EXPLORATION AND PRACTICE ON PROJECT ARCHITECTURE WITH CDIO INITIATIVE FOR MECHATRONICS ENGINEERING UNDERGRADUATE

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ABSTRACT

In order to enable the mechatronics engineering undergraduates to train problem-solving in a real life context, improve the cultivating quality of mechatronics engineering talents, and meet the requirements and demands of the industries for attracting mechatronics engineers, we explore and practice new project architecture for mechatronics engineering undergraduate, which is consistent with the CDIO initiative and robotic technology. First of all, the present curriculum architecture for mechatronics engineering undergraduate was analyzed. Second, we revised the curriculum architecture and reconstructed new project architecture based on robots. Finally, we carried out this new architecture in Chengdu university of Information Technology (CUIT). The results from a student survey show that the mechatronics engineering undergraduates can make use of different scientific approaches to solve the engineering problems, which provide the students with valuable real life experiences. Meanwhile, these problems enrich the teaching process and improve all kinds of skills required by future mechatronics engineers.

KEYWORDS

CDIO, Mechanical engineering undergraduate, project architecture, problem-solving ability, Standards: 1, 2, 5, 8, 11.

INTRODUCTION

Rapid changes in science and technology have made an increasing number of industries demand new skills and experiences of engineers besides the technical and professional skills and knowledge (Mirks K, et al., 2014). However, in recent years, many industries gradually realized the graduates did not comply with the real needs of industries. It is difficult for the graduates to adapt to work provided by the industries and companies so that they feel frustrated. In order to narrow this gap between high education and industrial demand, many universities followed the CDIO initiative to adjust the curriculum architecture and change cultivating mode actively, such as Chengdu University of information technology (Shao J, et al., 2013).

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 (Shen Y, et al., 2014). Mechatronics engineering is one of important majors in CUIT, aiming at cultivate future mechatronics engineers whose mission is to develop and operate products and systems that promote safety and quality of life for a growing population. Because this major has the highly integrated inter-disciplinary nature which requires graduates have a broad knowledge, professional skills, and a system-level mindset, it also followed the CDIO initiative to construct the curriculum architecture and got some achievements. However, in this curriculum architecture, the educational objectives were somewhat ambiguous. The existing objectives were as follows:

(1) Let students have broad-based curriculum in mechanical engineering and electronic engineering fundamentals and knowledge for product design, development, and manufacture and maintain.

(2) Provide students with a solid foundation for successful professional careers in fields associated with mechatronics engineering and related fields.

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

(4) Develop students' understanding of global issues

(5) Promote an understanding of ethical and professional responsibilities

(6) Develop students' abilities to communicate skill effectively both orally and in written form

(7) Train students' teamwork.

Curriculum program in accordance with the existing objectives, which was combination with electronics knowledge and mechanics knowledge, was set up. During whole teaching, the teachers carried out the syllabuses strictly, taught the knowledge and contents seriously, gave the students many assignments, arranged a lot of experiments and test provided uniform answer for the student. Meanwhile, we provided the students with some projects which were somewhat apart from the real engineering environment. Under this circumstance, the students still accept the knowledge passively in this educational mode. They do not make connection between theory and practice. In fact, the ability of students to solve practical engineering problems is weakened and some abilities of the students do not be cultivated, as shown in table 1.

In order to enable the mechatronics engineering undergraduates to promote their engineering abilities and skills and meet the societal needs and/ or emerging opportunities (Daniels, et al., 2011), it is necessary to revise the existing curriculum architecture, and explore and practice a new project architecture based on the concept, syllabus, and standard of the CDIO Initiative combined with the newest scientific technology, aiming at cultivation of the engineering abilities and skills of students. After the education reform and practice on mechatronics engineering major in CUIT, these ways motivate students' interest in study, improve their enthusiasm and consciousness of study, and promote their efficiency and quality of study. The engineering abilities and skills of mechatronics engineering undergraduates in CUIT have been improved obviously as expected.

