IMPROVEMENT OF CDIO SKILLS BY USING INTEGRATED CURRICULUM ARCHITECTURE IN ENGINEERING DRAWING

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ABSTRACT

Engineering drawing course is a very essential subject in training and improving the students' divergent thinking, imagery thinking, spatial imagination ability and creativity. In order to improve CDIO skills, especially the students' innovative ability, meet the requirement of industry development, and improve the quality of engineering drawing education, it is necessary to design and practice the new curriculum architecture for engineering drawing. We have rebuilt curriculum architecture of engineering drawing education based on the concept, syllabus, and standard of CDIO. After 4 year's education reform and practice on engineering drawing in Chengdu university of Information Technology (CUIT), we have achieved obvious efforts. Not only the engineering undergraduates learn how to communicate using the graphic language, such as the surveying and understanding the engineering drawing, but also the CDIO skills, especially innovative ability of engineering undergraduates, have been improved significantly.

KEYWORDS

CDIO, Innovative ability, Engineering Drawing education, Integrated curriculum architecture, Standards: 1, 2, 7, 11.

INTRODUCTON

Increasing creative engineering talents are demanded in Industry development under the background of economic globalization nowadays. To cultivate the innovative consciousness and ability of engineering undergraduate has become an essential content of the higher education reform in China. As a visual means to develop ideas and convey designs in a technical format and the primary means to communicate among engineers in industries, engineering drawings play an important role in industries. Moreover, Innovative ability including the main and basic contents: divergent thinking, imagery thinking, spatial imagination ability and creativity, and the ability of analyzing and solving the practical engineering problems can be cultivated through surveying and understanding the information contained in the engineering drawings. Therefore, engineering drawing education plays an irreplaceable role in cultivating these abilities (Bao Y et al., 2001). Engineering drawing course, the first theoretical and practical course is usually scheduled for all the engineering freshmen who cannot design any mechanical products with their existing knowledge. It is difficult for most freshmen because this course requires strong practice (Yuan L et al., 2011).

However, in the traditional curriculum architecture of engineering drawing, the students' multi-abilities do not be cultivated because they accept the knowledge of engineering drawing passively because we usually emphasize theoretical teaching for engineering drawing and neglect the relationship between theory and practical engineering. As shown figure 1, the teachers participate in making teaching objectives and selecting teaching contents. The students only participate in teaching activity and evaluation. Teaching objectives and contents make the students not learn how to apply the knowledge to the practical engineering so that the students' innovative ability can be limited.

