A Structured Training Course for Non-structured Design Course

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***Abstract*—In an engineering design course, teaching assistant plays a critical role to in supporting the teaching and the learning process for the participants – students and instructors. The instructors would invite or hire a postgraduate student to be the teaching assistant. In most cases, the postgraduate student does not has any teaching experience. This work proposed and implemented a quick start training course for the teaching assistant specifically for an engineering design course, by adopting concept-design-implementation-operation.**

***Keywords*—CDIO, design course, non-structured, structured, teaching assistant;**

I. INTRODUCTION

At university level, an engineering design course always involves the instructors, the teaching assistants (TA), and the laboratory assistants. Those parties heavily support the course, which mostly is organized under concept-design-implementation-operation (CDIO) framework, [1], [2]. The instructor is the designer of the course which involves all CDIO elements, from concept generation, to design phase guidance, till the implementation and the operation iterations. However, to cover the details of the design work, the TA plays a critical role in supporting the course. The teaching assistant must prepare the design materials, the design implementation details and dealing with the operation issue, which are very time consuming and requires a lot of details effort. More than one teaching assistant is often required in a design course. The design course is highly non-structured, [3] with lesson plan that is the emphasis on the flow of the design [4]. In such case, the teaching assistant must participate in the initial phase of the course organization, and understand the design science, [5]. This work proposes and implements a training course for the teaching assistants who involve heavily in the design course. A typical design course in our contest involves the multi-disciplinary engineering principle, the fundamental design science concepts, the practical implementation aspects, and the essential academia assessment.

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The training course, however, kick starts with the requirement in design courses, and end with the essential academia assessment [6]. In this training course, the main elements are:

- Teaching team's teamwork,
- Interaction,
- Active-research,
- Learning outcomes,
- Grading rubrics,
- Course evaluations.

The key component of the training course is essentially the teaching team's teamwork, interaction, and active-research. Unlike conventional course which is conducted separately by instructor and TA in different sessions, the design course lessons involve all the participants as well as all the teaching team members. For instance, there are two instructors and one TA in a cohort classroom. The cohort may have thirty participants (students).

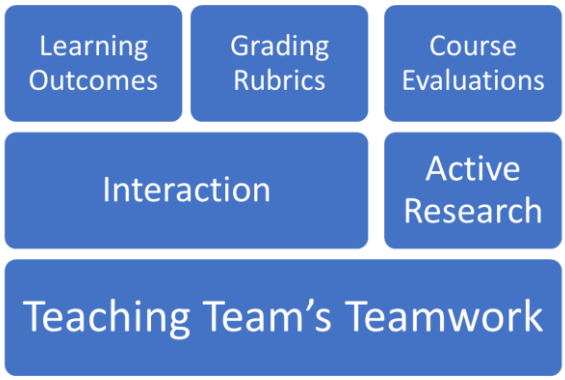

Figure 1. Components of the training course

This paper is organized as follow. Section-II describes the organization of the training course. The detail components of the training course are then discussed in Section-III. Section-IV concludes the paper.

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II. Training Course Organization

The teaching and learning team should be carefully organized to achieve the goal of the training. The training aims to training the instructors and their teaching assistants. Unlike teaching the undergraduate students, the background of the course-instructor (instructors for the training course) cannot be compromised. The basic qualifications of the course-instructor:

1. Strong background in engineering practice, with principal engineer position for at least five years,
2. Strong background in research and development, with principal investigator position for at least five years,
3. Strong background in teaching and learning experience, which are pedagogy research, curriculum development, classroom management, accreditation, organizing new courses, undergone formal pedagogy training, with senior academic position for at least five years.

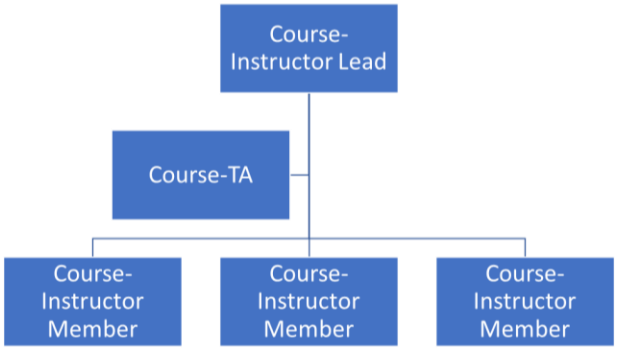

Figure 2. Organization of the training course

It is in fact not common to have the course-instructor with the above-listed qualifications and experiences. Thus, finding suitable instructors is the most challenging task in the training course organization. This requirement explains how difficult in setting up a good educational institute. The trained instructor and TA still need to have another at least three years extensive practice to gain sufficient experience in teaching and learning. The course-TA (TA for the training course) must also have the following qualification:

1. Strong hands-on experience in engineering product design and development,
2. Strong background in industries and participated in team-based design group,
3. Strong background in teaching and learning experience as TA and undergone formal pedagogy training.

