CDIO IN ENGAGING STUDENTS FOR ENGINEERING COURSES

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ABSTRACT

Detailed outcomes up to the 4th level in the CDIO syllabus of the program are mapped into outcomes for various courses in different semesters. With given set of outcomes, a lecturer has to makes sure that students possess these outcomes within the available student and faculty time, funding and other resources. Currently, ineffective teaching methods, passive learning, lack of development of soft skills, engineering skills, and English skills, are becoming alarming issues at Ho Chi Minh City University of Technology (HCMUT). In this paper, the authors would like to deal with this problem based on CDIO approach for a course of 'Introduction to industrial robots' taught at the Department of Mechanical Engineering, in which the lecturers have gone through four phases: Conceive the context, Design learning activities, Implement the learning by playing and Operate the process.

KEYWORDS

Course outcomes, active learning methods, learning by playing, classroom assessment.

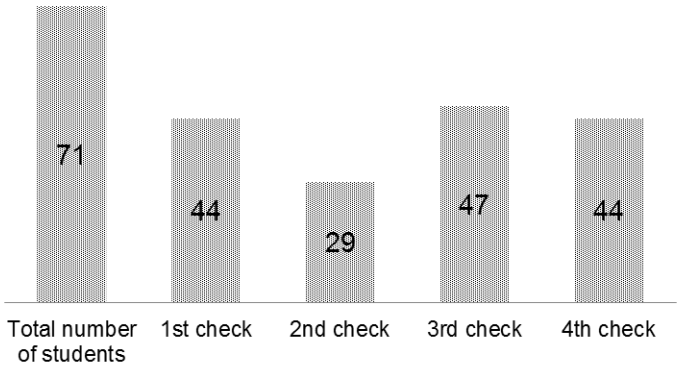
INTRODUCTION

Foreign investment into Vietnam, especially in high-tech fields, has recently been growing. This development requires work-ready engineers with necessary skills to succeed in team-oriented workplaces. However, there are concerns of the content and methods of undergraduate teaching and learning in Vietnamese universities. Specifically, some issues or problems were identified [1]:

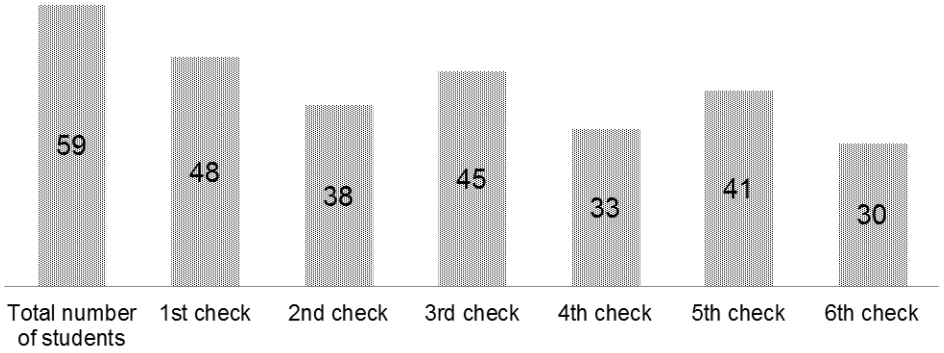
- Ineffective teaching methods, which have too high a dependence on lectures and little use of active learning techniques, result in not much interaction between faculty and students in or outside of the classroom.
- An overemphasis on rote memorization of factual knowledge and a lack of emphasis on conceptual learning or higher order learning (e.g., analysis and synthesis) result in shallow versus deep student learning.
- Most undergraduate classes are too large.

- Student learning is passive (listening to lectures, taking notes, and reproducing memorized information on exams).

While instructors are dedicated, hardworking, and competent, with those issues above, there are still more and more students not attending the classes as illustrated in Figure 1 for two courses in two academic years (AY). The data show that rate of attendance is rather low (from 40.8% to 81.42%) and dramatically decreases toward the end of the course.