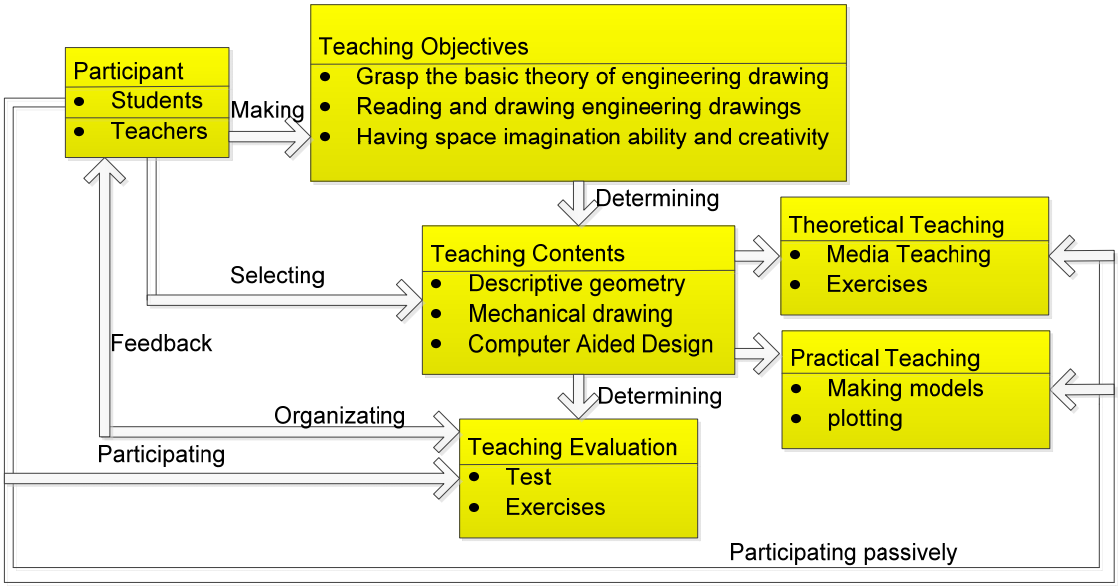

Figure 1. Traditional teaching mode for engineering drawing

Therefore, In order to develop a deeper working knowledge of the technical fundamentals, while simultaneously developing the skills to lead in the creation and operation of new products and systems (Johan, B., et al., 2005), it is necessary to design and practice the new curriculum architecture for engineering drawing. We rebuild curriculum architecture of engineering drawing education based on the concept, syllabus, and standard of the CDIO Initiative, aiming at cultivation of the innovative ability of students majoring in engineering. After 4 year's education reform and practice on engineering drawing course in CUIT, the innovative ability of engineering undergraduates in CUIT has been improved obviously as expected.

CDIO KNOWLEDGE AND ABILITIES FOR ENGINEERING DRAWING COURSE

Engineering drawing course includes mainly three parts: descriptive geometry, mechanical drawing, and computer aided design. The main teaching objective of this course is not only to teach the student to communicate using graphic techniques, but also to cultivate the students' innovative ability. To accomplish this objective, we explore CDIO knowledge and abilities for engineering drawing course based on the CDIO Initiative, combined with demands of domestic and foreign enterprises, as shown in figure 2. In the new curriculum architecture of engineering drawing, we aims at strengthening the students' engineering basic knowledge, improving the abilities of reading and plotting engineering drawings,

teamwork skills, engineering consciousness, and providing solid foundation for innovative ability.

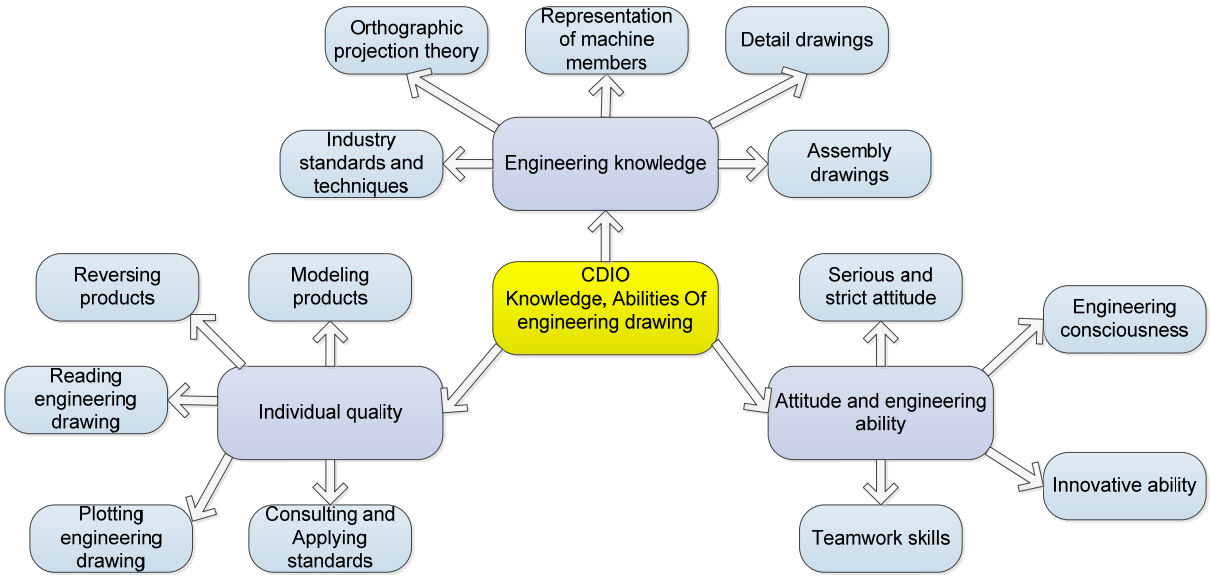

Figure 2. CDIO knowledge and abilities for engineering drawing

Engineering Knowledge

(1) Let the students comprehend orthographic projection theory and use orthographic projection to represent three-dimensional objects in two-dimensional views.

