ENHANCING STUDENTS' CAPABILITIES THROUGH INTERNATIONAL ENGINEERING PROJECT

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ABSTRACT

TOPCARES-CDIO is a CDIO engineering education concept adopted by Dalian Neusoft University of Information (DNUI). This innovative concept has proved to be a suitable engineering module and methodology for most courses of engineering in DNUI. It is designed to allow each stage of CDIO to have an impact on students. Now its concept has also been as a primary reference in design and implementation processes of one cross-culture project collaboratively operated by the School of International Education and IT innovation, Inc. Japan. With a few years of implementation of the project, we welcome to discover that, in the international environment, the participants greatly improve their capabilities of not only foreign language skill, but also cooperation and communication as their global awareness and vision are extended. All indices defined within the framework of TOPCARES-CDIO have displayed improved or enhanced.

KEYWORDS

TOPCARES-CDIO, Cross-culture

INTRODUCTION

Nowadays people are witnessing the rapid changes of the human engineering ability and innovations in science and technology. In the meantime, higher requirements are put forward for engineering education as well. However, one common problem which engineering education faces at present is that talent cultivation still lays particular stress on learning knowledge, and especially neglects the students' core competence of engineering projects. The training quality of engineering education is often unsatisfied and criticized, for example, operational ability is not strong, irrelevant to the development of the industry, lack of innovation, and so on. These are the problems concerned by colleges and industries, and expect to be solved.

After several years of development since 2007, engineering graduates have been relatively satisfied by industry with some of their professional abilities such as elementary theoretical knowledge, information ability, ability to learn and adapt, and professional ethics. But it is still necessary to strengthen the abilities of knowing the cutting-edge status and development

trend of engineering science and technology, comprehensive consciousness of engineering design, international communication, social responsibility, etc.

CDIO

The original development and implementation of the CDIO approach was initiated by a research group that consisted of four celebrated institutions. They are Chalmers University of Technology (Chalmers), Royal Institute of Technology (KTH), Linköping University (LiU), and Massachusetts Institute of Technology (MIT). By now, there are more than 100 universities worldwide using the approach (Crawley et al., 2014).

CDIO approach is one of research achievements in the international engineering education field. The acronym represents Conceive-Design-Implement-Operate, which takes a life cycle of product development as the carrier to let students study more actively and practically, meanwhile setting up structured connections among different courses. It also indicates what knowledge, abilities and qualities an engineer should possess, and how engineering education can make the students master or behold them.

The integration of the curriculum design in CDIO engineering education is required to give a student a learning experience that enables students to learn all sorts of professional knowledge that supports each other. On the other hand, it should have a clear plan to develop students' personal, interpersonal skills, and abilities of procedure building.

TOPCARES-CDIO

In 2010, CDIO was sinicized by DNUI, one of the most collaborating institutions all over the world, based on the concept of "Education Creates the Values of Students". By inheriting CDIO engineering education concept, fully considering of the demand of each relative stakeholder such as students, teachers, industrial field and entire society, the learning outcomes of CDIO syllabus is summarized as TOPCARES-CDIO indicator system. It also refers to the reality of higher education in our nation, and the evaluation of the school and major settings. Its specific meaning is represented in Table 1 (Wen, 2010).

Table 1. The Meaning of TOPCARES

Acronym Letters	Connotation
T	Technical knowledge and reasoning
O	Open minded and innovation
P	Personal and professional skills
C	Communication and teamwork
A	Attitude and manner
R	Responsibility
E	Ethical values
S	Social contribution by application practice

About the Project

This project is one two-week short-term project that began in cooperating with IT innovation Inc. (here referred to as IT innovation) starting from the year of 2012. The objective of the training program was introduced to the Japanese enterprises, in order to let the Japanese

staff from industry be able to learn more about Chinese culture and be better to successfully promote projects in cross-cultural environment. Simultaneously, pair with a junior or senior Chinese student majoring is in related for each Japanese trainee to be grouped. We expected that the students, participating in the project, could also experience differences between excellent engineers and themselves in person. In the end, the project can be considered as a good win-win project.