Table 1. Students Abilities and Attitude in old Curriculum Architecture

Students Abilities and Attitude	Yes	No
Knowledge Applying	√	
Design and Implement Experiments	√	
Analyze Experimental Data	√	
Design and develop a system, parts or program	√	
Team Work	√	
Base Skills for Engineering Practice	√	
Utilize Modern Development Tool	√	
Solve Engineering problems		√
design and develop products and systems with consideration of human prerequisites and needs and the society's goals		√
global issues		√
Insight into the possibilities and limitations of technology		√
Sense of Responsibilities, Good professionalism, and Hard work		√
Communication Skills in Groups		√
Self-study and Life-long Learning		√

CURRICULUM ARCHITECTURE REVISION

Objectives

Nowadays, robots are playing an increasingly important role in societal development. Robots are very typical mechatronic products. In order to meet societal needs and the development of robots, we firstly revised the educational objectives of mechatronics engineering undergraduate, combined with robotic technology and knowledge. Our objective is to let students have solid basic knowledge and general principles about mechatronics engineering and have the capability of scientific research, the responsibility of humans, including ethical, social, economic as well as environmental and occupational health, and creativity and innovation. The graduate students will have the abilities in design, development, and manufacture and maintain, and management and system integration in robotic product.

To accomplish this objective, we explored required knowledge, abilities and attitude for mechatronics engineering undergraduate based on the CDIO Initiative, as shown in Figure 1.

New Curriculum Architecture Based on Robots

After knowledge, abilities and attitude for mechatronics engineering undergraduate were identified, we revised curriculum architecture, as shown in Figure 2. New curriculum models and designs entail a set of identified program outcomes which students are expected to gain by the time of their graduation. In theoretical teaching, we set up three platforms including general education, general discipline and specialty platform. Each platform includes a set of modules to help students achieve wide range of knowledge, skills and values. Meanwhile, we determined in what courses in the current curriculum specific knowledge, abilities and attitude would be covered.