(2) Let students grasp common representation of machine member, read and plot detail drawings and assembly drawings by using the principals and standards of mechanical drawing.

(3) Let students utilize CAD software for creating 2D engineering drawings and 3D models efficiently.

Individual Quality

(1) Let students make use of drafting equipment correctly.

(2) According to the principals and standards of mechanical drawing, let students apply imagery thinking and spatial imagination ability for reading and plotting drawings related to mechanic industry correctly.

(3) Promote students' ability to analyze, solve problems and self-study.

(4) Cultivate students' ability to model and reverse products.

(5) Employ freehand sketching and CAD software to aid in the visualization process and to efficiently communicate ideas graphically.

(6) Let students document and present results in technical reports and through oral presentations.

Attitude and Engineering Capability

(1) Promote students' sense of responsibility, good professionalism, and hard work.

(1) Train students' teamwork and communication skills in groups.

(2) Develop students to have quality of an engineer.

(3) Cultivate students' innovative ability.

TEACHING CONTENTS REFORM

Shorten the Contents of Descriptive Geometry and Mechanical Drawing

In descriptive geometry, we lay the emphasis on the three-dimensional point, line and plan projection instead of the traditional point, line, plane and their projection knowledge by the orthographic projection theory so as to exercise the spatial imagination ability of the students. Moreover, we focus on the configuration design, aiming at cultivation of the imagination, reproduction and creation ability of the students. The representation of composite solid and the parts is taught in detail with the help of the theory of 3D modelling (especially solid modelling).

In mechanical drawing, the hours of surface roughness, dimension geometrical tolerances of the parts, standard parts and common used parts are shortened. The exercises of surveying and drawing of mechanical systems such as the gears transmission system and gear pumps are strengthened to improve the students' freehand sketching ability, operating ability, representing and collaborating ability, and provide the students with the successful innovative experience.

Strengthening the CAD Contents

The students are strengthened to make use of computer to realize the engineering drawings along with the surveying and drawing practice. The students are required to design the assembly and part drawings with the aid of the 2D and 3D computer software such as AutoCAD, Solidworks, especially strengthen the ability of 3D model so that they design freely in their further study such as course design, innovative practice and graduate design. Moreover, they have good training on their CAD competence to meet the requirement of enterprises

TEACHING METHODOLOGY REFORM

Introduce project into course

Profound engineering knowledge and practical experiences are helpful to cultivate the students' innovative ability (Sun S et al., 2012). In order to have a good comprehension of the engineering drawings, the students are requested with sound spatial imaginary ability

and creativity. However, it is fact that some students have good spatial imaginary while the others are poor. Meanwhile, most students have no knowledge to the mechanical parts. We introduce project into course relying on Engineering Training Centre, which provides the students with practical platform, help them have intuitionist sense about the mechanical parts and form clear knowledge of the parts and machines, as shown in Figure 3. We make study framework of engineering drawing based on the CDIO initiative, as shown in Figure 4. For example, as shown in Figure 5, we introduce gear reducer assembling, disassembling, and parameter design of the parts into the architecture and teach them how to represent machine members, standard parts and commonly used parts, detail drawings, assembly drawings. The students are trained with the repeated thinking process of “space to plane” and “plane to space” so as to excite students’ interest and consequently improve their imaginary thinking. It is a shortcut in teaching and learning the detail and assembly drawings.