In the process of project to promote, both IT innovation and DNUI are clear about the roles. IT innovation takes in charge of the business in Japan as well as collaborates to implement the actual training in DNUI. By the end of 2014, there were already three sessions of trainees from Mitsubishi Electronic Company attending the training project.

It is important to design an appropriate training plan for this special two-week program so as to achieve the objective of the project. However, how to plan to meet the customer requirement and observably improve students' engineering abilities has the certain difficulty. How to design can guarantee in a short time, meet customer demand, and improve the students' engineering abilities, has certain difficulties. Therefore, adopting the CDIO approach and referring to the indices in TOPCARES-CDIO as a basis for the design and standards for the implementation. Please read the next chapter for the detailed design considerations and strategies.

In the last part of this paper, the procedure of project implementation in strict accordance with the previously designed syllabus and the main content is narrated. After analysing the phenomena occurred during training procedure and the feedback from the last three sessions of Japanese trainees, a result analysis is demonstrated as well as showing the learning theory behind could support the result analysis.

DESIGN

The design of such a short-term project is a complex process, so need to learn from existing mature theory and evaluation system. Because in such a two-week short-term project, on the one hand trainees are expected to greatly improve communication and problem-solving skills in a cross-culture environment (the original objectives are listed in Table 1.), on the other hand students should significantly promote abilities defined in TOPCARES-CDIO indices, especially of attitudes, thoughts, and learning. In addition, during the training process, we also hope literacy (e.g. ideological quality, learning motivation, professional ethics, etc.) can be organically combined together with knowledge acquiring, capacity-building, and problem solving. Therefore, CDIO approach and TOPCARES-CDIO are applied well-reasoned as one of the most important methodologies.

Table 1. Original Objectives of the Project (for Trainees from IT innovation Inc.)

Language Training (English)	Improve abilities of discussion and presentation in English environment or international environment.
Cross-culture Training	(1) To experience and understand the cultural differences between Chinese and Japanese by accessing Chinese culture, habits, and social life. (2) To investigate how to obtain the current information about China through the media. This is for correctly mutual understanding the

	differences in values between China and Japan.
	(3) To train the ability of being equal to independent research and development in China. Even though couldn't understand the Chinese language instead using simple English to achieve cross-cultural communication.
Cross-cultural Practice	(1) To constitute a development team with Chinese students, and be the team leaders and technology directors, and learn the work method in a cross-cultural team environment via simulation exercises. (2) To find an approach to reach a consensus on project goals and plans with team members, then implement and evaluate it. (3) To enhance the ability to promote group work and the final consensus by communicating through various discussions with group members, even though the team members have distinct technical background and language skills, or limited capability. Simultaneously, to learn how to encourage team members to keep enthusiastic in cross-cultural environment.

In addition, because we simulate the scenario of which several virtual development teams to achieve the same target, we try to establish another role of the Japanese trainees to exercise capabilities of project management. The fact is that, after investigating all trainees' past background, there is not anyone having the experience of leading a group to finish product development and system operation. In order to make sure the project objectives can be reached, there should be management levels within each group. Engineers from Japan's top-level companies tend to have very strong technical and engineering capabilities, which can serve as "technical director", plus make them responsible for the management of the entire team, as well as, if necessary, communicate with the other groups to share part resources. When problems occur, they can also discuss among different technical teams to achieve the purpose of sharing knowledge and skills. Students can experience close to the real development team in such a virtual environment. This can either upgrade their engineering capabilities but also to expand their horizons. Furtherly, it complements the teamwork and communication skills necessary to collaborate in development activities.

