Hands-On Education at Kanazawa Technical College

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ABSTRACT

Kanazawa Technical College (KTC) is one of the newest members of CDIO. It is also the first institution in Japan to join CDIO as a Collaborator. Since applying for and receiving a grant in 2007, KTC's Mechanical Engineering department has led the school in educational reform by reviewing and enhancing the curriculum to ensure its students have all of the skills both necessary and desired for industry upon graduation. Through this process, the "Creative Design" series of courses were developed and instituted. They conform to the CDIO Syllabus and Standards more closely than any other courses currently offered, so KTC has started benchmarking and analyzing its curriculum with these courses. Additional courses and departments will follow, but due to the cultural and language differences, adoption will be a slow process. Stakeholders will be involved throughout the curriculum enhancement process and current survey practices will be used to understand how KTC education as a whole compares to the CDIO Syllabus. Many documents and tools provided by CDIO are still being understood and translated, such as ITU assessments, and will be used in the future to assist with curriculum integration. KTC is also assisting additional institutions to learn about and join CDIO as future Japanese collaborators.

KEYWORDS

hands-on education, CDIO Standards Evaluation, Adopting CDIO, CDIO Japan

PREFACE

Japan's industrial sector has faced many challenges in recent years. Some of the challenges include reduced competitiveness in the international arena, an educational focus on theoretical rather than practical knowledge [1], and an ever-increasing average age in small and medium sized enterprises [2]. Many companies have a global presence and must adapt to working with people from other cultures. In addition to industrial problems, Japan's birth rate has been declining [2]. Some of these problems can be addressed through a re-examination of technical education in Japan.

Since recognizing these problems, Kanazawa Technical College (KTC) has been studying the technical education provided to students. With a grant from the government, KTC has created and implemented a Project Based Learning (PjBL) curriculum component. This program introduces students to hands-on manufacturing techniques and the product development lifecycle as well as cultivating management ability in graduates. This group of courses, one full year course per year level, is called "Creative Design" and forms the backbone of the hands-on curriculum at KTC. Considering the success of this program as well as results from stakeholder surveys, KTC petitioned to join CDIO in 2010.

This paper will discuss the current state of engineering education in the Mechanical Engineering Department at KTC, specifically, the hands-on course sequence, as well as what KTC is doing to adopt CDIO in Japan.

CREATIVE DESIGN

Creative Design is a hands-on program designed to cultivate the overall skills and abilities of students by incorporating disciplinary knowledge, personal and interpersonal skills, as well as technical know-how individually and in teams for students of all year levels. Assessment techniques include portfolios, presentations, as well as milestone deliverables and tested final products. Students take on various roles in teams and engage in Conceive, Design, Implement, and Operate experiences as well as evaluation of self, group, and peers through hands-on projects that enhance students' problem solving and leadership abilities. Students are also exposed to project management tools and techniques especially in the fourth year when they are expected to design and build a robot, to create and follow a schedule, create a comprehensive bill of materials, and work within a budget in order to complete their robot on time and within required parameters.

Approach

The Creative Design series of courses in their current incarnation were developed through a grant from the Japanese Ministry of Education (MEXT). Project based learning (PjBL) was used as the basis for these courses, as well as the Plan-Do-Check-Act model to build on students' skills each year [3]. For the first three years, students work on projects that are heavily Implement-oriented, with some Design work where appropriate, to teach them how to use various tools in the machine shop and guide them through creating finished products that are guaranteed to be successful in order to build students' confidence in their work and guide them in learning necessary skills for later courses. For their fourth and fifth years, students are given projects that can run the gamut from Conceive through Operate.