(a) The course of 'Introduction to industrial robots' taught in AY 2009-2010



(b) The course of 'Introduction to control system technology' taught in AY 2010-2011

Figure 1. The number of students attending the class

In order to engage students learning engineering courses, instructors have to incorporate active learning strategies into class discussions. In this paper, the authors would like to address this for the course of 'Introduction to industrial robots' taught at the Department of Mechanical Engineering in the academic year 2011-2012 at HCMUT according to CDIO approach, in which the lecturers have gone through four phases: Conceive the context, Design learning activities, Implement the learning by playing and Operate the process.

CONCEIVE THE CONTEXT

In the context of increasing globalization, Vietnam needs an accreditation system to ensure that graduates are accepted internationally. Specifically, in the last five years, Vietnam National University – Ho Chi Minh City (VNU-HCM) have been conducting program accreditation from AUN (ASEAN University Network). In addition, the University of Technology, VNU-HCM System, is seeking ABET (Accreditation Board for Engineering and Technology) accreditation for programs in Department of Computer Science & Engineering and in Department of Electrical and Electronic Engineering [2].

Since 2010, a model framework for widespread implementation of CDIO in Vietnam [3] has been developed by Vietnam National University – Ho Chi Minh City in which instructors are trained to develop and use interactive teaching and active learning methods in class. At the same time, some engineering faculty members have been selected to participate in the Higher Engineering Education Alliance Program (HEEAP). Its overarching goal is transforming engineering education from passive, purely theory-based instruction to active, applied and theory-based instruction and learning [4].

Although there are national efforts in curriculum reform [5], many students still do not attend class as shown in Figure 1. Being a lecturer, he must solve this problem by developing a course syllabus that engages students in their learning activities. To make this successfully, lecturers should conceive that utilizing various active learning methods to engage students is like using different fighting styles to defeat opponents. As demonstrated in Figure 2, if a certain teaching method fails to facilitate student's engagement, the lecturer should think of other appropriate ones.

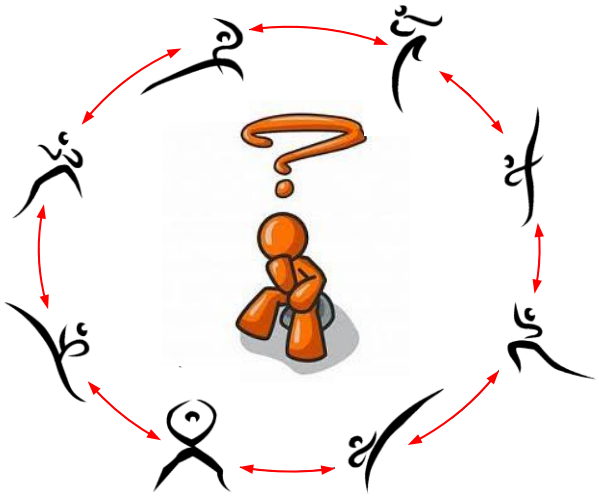


Figure 2. Conceiving of different teaching methods in engaging students

DESIGN LEARNING ACTIVITIES

In this phase, together with traditional teaching methods, several active learning methods [6] have been employed, developed and used in class with one thing to bear in mind 'learning by doing, learning by playing'. Followings are learning activities designed when teaching the course of 'Introduction to industrial robots'.

Activity 1: Jeopardy Game

This game is designed in Microsoft PowerPoint (PPT) to review knowledge in chapter 1 (Overview of robots) and chapter 2 (Robot anatomy) as shown in Figure 3. The contents in these two chapters are mainly concepts and terminologies, covering industrial applications, classification and components of robot systems; actuators and transmission drives, sensors equipped in robots, and robot control system. During teaching these two chapters, active learning methods used in class, e.g. 'group-based learning', 'student-led review'. In addition, skills of teamwork and presentation are also addressed so that students know how to work effectively in a team.

218033 Jeopardy

Robotics introduction	Robot anatomy	Robot drive system	Soft skills
100	100	100	100
200	200	200	200
300	300	300	300
400	400	400	400
500	500	500	500

(a) Main PPT slide of the game

The robot in the figure is an example of _____ ?