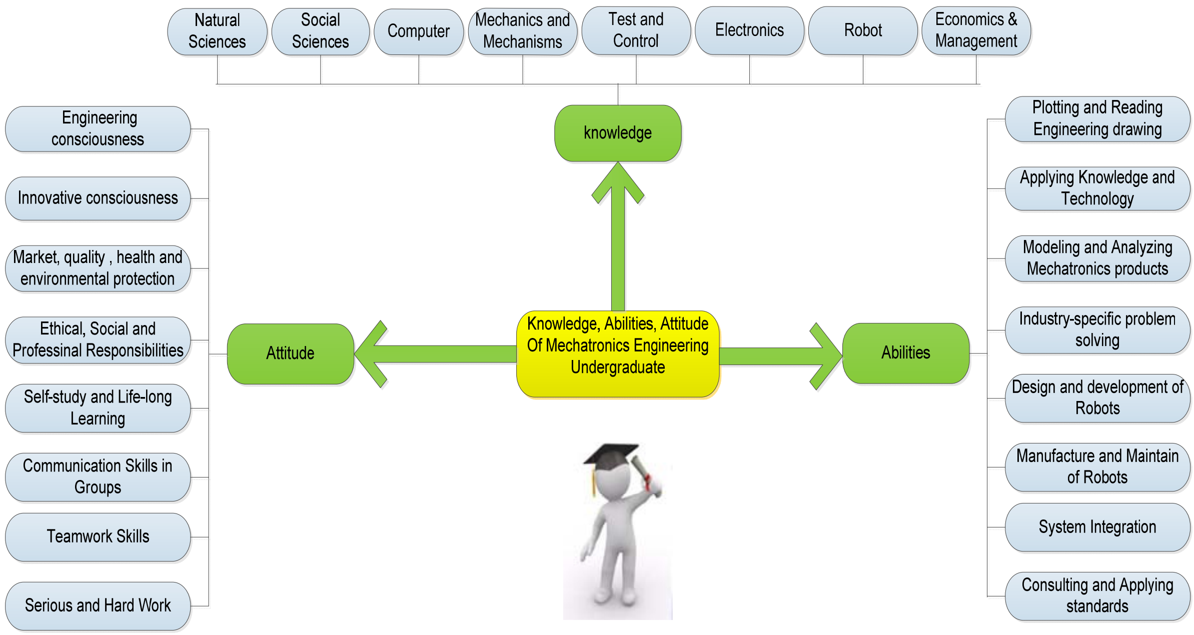


Figure 1. Knowledge, abilities and attitude for mechatronics engineering undergraduate

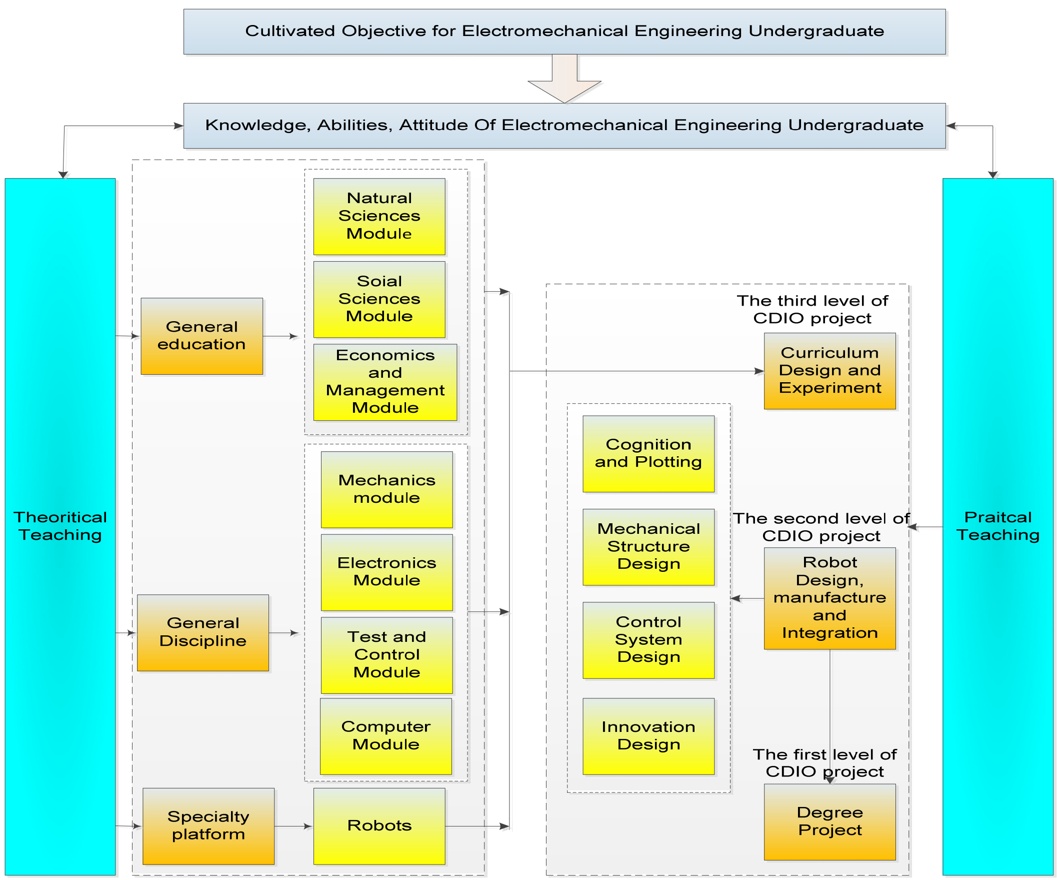


Figure 2. New curriculum architecture

In specialty platform, we set up all kinds of specialty knowledge based on robots, including Basis of Robotics, Industry Robot, Design of Mechanical and Electronic System, and Ergonomics. These specialty courses help the students to understand the theoretical knowledge about various robots and grasp them.