We hope that can find some clues from CDIO Syllabus (illustrated in Figure 1), which can help to discover the guideline of the training. And with the guideline, we think about how to take advantage of the integration of curriculum design, and also include the other ability indices need to be raised.
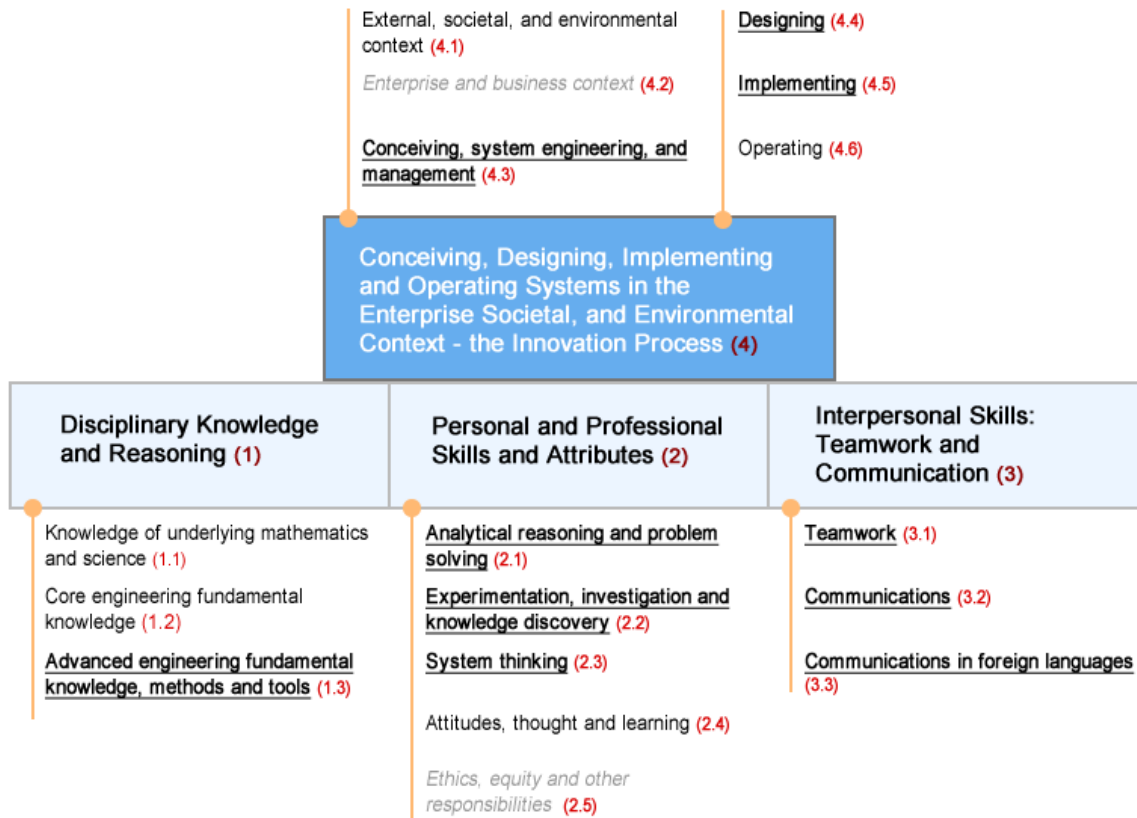
Figure 1. The CDIO Syllabus at the first and second levels of detail.

By analyzing the objectives and content of the short-term project, it is preliminarily sure: almost all ability indices (including the first and the second levels) defined CDIO Syllabus can be covered. As shown Figure 1, the first level in CDIO Syllabus is organized of four parts, and each one consists of corresponding second level skills. Bolded and underlined ones are what expected to be strongly improved, while there are only two, '*ethics, equity and other responsibilities (2.5)*' and '*enterprise and business context (4.2)*' (styled in gray and italics), weakly covered.