Row 2, Col 1

What is the structure of this SCARA?

RRP

Row 3, Col 2

Put 'Electric motors', 'Hydraulic systems', and 'Pneumatic cylinders' into appropriate places of the paragraph.

Electric motors are the most commonly used actuators. Pneumatic cylinders are used in on/off type joints, as well as for insertion purposes.Hydraulic systems are very popular for large robots.

Row 3, Col 3

INESS are basic parts of an oral presentation. What does it stand for?

1. **I**ntroduction → Credibility; credentials
2. **N**eed to know → Why is it important for the audience to pay attention; How will they benefit
3. **E**xpectation management → How detailed is your presentation
4. **S**ubject matters → Interesting? Sequenced properly? Visual aids?
5. **S**ummary + Q&A

Row 3, Col 4

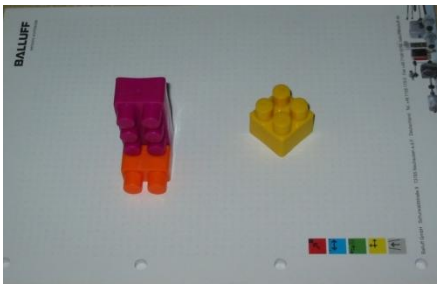
(b) Typical slides for the four groups of knowledge

Figure 3. Jeopardy game

Activity 2: Communication Game

For a concept of homogeneous matrix, students can gain the skill of formulating this matrix through computational exercises. However, it is more interesting for them to understand this matrix fully through an orally interactive game. In this game, students as runners, communicators or builders in a team all have to unify the way of assigning coordinate frames

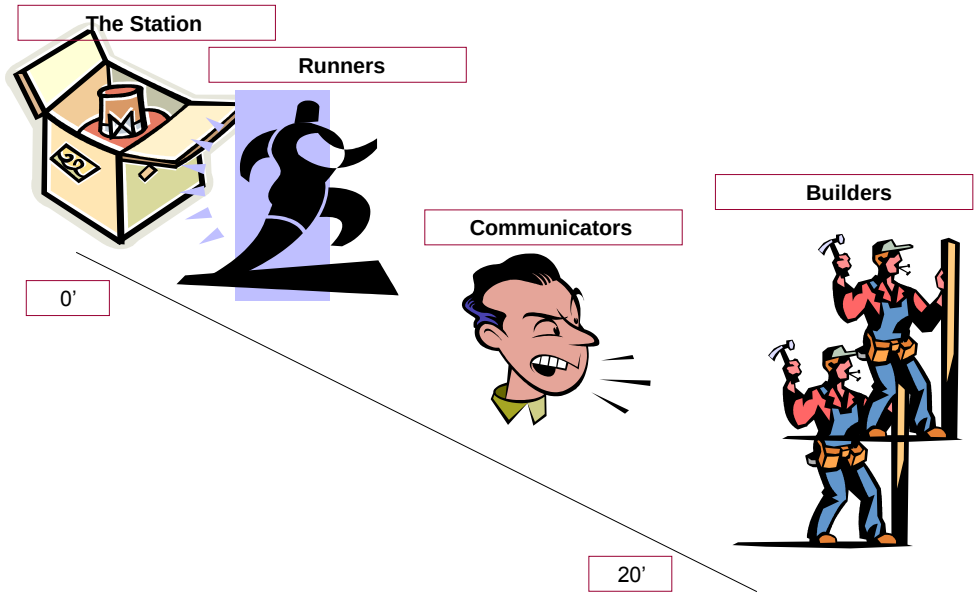
to items, know how to describe positions as well as orientations of these items as shown in Figure 4 so that the product from the builders matches the items in the station during 20 minutes.