PROJECT ARCHITECTURE

In practical teaching, we set up project-driven architecture. It consists of three parts: curriculum design and experiment, robot design, manufacture and integration, and degree project. In order to guarantee practical teaching to be carried out, we build up various platforms, such as robotic platforms, as shown in figure 3. These infrastructure and facilities can support our educational initiatives, promote active, team-based, hands-on project work, and incorporate experiences.

Figure 3. Robotic platforms

Curriculum Design and Experiment

In curriculum design and experiment, all design and experiments are related with each course contents and objectives. During this part, we gave students hands-on experience and help them build up engineering consciousness through curriculum design and experiments. For example, “Mechanical and Electronic Control System” course, students are randomly divided into design teams and are given the specifications to design and build a smart vehicle which carries out the routes patrol, as shown in figure 4. In this course, students learn about how to apply control principles to design and implement control program.

Figure 4 Smart vehicle

Robot Design, Manufacture and Integration

Robot design, manufacture and integration, which align well with the CDIO principles, consist of four steps: cognition and plotting, mechanical structure design, control system design and innovative design. Four steps are arranged in four semesters respectively. In this process, students need to have more knowledge and information except the formal theory provided by the courses, such as marketing, project managing, decision making, report writing and oral defense. We carry out four steps in four semesters respectively. Students are grouped in teams and given a design challenge over the semester-long project. The groups carry out the study independently, with support from scheduled course activities, a number of lectures and supervision from the teacher. The student teams are finally judged during the challenge receiving a score based on their approach and success to perform the specific challenge and the results reported orally in form of a presentation and in writing as a report.

In cognition and plotting, students learn about specific structure and link model of robots. Based on engineering drawing course, students are required to measure robots' key components and parts and use 3D software to plot them.

In mechanical structure design, according to 3D model given by cognition and plotting step, students try to design specific structure of robot. During this step, each student is required to finish the part of the whole design task, which has a good link with the other parts, and then specific assembly will be gotten.

In control system design, students propose control scheme in relation with control parameters, such as operative velocity and motion range. Meanwhile, students select electronica parts to build up control system hardware and software by control scheme.

In innovative design, students propose innovative design for robot combined with three steps before. We will select excellent products to make, which can inspire the students and are provide with the other students as research object. During this step, we also offer a unique opportunity to students, who practice in industries and companies, collaborated with CUIT. Industries and companies can provide completely clarified and explained real problems to make students try to solve them.

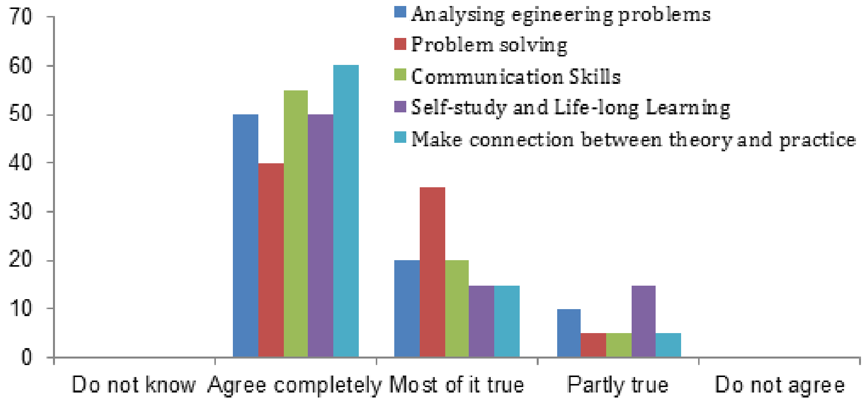
Degree Project

Degree project, which corresponds to 12 weeks of full-time study, is the final stage of the program. During degree project, the students are required to integrate with all knowledge, abilities and attitude design and implement suitable and real engineering problems.