From Figure 1, it can be also observed that, almost abilities should be strongly improved concentrate upon the first levels '*Personal and Professional Skills and Attributes (2)*' and '*Interpersonal Skills: Teamwork and Communications (3)*'. Therefore, we need to pay more attention on these two in curriculum design. The relationship of second level skills is illustrated in Figure 2. Skills 2.1~2.3, and 2.5 are relatively independent to 3.x. It can be considered focusing separately at design time. And they are all included in 2.4, belonging to individual "Attitudes, thought and learning', so it needs a unified design.
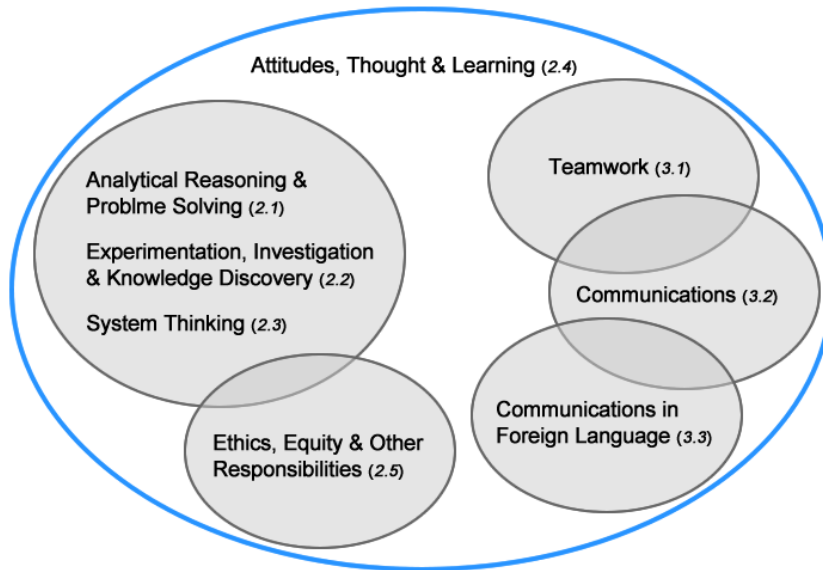
Figure 2. Venn diagram of CDIO syllabus: personal, professional, and interpersonal skills.
(Crawley et al., 2014)

It is obvious that: the project objectives in almost all skills can enhance the abilities of respective areas. However, still need to pick out the most important according to the original demand. Since the total class time of the project is defined as 76 classes (45 minutes per one class), we choose eight indices of TOPCARES-CDIO (Wen, 2010) from the most essentially important skills in different levels, according to the usual practice of our school, which defines the ratio of the total number of classes and the number of skills should be improved. They are :

- Advanced engineering fundamental knowledge, methods and tools
- Problem identification and formulation
- Experimental inquiry
- Thinking holistically
- Forming effective teams
- Oral presentation
- English
- Developing a global perspective

After that, according to the demand from IT innovation, all participants need more time to consolidate the English and presentation skills during the first week, in order to clear linguistic communication barriers for the next section. And in the second week, it is need to ask participants to deepen to consolidate skill through the "practice" section. The section names in Table 1 are used. The proportion of time is as shown in Table 2.

Table 2. The Proportion of Time of Each Section.

Sections	Number of classes	Proportion
Language Training (English)	26	34%
Cross-culture Training	8	11%
Cross-cultural Practice	38	50%

	4	5%
Other	4	5%

To choose the tool used in training is also very important. It is difficult to implement a very complex system within two weeks, but still need assure that the tools used by a considerable degree of flexibility and certain difficulty. It is best to extend participants' thinking by programming. Thus, ensure that trainees can use their professional background as well as students are able to apply knowledge learned before. Also make the procedure interesting, and not so boring. So, at last, we chose LEGO MINDSTORM suite because of its great creative flexibility and modularization.

Any project requires an output as a reference of evaluation. At the end of the project, we give each participant a comprehensive performance evaluation. The composition of evaluation results is shown in Table 3. A competition on track is arranged to test their 'product' in the process of CDIO.

Table 3. The Composition of the Evaluation Results in Cross-cultural Practice

Items	Weight
Project Plan & Team Task Board	30%
Contest Record	20%
Mid-presentation	30%
Improvement of Your Members (Chinese students)	20%

Evaluation needs to be determined in accordance with the training objectives. In the project, the main training objectives are a little inclined to the use of language, expression, and communication, therefore, their products and competition results do not occupy most of proportion.