(a) Items in the station

$$\begin{bmatrix} {}^{A}P \\ 1 \end{bmatrix} = \begin{bmatrix} {}^{A}_{B}R & {}^{A}P_{BORG} \\ 0 \quad 0 \quad 0 & 1 \end{bmatrix} \begin{bmatrix} {}^{B}P \\ 1 \end{bmatrix}$$

(b) Homogenous matrix



(c) Learning diagram of the game

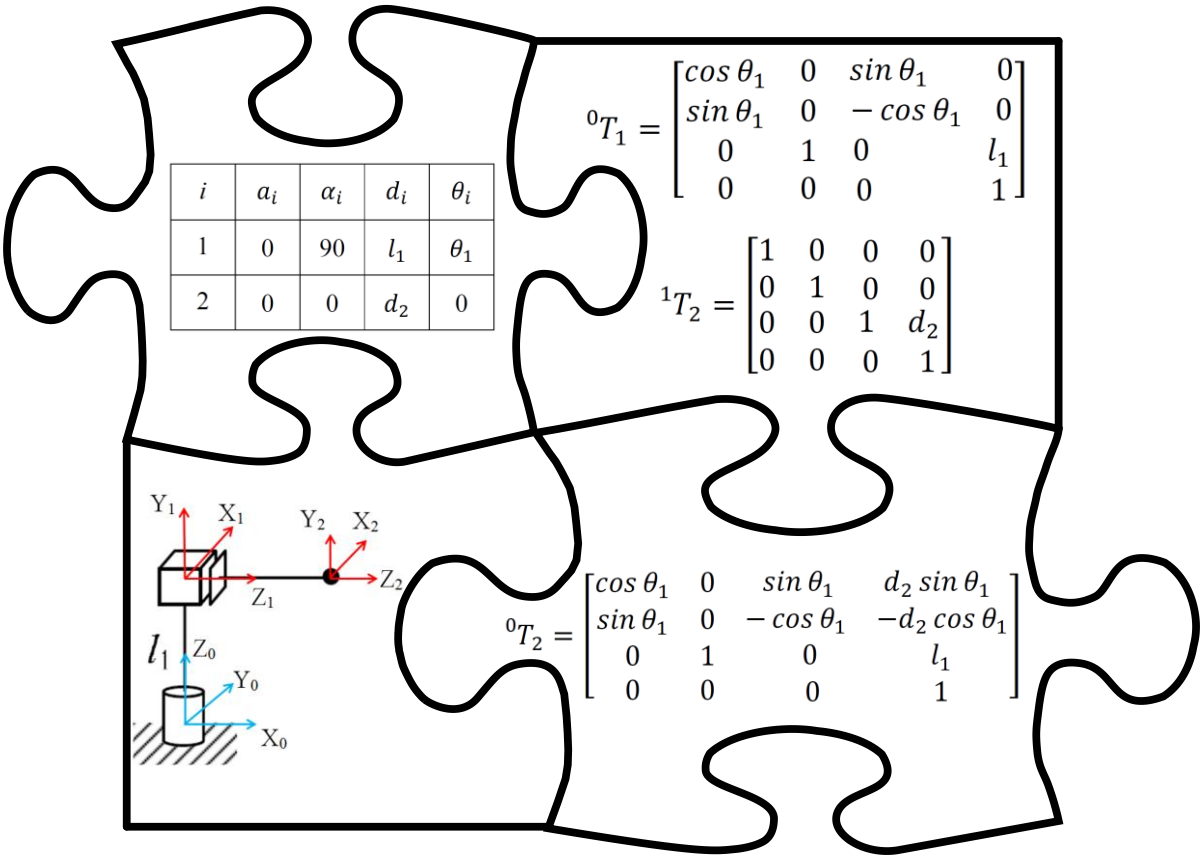
Figure 4. Communication game when learning about homogenous matrix

Activity 3: Jigsaw Game

In chapter 4 of the course, the topic is about manipulator kinematics. Four basic steps to formulate forward kinematics are:

- Step 1: Assign frame for each link
- Step 2: Determine D-H parameters for each link
- Step 3: Using D-H parameters to compute the individual transformations for each link.
- Step 4: The link transformations are then multiplied together to find the single transformation that relates the last frame to the first frame