Figure 3. Engineering Training Centre

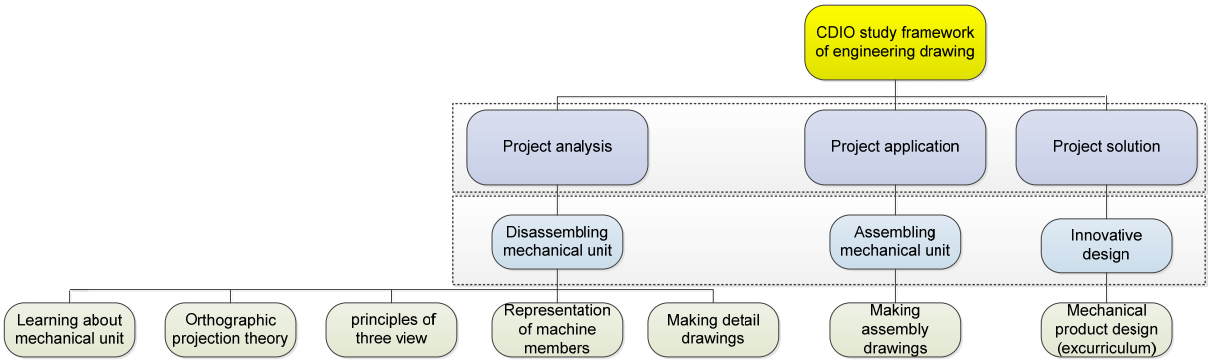

Figure 4. CDIO study framework of engineering drawing course

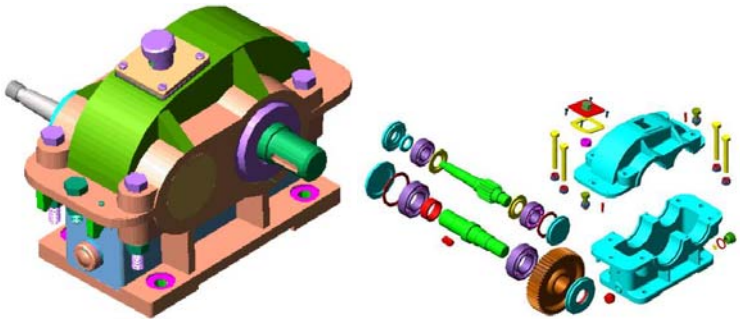

Figure 5. Gear reducer assembling and disassembling

On the other hand, to cultivate students’ innovative ability, we make innovative design, in which students are required to design mechanical product printed by 3D printers. This task

not only displays students' design Initiative, but also helps students learn about the context of the product-system lifecycle.

Encouraging Students' Self-study

In order to cultivate spatial imaginary ability and creativity and motivate the students' go-aheadism and enthusiasm, it is very important to let students think, conclude and consolidate repeatedly. Therefore, we begin with some questions, and then give enough time to encourage the students discuss these questions. After discussing with students, we make use of the real demonstration with solid and 3D models, AVI and animated cartoons to lecture the extractive contents by discussed results. It is helpful for students to learn how to self-study and cultivate the ability of spatial imagination and comprehensive analysis. Meanwhile, we provide the students with the corresponding training program related with the engineering practice. The students are encouraged to search more knowledge from the webs, including the courseware, teaching plan and the solution to the exercises so that they can learn with their own consideration. One of teaching situations is shown in Table 1.

Table 1. Teaching situation for gear reducer

Contents	Methods	Students' activities
Principle of Gear reducer	Display gear reducer Supposing question	Investigating composition of gear reducer
Fitting relationship	Discussion	Grouping
Representing parts in views and the related standards	Instruction	Disassembling and surveying parts
2D and 3D views for parts Machining structure of parts	Exercising Self-study	making detail drawings in 2D and 3D views

EXAMINING MODE REFORM

The examination is not only a very important evaluation for the students, but also a main means in inspecting the teaching quality and effect. Whether the examination mode is reasonable or not will affect the authenticity and objectivity of the examination results. However, in the general examining mode, the final grade is assessed in a whole by considering the final examination grade and meantime behavior including the exercises, surveying and drawing, CAD. Engineering ability of students does not be displayed. To satisfy the demand for the innovative ability education, we introduce configuration design and multi-solution to one-problem into the examination. Meanwhile, we also consider the following situations as a part of the examination: making the detail drawings and assembly drawings by specific project can be finished in 2D and 3D views and designing product with a simple specific function.

