance of Teaching and Students' follow-up study / work

Most students think that this course is related to their follow-up study/work. All the students, engaging in product design and technical consulting services, believe that their work involve reliability knowledge. One third of these, engaging in marketing analysis and management say the concept is extremely helpful. Especially, they mentioned "because the work involves the product development, which is closely related to reliability", "the course helps me establish the concept to pay special attention to the reliability and stability of products in the development process", "when the products are improved to higher quality, the reliability is the key " and so on.

4.3 Course Support for Students' Follow-up Study/Work

It can be found from questionnaire results that students' work contents decide whether the course is helpful. We found some interesting common phenomenon: students working in design industry believe that professional explanation is most helpful. They mentioned "The greatest help for me in this course is teacher's explanation.", "It's helpful, especially the professional knowledge." and so on, and even hope have a further study. Students engaging in consulting or market analysis believe that giving presentations are most helpful. They mentioned "I think the most helpful part for me is giving presentations, for it involves various practices, such as material integration, PPT production and presentation, all of which are important abilities in the work.", " What can help me most is the group discussion and presentation. My current work is not closely related to my major, but group discussion and personal presentation can improve my comprehensive ability." In addition, the "group research and practice" also has good reputation. Students said, they "learned a lot", and" understood why reliability plays such an important role in practice" and "hope more seminars can be held in the future".

4.4 Suggestions for Teaching

According to questionnaire results, students showed great enthusiasm and concern for this course and put forward their own suggestions, which are basically concentrated in three aspects: enriching the instance-driven theoretical teaching; increasing the group discussion time; strengthening the personal presentation.

5. Further Conception of Curriculum Reform

Explore innovation and keep pace with the times. Under this purpose, based on the existing teaching reform practice results and feedback, the teaching team will continue to promote the curriculum

reform, and strive to achieve the harmonious unity of CDIO concept and the curriculum's specialty characteristics.

As mentioned above, the engineering cases used in the course are all real cases accumulated by the teaching team over the years. However, due to limited personnel, time and funds, the cases are fragmented, which makes it difficult to further expand students' horizons and improve their cognition. Case base construction plans to be completed through companies' supporting and following educational reform project's funding.

In addition, only 62% of students responded to the questionnaire. Due to information lost caused by changing job and so on, there are still obstacles to the establishment of long-term teaching effect tracking system, which need to be explored in the future.

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