Instead of letting students go through these four steps for every mechanism, each piece of jigsaw contains a certain step of the solution as shown in Figure 5. Many sets of quite similar mechanisms are prepared in the same way. For this activity, students move around the classroom, talk to each other and discuss to find out whose step is before and whose step is after his step.



i	a_i	α_i	d_i	θ_i
1	0	90	l_1	θ_1
2	0	0	d_2	0

Figure 5. Four pieces of jigsaw form a complete solution of forward kinematics

IMPLEMENT THE LEARNING BY PLAYING

Those three games above were implemented in the class. Process for the implementing strategy is:

- Form groups
- State the game rules
- Pose a question / a problem to students
- Ask group for their answers / solutions. During the game, ask them feel free to share, to discuss and to argue …

There are some notes for instructors as summarized in Table 1. Those are:

- These games do not take much time in class. For Jeopardy game, it takes maximum 2 periods of 45 minutes in a 3-period class. For the other two games, they take only about 30 minutes.
- For the class scale, it works well for 10 groups of five students. Particularly, for the jigsaw game, it does not matter what the class size is as long as there are enough problem sets for the students in class.
- There is a need of supports from teaching assistants, especially for updating scores onto the board or identifying which team gets the priority.
- For the materials, they do not cost the instructors much to prepare. The instructors just need to know how to utilize some animations and slide transitions in PPT for the Jeopardy game; just try to make use of Lego toys for the communication game; and just arrange equations, figures onto pieces of paper for the jigsaw game.
- It is very noisy in the classroom… It may affect classes nearby.

Table 1
Remarks of implementing the games

Game	Jeopardy	Communication	Jigsaw
Time duration	60 – 80’	20 – 30’	20’
Total number of students	~50	~50	~50
Number of student / group	4 – 5	4 – 5	4 – 5
Need help from teaching assistants	Yes	Yes	Yes / No
Materials for the activity	Computer	Lego toys	Paper

OPERATE THE PROCESS

During the course, the number of student attended the class is shown in Figure 6. The result shows that the rate of attendance is in a range from 70.1% to 92.5%, increasing significantly compared to the attendance results shown in Figure 1 and that the rate just slightly decreases toward the end of the course.

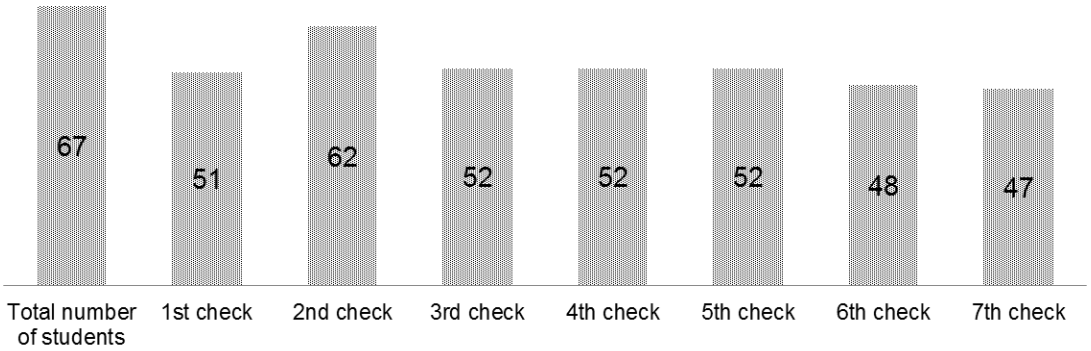


Figure 6. The number of students attending the course taught in AY 2011-2012

Table 2
Grading scales and the percentage of students passing the course

Grading scales	AY 09 – 10	AY 10 – 11	AY 11 – 12
Attendance	10%	10%	10%
Individual homework	25%	25%	25%
Group homework			15%
Assignment in class	15%	15%	15%
Oral presentation			5%
Final exam	50%	50%	30%
% students passed	66.2%	81.4%	85.1%

In addition, the number of student passing the course can also consolidate the effect of the teaching methods. As shown in Table 2, there is more assessment during the learning process, typically teamwork and oral presentation for the course taught in the academic year 2011-2012. Group activities make student more responsibility in their learning. Together with playing games between groups in class, the competition forces students to be active and to

show their abilities to others. That makes lessons interesting to students. As a result, they come to class more often and do much better in the exams.