The course-TA could be selected from a pool of postgraduates or graduate students with strong interest in the teaching career. The primary issue for existing research university is no strong emphasis in high-quality teaching due to poor support from the postgraduates or graduate students, who put extensive focus on research and publication. The course-TA must interact with the participants during the lesson as well as collecting feedback from them to improve the training. It is very important for the course-instructors to adjust the course content and course delivery approach. One should be aware that a successful lesson for a batch of the participant, does not guarantee the lesson plan can be used for the other batch. In this case, the immediate feedback is required, and the best source of feedback is the interaction between the course-TA and the participants. The course-instructor should focus on course delivery and content expert role, not a facilitator role. With only a proper course organization, as shown in Figure 2, the training course components as listed in Figure 1 can be executed effectively.

III. Training Course Components

The most important value in training the instructors and TAs for a design course is the teaching team's teamwork. This teaching team's teamwork can be trained through the role models by having good teaching team in the training course. There are at least two course-instructors in the training course, where one course-instructor leads the lesson and another course-instructor act as a member. It is important that the course-instructors and course-TAs have discussed and agreed with every single detail before the lesson. If there are any discrepancy and disagreement during the lesson, the course-instructors shall not confront or argue between each other. Any correction and amendment can be delivered in the next lesson. This arrangement is to avoid confusion and loss of confident among the participants about the teaching team and the course. In fact, the teaching team's teamwork determines the quality of the training course for a design course, which is not common.

Figure 3. Active research cycle

For a design course, the basic goal is to generate an innovative solution for a given problem [3], through systematic and scientific approaches. The question is how to generate the innovative solution if the problem is not a familiar topic for the team, which is always the case. Most often the instructors and TAs will only carry out comment and critic session without providing a constructive idea. In a proper design course, the instructor and TAs should lead each team member in carrying out research in different direction individually bases on their expertise, and then discuss among the team members for the solution. In this case, the diversity and interaction in a team are essential. The training, thus, must cover the effective interaction in the design team. In a nutshell, teaching team's

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teamwork and effective interaction form the foundation of the training course.

However, the design team should be motivated to generate and propose their idea and solution, which is another key element the training course – active research as illustrated in Figure 3. The instructors and TAs should draw the guidelines on how to carry out active research for a design project, which supports 'planning' phase. The basic design concept must be 'bottom up', not 'top-down'. Often mistake is the instructors and TAs have strong opinions and preference about the direction of a design project and reject the students' proposed idea without depth consideration, which turns the project into a pure passive-research mode. Again, the instructors and TAs need to put in effort in understanding the students' work by playing an active role in the 'observation' in the active research cycle. In this observation phase, both observable and not observable must be discussed. One should make a different between active-research and self-research. Self-research has no guidelines from the instructors at all, which happens at the very beginning stage of a design course. Figure 4 illustrates the elements of the active-research in general.

Figure 4. Elements of active-research

After the foundation of the training course – teaching team's teamwork, interaction, and active research, the common training components are presented, which are setting up the learning outcomes of the design course, determining the grading rubric, and how to evaluate the course for continuous improvement. The continuous improvement can only be make if the learning outcomes of the design course reserve room for flexibility and account for the possible update. It is common that the design courses encounter a significant change of learning objectives due to the current advancement in the topics that cover in the design course, e.g. the adaptation of 3D printer has changed the approach in fast prototyping and the learning outcomes on fast prototyping should be tuned to this direction immediately. In this scenario, it is recommended to combine the learning outcomes, and the measurable outcomes to avoid to specific outcomes that could not be updated during the lesson period. Combining both outcomes is the current trend. However, the course outcomes must in line with the university's student learning outcomes. To achieve both course outcomes and university's student learning outcomes, the later comes have bought down to the course outcomes through design project outcomes, [7]. Thus, there is two levels of learning outcomes in a design course that have to be prepared by the instructors and TAs – i. course level, ii. design project level as illustrated in Figure 5. The challenge could be meeting both accreditation and course requirement. Although the university student learning outcomes are broad and not specific to a course, meeting them is mandatory. In [7], the author found that design project outcomes can support the university student learning outcomes seamlessly if plan carefully. Besides meeting the accreditation requirement [8], the learning outcomes play a critical role in monitor the students' learning progress. Thus, the learning outcomes can be divided into three categories in a design course:

- Basic outcomes: these outcomes link the current course to the prerequisite courses.
- Core outcomes: the major learning outcomes to be achieved.
- Advanced outcomes: these outcomes prepare the students for other advanced courses or industries.

Bases on the learning outcomes categories, the syllabus and content are determined to support the lesson plan [9]. It is recommended to have an early assessment for the basic outcomes to allow the instructors to adjust the depth of the contents. More throughout assessment should be given to the core outcomes. It is up to the instructors if the advanced outcomes should be assessed in details.

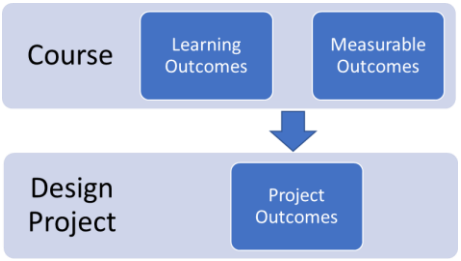

Figure 5. Multi-level learning outcomes

Once the learning outcomes is decided, the assessment methods and the grading rubrics can be decided accordingly. In this case, the learning outcomes serve as a 'contract' with the students. It is recommended that the grading rubrics is shared with the students before the commencement of the course and let the students propose reasonable amendments for them to have ownership of the course. The instructors and TAs must open in the grading policy which is transparent. Transparency in a course is one of the key aspects for the course evaluation. The students would like to have clear goals to achieve, especially in a design course. This requirement is contradicting with common practice for a design course, which prefers not to constraint the design idea. However, one should be clear that a properly organized design course must have a clear target application and goal. The evaluation of the course refers to the achievement of the goal, besides considering the feedback from the instructors and students. The evaluation criteria:

- Students' satisfaction.
- Instructors' satisfaction.
- Achievement of the goal of the design – a measurement of the learning outcomes satisfaction.

IV. Conclusion

This work provides general guidelines and experience sharing of conducting a training course for the instructors and TAs in a design course. A design course's instructors and TAs

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have to undergo a proper training course before conducting the course to provide meaningful support to the students. The main components to support the students are teaching team's teamwork, interaction, active learning, learning outcomes, grading rubrics, and course evaluations, which are the contents of the training course.

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REFERENCES

[1] "CDIO," CDIO Office - Chalmers University of Technology, [Online]. Available: http://www.cdio.org/.

[2] T. Hui, Teo, "An effective interdisciplinary teaching and learning methodology through crossed-subjects design project - an experience sharing," GSTF Journal on Education (JEd), vol. 3, no. 2, pp 18-22, 2016.

[3] T. Hui, Teo, "A very short capstone project design management and design tactics," *accepted to be published in GSTF Journal on Education (JEd), vol. 4 no. 1, 2017*.

[4] T. Hui, Teo, "Just-in-Time Teaching visual instruction for cohort base interactive learning-for engineering course," GSTF Journal on Education (JEd), vol. 3, no. 1, 2015.

[5] V. Hubka, and W. E. Eder, Design Science – Introduction to the Needs, Scope and Organizaiton of Enginering Design Knowledge, Springer, 1996.

[6] "Teaching Materials," Teaching & Learning Laboratory, MIT, [Online]. Available: http://tll.mit.edu/help/teaching-materials.

[7] T. Hui, Teo "Student Learning Outcomes accomplishment through design project," GSTF Journal on Education (JEd), vol. 3, no. 2, p. 19, 2016.

[8] I. E. Aliance, "Washington Accord," 1989. [Online]. Available: http:// www.ieagreements.org/ Washington-Accord/.

[9] J. M. Slattery and J. F. Carlson, "Preparing an effective syllabus - current best practices," College Teaching, vol. 53, no. 4, pp 159-164, 2005.

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