The fourth and fifth year courses also integrate many personal and interpersonal skills such as project management, presenting and defending their engineering decisions to not only their peers and professors, but also to local representatives from industry, as well as working in teams to complete a project with scheduling and budgetary requirements. Students build on their disciplinary knowledge and hands-on skills beginning with the technical fundamentals, applying what they have learned, developing products from start to finish, and finally many students partake in applied research as their fifth year capstone project. The fifth year capstone course is highly individualized, with teams participating in national and international technical competitions and students participating individually or in small groups in industry sponsored research or taking their own or a faculty advisor’s ideas as the basis for their projects. This course will not be discussed as its content is highly variable.

Creative Design I

Creative Design I acts as an introductory course to KTC and to engineering. Students are introduced to campus policies and procedures as well as major-specific information and general skills that will help them in their academic career such as good nutrition and effective study habits. After the initiation into life at the Technical College, students are separated into two groups. One learns how to use the various machines in the machine shop while one group studies drafting. The groups trade places when the module finishes. During the second semester, students use the plans they have drafted and the machines they have been introduced to in order to create a calligraphy paperweight with a handle that screws into the base. The other half of the class studies bridges and creates a balsa wood bridge, testing how well the trusses hold weight, before trading places to finish the term. Students end the year with a good general understanding of the machine shop, basic drafting and design, and statics.

This course focuses heavily on Implementing, with some Design in well-defined areas. This course deals mostly with introducing students to the processes and ideas of hands-on projects, and has minimal personal and interpersonal skills integration. Students design the trusses of the bridges they build as well as the cross-section and handles of their paperweights, as seen in Figure 1:

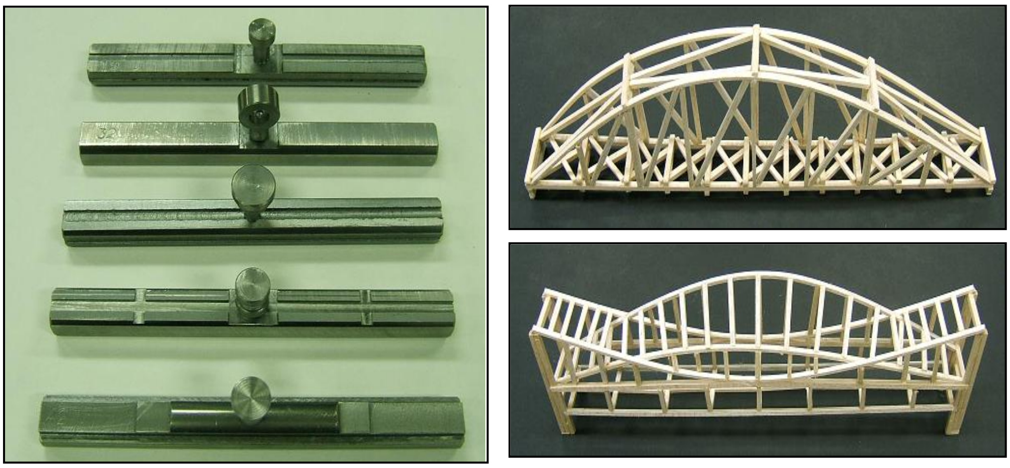

Figure 1. Creative Design I Projects

Creative Design II

In Creative Design II, the class is divided into three smaller groups and each group takes part in three ten-week courses. One experiment-based course focuses on springs, where students make their own spring and test it using various methods. The second section deals with electronics; the students learn how to solder and build the electrical components of a line tracing car with various sub-steps, including a light-powered car. The final section teaches students the principles behind gyroscopes and brings them back to the machine shop to build their own, competing to see whose will spin the longest.