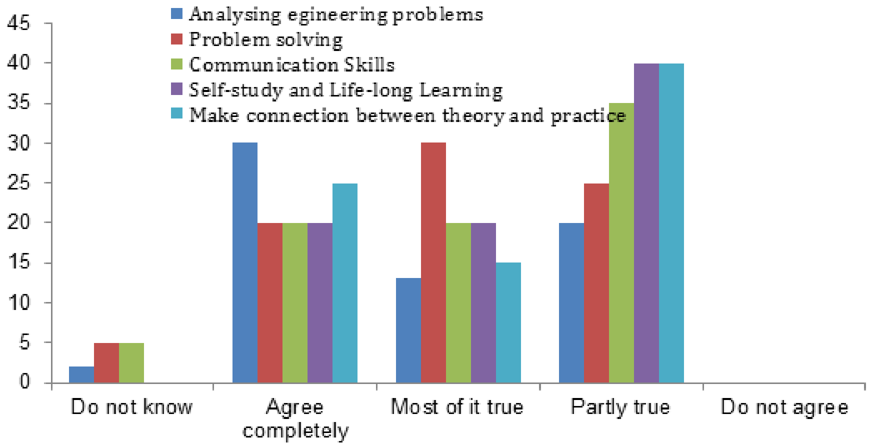
When students accomplish their degree project, the project becomes a bridge between the university and industry or between their studies and professional work. Graduate design maybe helps students as well as industry to find a suitable partner for a specific type of project and becomes an entrance to the first job as well.

STUDENT ACHIEVEMENT

All the teachers of mechatronics engineering reform group also engage in a series of research and reform practice. A comparison about students' assessments before and after the reform was taken. We select two grades to take part in the test. Grade2013 is to use new curriculum architecture; Grade 2012 is to use the old one. The answers are collected from the evaluations from Grade 2012 and Grade 2013, in total 80 responses respectively. Figure 5 shows the results of the improvement of some skills by asking students given evaluation questions. As shown in figure5, communication skill is obviously improved. To some extent, the other abilities have been promoted, such as problem solving. Most students think that they have the opportunity to work with something you are interested of and to apply the theories in real work through new project architecture. It is very positive and instructive for them.



(a) Grade 2013



(b) Grade 2012

Figure 5. Comparative result before and after the reform

CONCLUSION

Nowadays, higher education is multidimensional and multi-purposeful process. If universities provide students with the industrial projects during the study time, students are inspired to study actively by getting a really good education. The real engineering environment makes them broaden the their minds, take theory to practice and put together all the concepts learned, manage their time efficiently to meet deadlines and improve their various abilities. Through newly project architecture, we provide an excellent training for their professional future and cultivate the excellent innovative graduates to meet the demand of industry and society.

REFERENCES

Mirka, K., Valentina, H., & Samir, K. (2014). Interdisciplinary, international and industrial cooperation efforts within the mechanical engineering department. Proceedings of the 10th International CDIO Conference, Barcelona, Spain.

Shao, J., Sui, X., (2013). Exploration and Practice on school-enterprise cooperation personnel training mode of Mechanical Engineering "Excellence Engineer Training Plan" Based on CDIO model. *International Conference on Education Technology and Management Science (ICETMS 2013)*, 1308-1322.

Shen, Y., Zhu, M.,(2014). Improvement of CDIO skills by using integrated curriculum architecture in Engineering Drawing. *Proceedings of the 10th International CDIO Conference, Universitat Politècnica deCatalunya, Barcelona, Spain, June 16-19, 2014.*

Daniels, J.L., Wood, S.L., & Kemnitzer, S.C.(2011). The Role of NSF's Department Level Reform Program in Engineering Education Practice and Research. *Advances in Engineering Education, America Society of Engineering Education (ASEE)*.

Pei, L., & Nan, S.,(2011). CDIO engineering education mode. *China Metallurgical Education*, 5, 9-13.

BIOGRAPHICAL INFORMATION

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