THE PROCESSES AND THE RESULTS

In the course of the overall implementation of the project, we strictly operate in accordance with established design of programs.
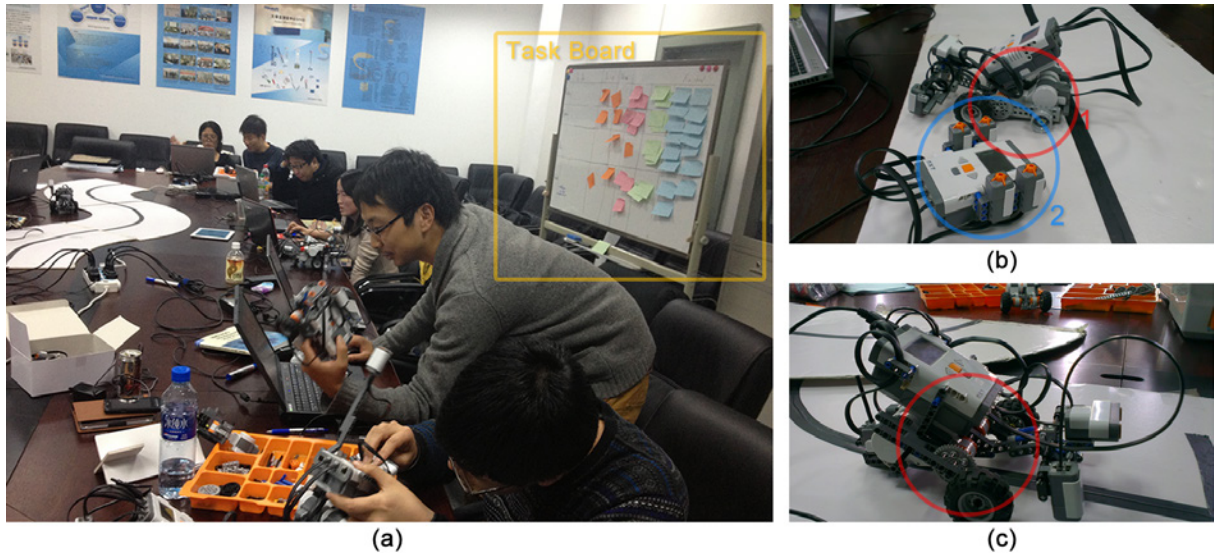
Figure 3. Pictures of the training room and the works. (a) Participants and the Task Board framed with partially transparent yellow rectangle. (b) One of 2014 works: a modified Tribot with gear boxes and a remote controller. (c) Another one of 2014 works: the Tribot is tracking the black line on the track.

A project management method, Task Board, is recommended to teams in order to track the progress. Trainees can also exercise decomposing large task into small ones and organizing development tasks. The general idea of Task Board is illustrated in Figure 4.
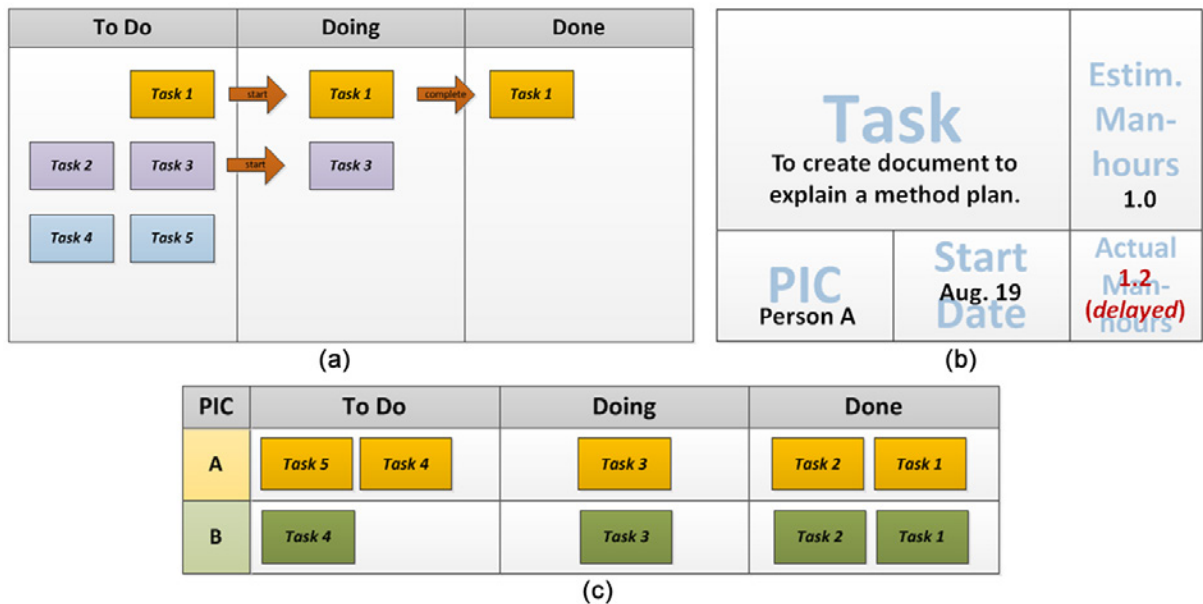
Figure 4. Illustration of Task Board. (a) General view of Task Board. A Task Board is divided into three parts: To Do (target), Doing (current job), and Done (achievement). The pattern of each 'Task' tape is pictured in (b). (c) Two task flows for two individuals. And a large task can be composited and organized by PIC (person in charge). Note that for a PIC, there should be no more than one task in Doing zone.