Table 3
Survey results from student's feedback on teaching

Criteria for consideration		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Preparation & Organization						
1	The instructor is well-prepared for the class			1	14	35
2	Lessons are systematically structured and organized			2	21	27
Knowledge						
3	The instructor appears knowledgeable in teaching his/her subject			2	17	31
4	The instructor is able to use alternative ways of explaining the material when necessary			4	19	27
Enthusiasm for the subject						
5	The instructor teaches the subject with passion		1	1	22	26
6	The instructor stimulate my interest in the subject			3	27	20
Learning and thinking						
7	The instructor's teaching approach stimulates thinking and problem solving			3	32	15
Delivery						
8	The instructor communicates effectively			4	22	24
9	The pace and the pitch of the class session is appropriate			4	24	22
Effectiveness						
10	I learn a lot about the subject from the instructor			6	22	22
11	Overall rating : the instructor is proficient in his/her teaching			3	21	26

Student's feedback on teaching has been conducted every two chapters to assess how students achieve course learning outcomes. Data, as shown in Table 3, are survey results from 50 student's feedback on teaching at the end of the course. The results show that the contents of the course are quite appropriate and interesting. Moreover, there are some encouraging words from their feedback as follows:

- Simulation is perfect
- Enthusiastic, on time, vivid lessons
- Employed many IT programs in the course
- Provided tutorial clips clear and easy to understand.
- Enhance student's ability of reading materials in English and oral presentation

- Passion and well prepared
- Gave a clear outline before lecture
- Got supports from teaching assistants in computer simulation
- Active teaching method
- Lessons in English is interesting to students

CONCLUSIONS

In this paper, the authors demonstrated a C-D-I-O process employed to solve the problem 'how to engage students for engineering courses'. It has been found that using course contents in English definitely makes chances for students to utilize and develop their English skills. The use of a single mode of instruction, such as lecture, often leads to complacency and boredom in the classroom. By varying teaching methods in each class meeting, students are more engaged and learn well in the end. In other words, lecturers have to be creative so that lecture is interspersed with the use of visuals, group activities, multimedia demonstrations, games, and other instructional techniques. Activities of 'Learning by doing & learning by playing' are possible to implement in classes of 60 students, which are common in Vietnamese universities, with one or two teaching assistants.

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Biographical Information

Dr. Cong Bang Pham is a senior lecturer in Mechatronic engineering at the University of Technology, Vietnam National University Ho Chi Minh City. His research interests are in mechanism design, flexible manufacturing systems, robotic systems, and rapid prototyping techniques. Since 2010, he has been a CDIO implementation team member at the Department of Mechanical Engineering. He has also participated in Higher Engineering Education Alliance Program (HEEAP) transforming engineering education from passive, purely theory-based instruction to active, applied and theory-based instruction and learning at Vietnamese engineering universities.

Jeffrey S. Goss has served as the Executive Director for the Office of Global Outreach and Extended Education and Assistant Dean in the Ira A Fulton Schools of Engineering at Arizona State University for the past seven years. Mr. Goss has more than 18 years experience in professional and executive education collectively at University of Maryland, George Washington University, University of Michigan, and Arizona State University. His research areas include global workforce development learning models and the development and application of new technologies and distributed-media models for adult learning. Since 2010, Mr. Goss has been the Principal Investigator/Project Director for the Higher Engineering Education Alliance Program (HEEAP), focused on modernization and transformation of teaching and learning in undergraduate engineering programs in Vietnam. In this role, he has worked in both Vietnam and the United States on faculty and curriculum development to advance Vietnam's economic growth. Under an existing project funded by USAID and Intel, Mr. Goss has partnered with five major universities in Vietnam to prepare faculty to excel in teaching students to attain technical expertise, English, and the soft skills and competencies to succeed on a global engineering stage.

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