This course is mainly guided Implementation and experimentation. There is little independent Design; students are typically asked to utilize the given tools and parameters to find the solution to problem with a single solution. Examples of the projects can be seen in Figure 2:

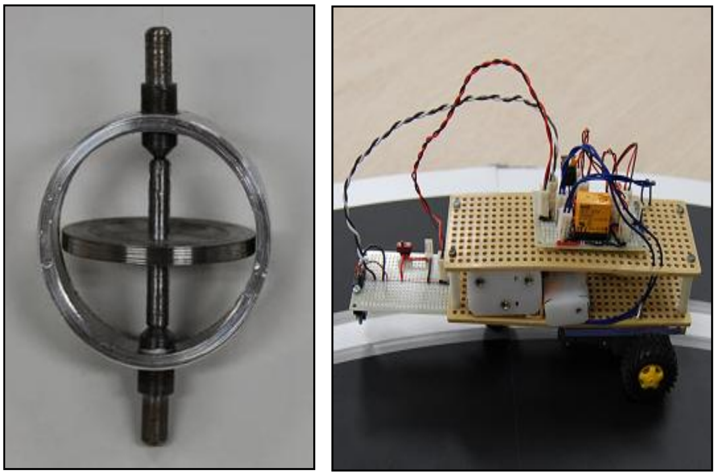

Figure 2. Creative Design II Projects: Gyroscope and Line-Following Car

Creative Design III

This course is a mechatronics course. Students are given line-following robots from the year before. They determine whether or not the cars were successful, then consider what modifications, if any, should be made to create a better robot in terms of operations and ease of machining. The robots all have the same bill of materials, but the specific dimensions of individual components can be modified. Students revisit skills and techniques they have used in earlier courses to complete their robot while adding aspects such as CAD drafting, CNC machining, and making design decisions.

While this course is mainly an Implement course, there is some Operation in the design modifications students make at the beginning and the analysis students provide at the end of the course. There is also some Design utilized in improving the prior years' model, which is used as the template for the robot they will make. In addition, students build on personal and interpersonal skills by sharing initial work in pairs and presenting the results, including design and manufacturing optimization suggestions, to the class.

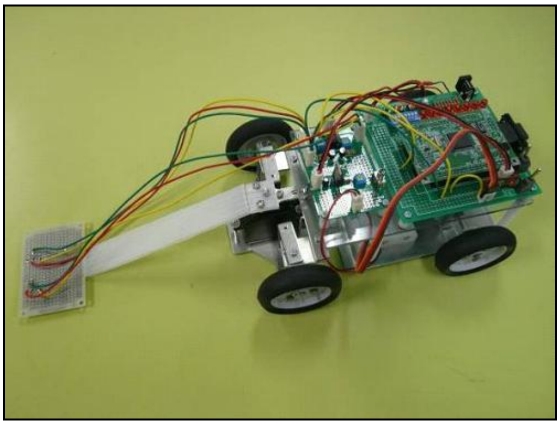

Figure 3. Creative Design III Line-Following Robot

Creative Design IV

For their fourth year, students are separated into groups of six or seven students. Each group builds a line-following robot that must perform, activating multiple mechanisms, at specific points around a given course. The teams split into subgroups of two to three students working on the three main aspects of the robot: mechanisms, control, and structure. In addition, a team leader is chosen to manage documents and a second-in-command is named to assist with overall group documentation and management. The students keep portfolios, give presentations, and deal with project management aspects such as scheduling, time management, and budgeting.

This course has the strongest connection to the CDIO Syllabus. The students Conceive, Design, and Implement, as well as consider some aspects of Operation, while integrating a large number of personal and interpersonal skills through their project. Each team exercises not only disciplinary skills but also creativity in choosing a theme for their robot, mechanisms that match the theme, and explaining through presentations what their theme is and why they have chosen it. An example, a penguin robot that has a party whistle in its mouth, can be seen in Figure 4:

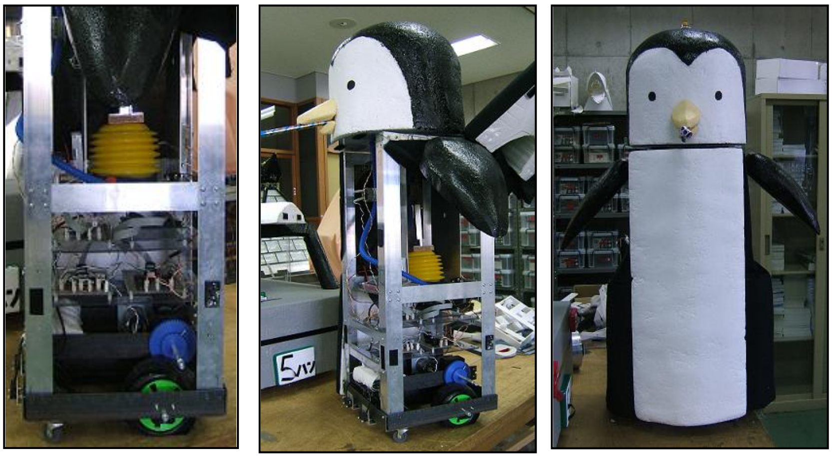

Figure 4. Creative Design IV Robot

ADOPTING CDIO

The most significant challenge for KTC in adopting CDIO throughout the curriculum is the language barrier. CDIO documents do not yet exist in Japanese, and as the first Japanese institution to join as a Collaborator, an effort to understand and correctly translate the nuances of the Standards [4] and Syllabus [5] must be made. Many common words and phrases, especially in the areas of engineering and education, take on a slightly different meaning when appropriated by another culture. The word “research”, written as “リサーチ” and pronounced “resaachi”, for example, simply means finding the answer in Japanese, as opposed to the Merriam-Webster Dictionary definition of “1: careful or diligent search, 2: studious inquiry or examination; especially investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws, 3: the collecting of information about a particular subject” [6]. Some of the Standards, including the Context and Learning Objectives, have not been translated but rather are going to be used as-is because there is no direct Japanese translation. One concern will be to keep the original, intended meaning intact.

In addition to language and cultural differences, KTC is one of Japan’s sixty-three Technical Colleges. A Technical College is a five-year program combining the three years of high school with two additional years of higher education, as seen in Figure 5 [7]. This allows students to either transfer to typically the third year of a four year institution or enter the job market upon graduation. The class structure is very rigid, with students taking all of their core and disciplinary courses at the same time. While this does limit flexibility for students' personal strengths, weaknesses, and learning interests, it offers a greater ability to integrate the curriculum as all teachers know exactly what courses their students take and with which professors. Up to this point, however, collaboration has not been a part of the curriculum and so will be a later implementation.