No one of the participants ever expressed dissatisfaction on the scientificity and integrity of the project. Following, look at the feedback (translated from Japanese to English here) of each section from the previous Japanese trainees.

Table 4. Trainees' feedback in 2012

Language Training (English)	• Can recognize the weaknesses in English. • Can learn skills of public speaking abroad. • Learn basic business English conversation. • Realize that enhancing English is greatly necessary.
Cross-culture Training	• Can understand the national character of Chinese (traits, habits, etc.). • Realize that cannot hold preconceived notions. • Practice to communicate with Japanese culture in English. • Understand the differences/similarities between Chinese culture and Japanese culture.
Cross-cultural Practice	• Practice communication skills such as manners and text. • Improve C programming language. • Not grasp the subtle parts of English (grammar, pronunciation), but rather to learn how to use a variety of methods to communicate – this is very important. • Latch onto the difference between Chinese and Japanese on the methods of pushing work progress. • Become self-confident in using communication skills.

Table 5. Trainees' feedback in 2013

Language Training (English)	• Can realize the importance of preparation before speaking in English. • Can learn a lot of rhetoric used in speech. • Can begin to like English, and realize the importance of learning English again.
Cross-culture Training	• Can learn the part of Chinese that unknown before. • Understand must pay attention to issues in the future such as etiquette, taboo and so on.
Cross-cultural Practice	• Study the method that smoothly takes a technology or programming related dialogue. • Understand the communication via which is easier to be understood by each other (Change speech patterns, illustration, using simple words, etc.) • Understand the method of spurring project progress in a different cultural environment. • Be aware of the importance of confirming the more detailed job process than usual.

Table 6. Trainees' feedback in 2014

Language Training (English)	• Be able to speak English more fluently. • Understand the importance that not only speak English, but also prepare for speech with objectively considering the content, and never prepare sloppily. • For a non-native speaker, can learn some simple expressions or words that are helpful to communicate smoothly.

Cross-culture Training	• Can understand the differences between Chinese culture and Japanese culture (food, rituals, taboos, banquet, etc.).
Cross-cultural Practice	• Respect each other's values as well as realize the importance to project. • Be aware of the importance and necessity of clarify each task and the progress every time as leader in a different cultural environment. • Deeply experience the difficulty of allowing the other to really understand without using specialized terminology.

Through the project, we notice that the students' language ability has been greatly improved in the short term. As an international engineering project, it helps the students a lot in cross-cultural communication and collaboration. It is proposed that the capabilities be graded in four levels, according to Hymes (Hymes, 1972) and Bachman (Bachman et al., 1996) researches. The first level is to understand and use a foreign language. The second level is to respect the differences among different cultures and keep a higher degree of sensitivity and acceptance. The students should have the ability to use a foreign language, i.e. the illocutionary competence and the social cultural language abilities. The third level is to engender a strategic competence in handling all kinds of problems and barriers, when achieve and maintain flexibly in a cross-culture environment. Last but not least, an emphasis will be placed on improving cultural quality and personalities which enrich life experiences by proper cross-cultural communications. While the participants work together, they are 'encouraged' to communicate in unfamiliar English, with the intention of overcoming any cultural differences and deal with various problems methodically and with tact. It helps each other to jointly participate in the development planning, achieve milestones, refine specific tasks, implement, and complement each other when needed to solve a problem together. The process covers all four levels above and meets the 3.x level of CDIO.