TEACHING RESULTS and STUDENT ACHIEVEMENT

CUIT is a provincial key university in Sichuan Province, China. CUIT usually focuses on improvement of education quality and research on the theory and practice in education reform for long term. All the teachers of the engineering drawing course reform group also engage in a series of research and reform practice related to engineering drawing course

aiming at the cultivation of the innovative ability. For 4 years' reform, we have harvested obvious achievements on teaching contents, teaching methodology, and examination means. Not only the students learn how to communicate using the graphic language, such as surveying and understanding the engineering drawings, but also the innovative ability and the design skills of mechanical systems have been improved significantly.

A comparison about curriculum assessments before and after the reform was taken. We select six classes to take part in the test. Six classes are divided into two groups. One is to execute CDIO teaching mode, the other is to carry out the original teaching mode. All the classes used the same paper in the final exam, and the course teachers remain unchanged. Annual assessment results are shown in Figure 6.

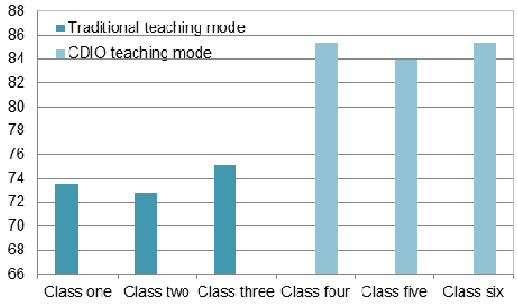

Figure 6. Comparative result before and after the reform

As shown in Figure 6, the grades of the classes carrying out CDIO teaching mode improved obviously. Students' interest and enthusiasm are promoted greatly. Moreover, increasing students own the innovative consciousness and take part in all kinds of innovative activity and practice. For example, the students of Grade 2010- 2013 have very good achievement in many contests such as mechanical design and innovation contest of Sichuan Province, as well as the Challenge Cup Competition, China. The total prize winners total prize winners in CUIT are increasing obviously, as shown in Figure 7.

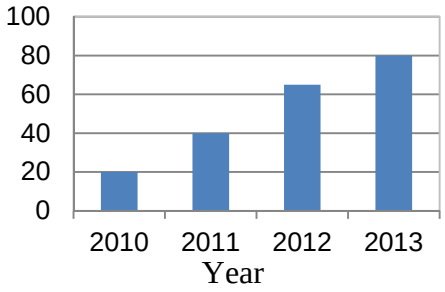

Figure 7. Data of CUIT total prize winners

CONCLUSION

Innovative consciousness and ability is vital for progress of a person, even a nation. The engineering drawing course is a very important technical fundamental subject in training and improving the students' innovative ability. As an engineering drawing teacher, we should take on holy mission and the important task to cultivate the innovative talents, enhance our knowledge and innovative ability to be practiced in our teaching activities so as to cultivate

the excellent innovative graduates to meet the demand of industry and society.

REFERENCES

Johan, B., & Karl, B. (2005). Benchmarking engineering curricula with the CDIO syllabus. *International Journal of Engineering Education*, 21(1): 121-133.

Bao, Y., & Jiang, X. (2010). Engineering graphics education reform based on CDIO concepts. *Proceeding of EMSE'10*: 590-594.

Yuan, L., & Wang, L. (2011). Teaching method reform of the drawing course by integrating CDIO mode. *Proceeding of ICCSE'11*, Singapore: 1301-1302.

Sun, S., Yu, W., & Wu, Y. (2012). Practice of engineering education idea of CDIO, based on the platform of industrial center. *Proceeding of ETME'12*: 9-13

Guo, N. (2012). Research and practice of effective teaching methods of CDIO based on engineering drawing and draft-reading skills. Journal of Suzhou Vocational University, 23 (2): 66-69

BIOGRAPHICAL INFORMATION

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