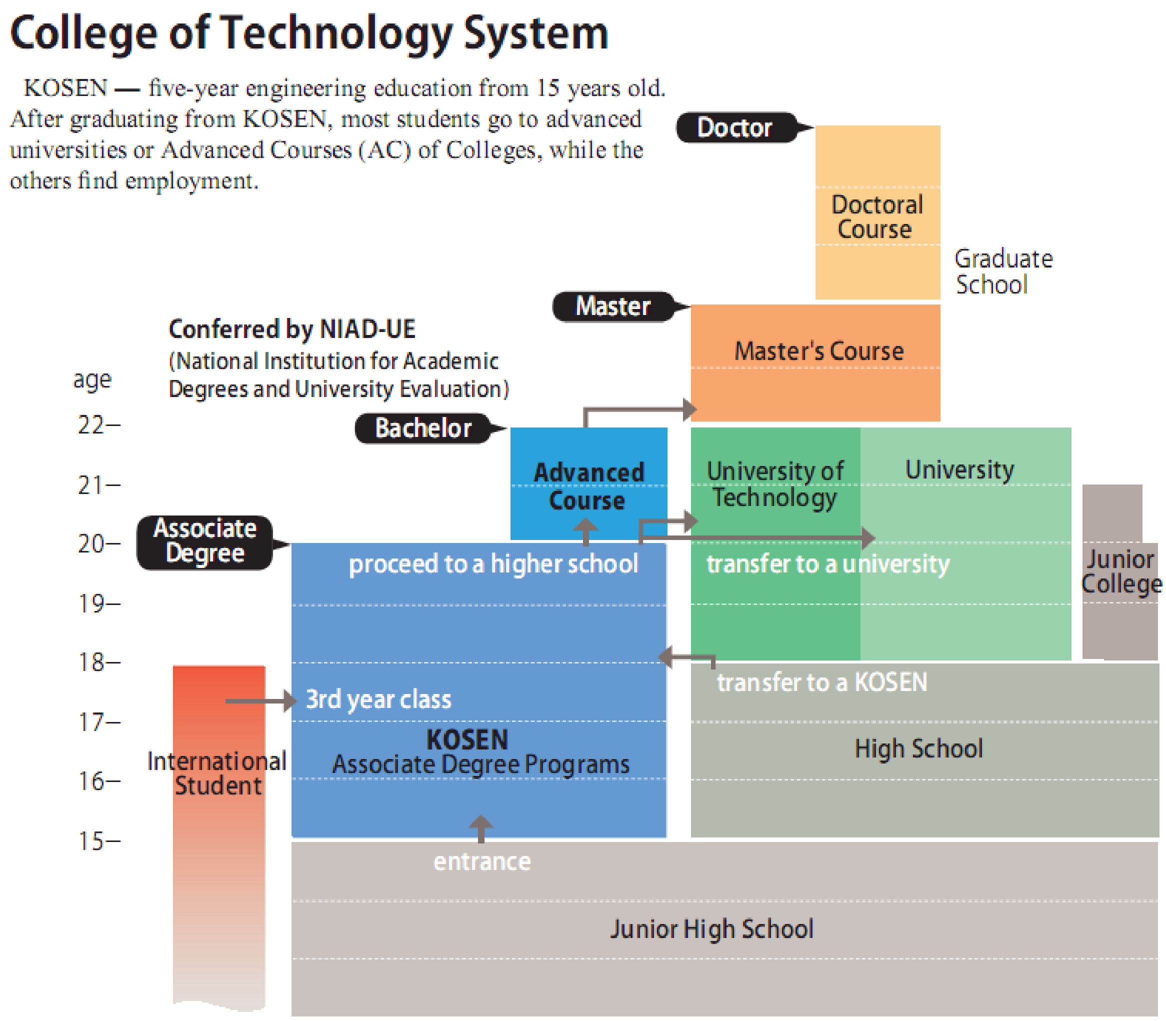

Figure 5. Japan's College of Technology System [7]

Stakeholder Evaluation

The opinions of stakeholders are important in shaping graduates who are ready to enter industry, well prepared for what will be expected of them. Surveys of students and faculty are performed yearly, and recent alumni along with partners in industry are surveyed every five years. The corporate survey asks about not only the proficiency of KTC graduates but also the expected proficiencies for new employees [8]. Students who have graduated since the last survey was given are asked how well their education is serving them as well as what areas have been found to be lacking in order to understand the strengths and weaknesses of their KTC education [8].

The most recent survey, performed in 2009, included the following questions (translated from Japanese) regarding specific student skills:

1. Research
2. Organization of Research

3. Critical Thinking
4. Ability to Understand Others' Perspective
5. Problem Formulation and Hypothesis Creation
6. Autonomy
7. Communication
8. Articulation of Opinions
9. Leadership
10. Empathy
11. Curiosity
12. Initiative
13. Perseverance
14. Honesty
15. Common Sense
16. Social Responsibility
17. Disciplinary Knowledge
18. Application of Disciplinary Knowledge
19. International Communication (including written and conversational language skills)
20. Computer and Internet Abilities
21. Career Planning
22. Ethics

While this survey was not created with the CDIO Syllabus in mind, as do typical stakeholder surveys implemented by CDIO institutions [9], it does involve many of the aspects of the Syllabus already. By adopting the CDIO Syllabus, areas that are known to be deficient can be better served and areas that had not been considered, but are important in engineering education, can be addressed. In particular, KTC ranks lowes in leadership and English language communication. While the majority of the stakeholders surveyed have similar opinions about the abilities of KTC graduates, the faculty tend to have a much lower opinion across the entire range of skills surveyed, as seen in Figure 6:

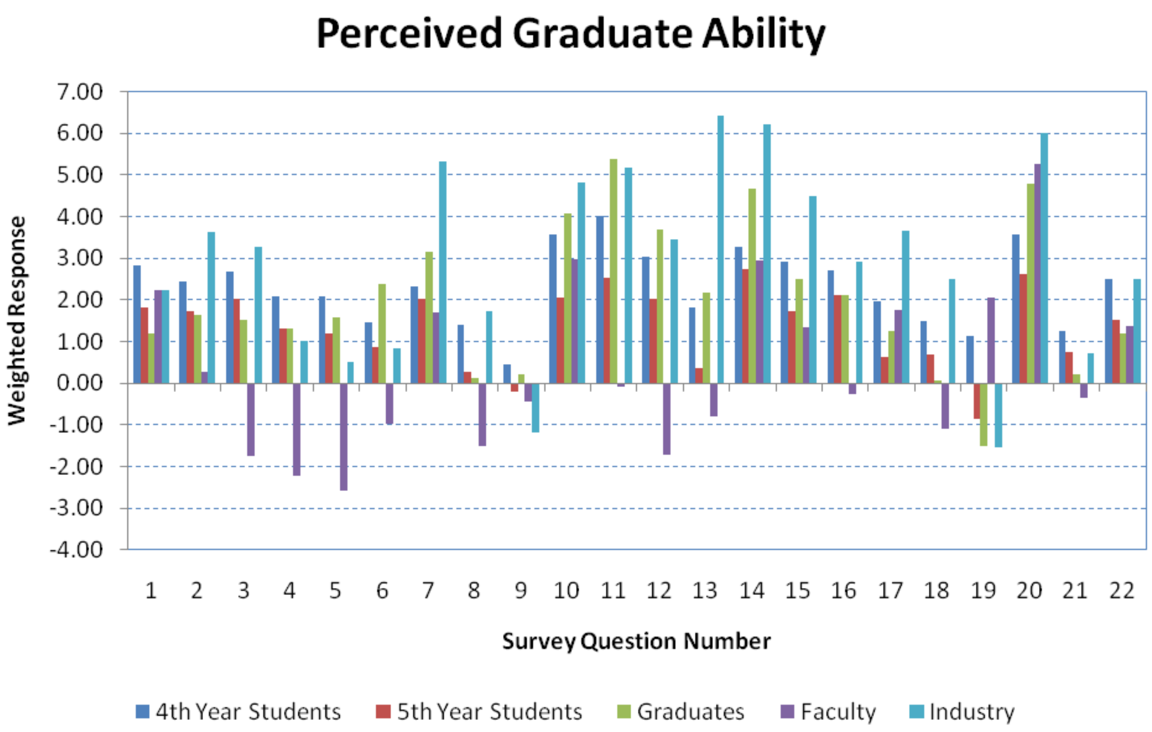

Figure 6. Perceived Graduate Ability, various stakeholder groups surveyed [8]

The courses that are already highly compliant with the CDIO Syllabus, the Creative Design hands-on courses, tend to have the highest student approval ratings among Mechanical Engineering students when compared to other courses taken by ME students as well as compared to the hands-on classes in other majors at KTC as seen in Figure 7:

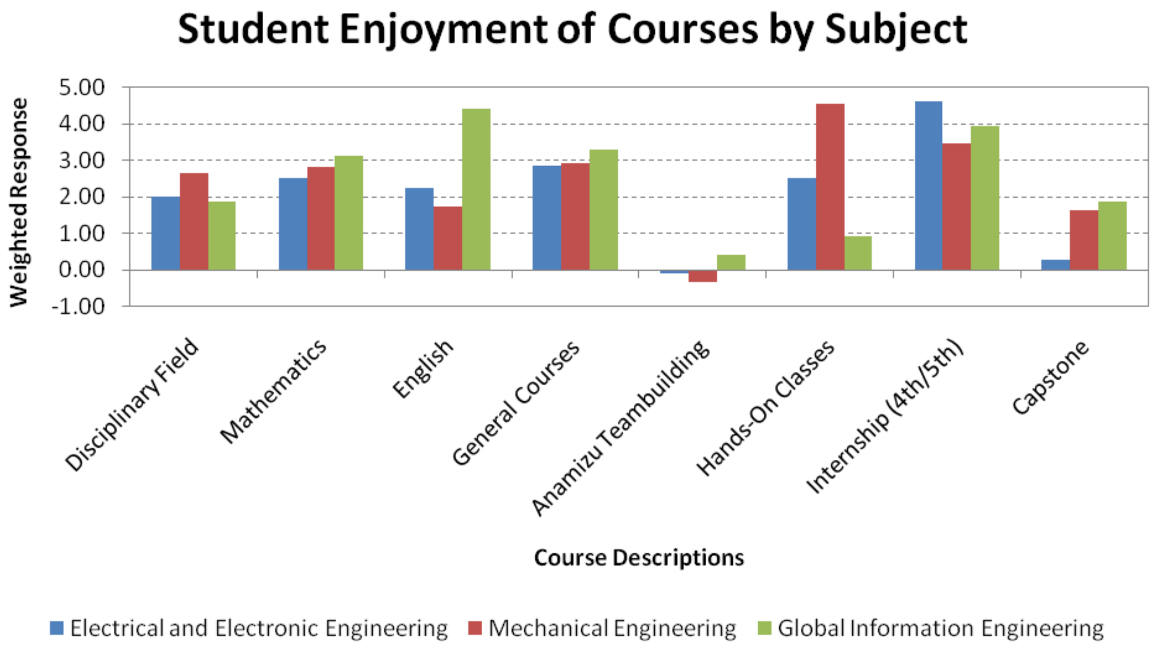

Figure 7. Student Enjoyment of Courses by Subject, separated by major [8]

As other courses are modified based on the CDIO Standards and Syllabus, it is believed that enjoyment of courses will increase. While student enjoyment of courses is not the main reason for adopting CDIO, students are more likely to succeed if they are interested in the coursework and subject matter.

FUTURE DEVELOPMENT

Once a final translated version of the main CDIO documents are completed, benchmarking tools will be translated and implemented, such as ITU charts and surveying the faculty to see which areas of the Syllabus are used in class [4, 10]. When benchmarking is completed, the Creative Design III and IV courses will be modified to include more aspects of the CDIO Standards and Syllabus. Once the Mechanical Engineering department has begun implementing CDIO, the Electrical and Electronic Engineering and Global Information Engineering departments will take the best practices found by the Mechanical department and begin adopting CDIO as well.

Through industrial trade fairs, conferences, and other venues both formal and informal, KTC will introduce more Japanese institutions to the CDIO approach and methodology. The Kanazawa Institute of Technology hopes to become the first university in Japan to join CDIO and is working with KTC to better understand the program and its requirements. Additional institutions have already shown interest in adopting CDIO as well; KTC will be assisting any that decide to pursue a CDIO curriculum.

CONCLUSIONS

As the first institution in Japan to join as a Collaborator, KTC is beginning to translate and interpret the CDIO documents for Japanese language as well as Japanese educational and cultural differences. In order to correctly adopt CDIO, this process will be slow to ensure all educators and policy makers are able to understand the CDIO methodology. In addition to working with the documentation, benchmarking and stakeholder surveys are being undertaken to understand, through the lens of CDIO, where KTC currently stands and to identify areas for improvement. While KTC has a strong program of project based classes focusing heavily on Design and Implementation, other areas of the curriculum are lacking in depth of learning and breadth of teaching and assessment methods. Once a full assessment of departmental curriculum and policies has been made, testing and implementation of new techniques will begin.

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