During the course of the project, we observed the spark of innovation burst out from time to time due to cultural differences. Take a recent session for example. Before then, when the participants considered the final racing competition, Tribot moving speed was absolutely crucial, but previous students never had thought to increase the speed. Even they attempted to increase the speed, they just simply maximize the output power transferred from the motor via writing code or adjusting parameters. But in the latest session, students designed and increase the Tribot speed more than two times by taking advantage of the similar principle of auto gearbox. The student works is shown in Figure 3 (b) and (c). And it was achieved by strong engineering capabilities of Japanese trainees as well as Chinese students' creativity in this process.

After the project, Japanese trainees have had a better latching onto Chinese culture and their experiences have been enriched, on the way to achieving the goal in an international environment. Chinese students benefit a lot from the program as well, and they will learn, and have learned in the past, a lot from their Japanese team members, especially as it regards to attitude and work ethic and a way of thinking. They will realize the importance of methodological quality and conventional practices of engineering.

Of course, we also found some aspects unsatisfactory. For example, for the first level of ability "*disciplinary knowledge and reasoning*", although they were able to use high-level programming language and integrated development environment such advanced tools to program the robot (the so-called *1.2*, *1.3* corresponding abilities), the "*1.1 knowledge of physicist mathematics and sciences*" emphasized in the CDIO had exactly missed. This phenomena should show up as both trainees or students fail to flexibly use basic knowledge

to solve problems, for instance, how to apply mathematical knowledge for designing a robot program or classifying different situations on the track, how to precisely control the robot posture with mathematical modeling, and so on. That means the ability to utilize mathematics need to be improved. As well, this also offer a hint for the follow-up sessions, and even the modern engineering education.

Next, should continuously consider how to strengthen basic education instead of always insisting on indoctrinating senior engineering knowledge. Kindly advised to ask students to review the application of the basic mathematical and physical principles when they are studying advanced engineering courses to achieve a virtuous circle of learning, which complements upper level ability with the underlying theories.

THE JUDGEMENT OF THE FUTURE AND THE METHODOLOGY

The multinational project will continue. In order to add more multinational elements for the team, we consider recruiting some Russian students from the major of computer science in our college in the near future. If so, another benefit is that the importance of task allocation and teamwork will be more highlighted by enlarging the team. Whether Japanese trainees, Chinese or Russian students, all need to get rid of unilateral communication, and become a multilateral one, by which will contribute to more interactions. That will play a role in promoting their abilities of communication, teamwork, and cross-culture.

Moreover, it is also necessary to continue delving into researching on learning sciences and the teaching methods in an international environment. The statistical monitoring of the students' learning effects should be strengthened, meanwhile gradually realize evaluating the project with quantitative methods.

CONCLUSION

CDIO approach is one innovative framework for cultivating the next generation of engineers. With referring to the advanced concept of CDIO, DNUI forms its own ability index system, TOPCARES-CDIO. This work applies above approach and indices for designing and implementing an international cross-cultural training project. The results basically meet the TOPCARES-CDIO indices collected previously. Especially, the participants could greatly improve various aspects of capabilities in the international engineering project.

ACKNOWLEDGEMENT

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BIOGRAPHICAL INFORMATION

Shukun Zhao, is a lecturer and vice director of the Microelectronic Science and Engineering teaching group, Electronics Department, DNUI. He is also a doctoral of Microelectronics and Solid-state Electronics, DUT. He always focuses on new concepts of engineering education, exploring the CDIO specific practices. He involved in the major reform of engineering education, and improved multiple specialized courses. At the same time, he is engaged in international related affairs in the long term. He is a cofounder that takes part in joint design with IT innovation Inc., and as the lecturer of "Cross-cultural Practice Training" of the short-term project. Now one of his scholarly activities focuses on the MOOCs/SPOCs in engineering education reform.

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