Practice of Engineering Skill Training by Design Thinking Team Works in Laser Serious Courses

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Keywords: Engineering Skill Training, Design Thinking, Practice, LASER.

Abstract. According to the industry four times and ABET requirements, the practice of engineering skill training by design thinking team works in laser serious courses is introduced. Our practice experience of team work in laser serious courses has three parts: the preparation shows the student centered at first, includes learning styles test, to establish good cooperation and rules of courses. In the practice duration of the teachers include design thinking, multiple teaching activities, flipped classroom and reports and the students’ includes project chosen, review, peers chosen three sections, the benefits are listed and over 400 students are benefited. In our opinion, the combination of team work and design thinking benefits the students to improve their skills – both technical skills and non-technical skills greatly.

Introduction

Now is in industry 4.0 times that expresses the current trend of automation and data exchange in manufacturing technologies, and it creates what has been called a "smart factory", including cyber-physical systems, the internet of things, cloud computing and cognitive computing. Since the invention of laser till now, laser has been wide applications from ground base to airborne and aerospace, and is already as a fundamental tool being used in our daily life, science, industry, commercial and military fields.

In China, the common ways of teaching engineering practice may be characterized by several of the following items: research-trained faculty, one-answer problems, lecture, “recipe” labs, analytical sophistication, individual work, few presentations one country, one culture, few constraints, risk discouraged, “just-in-case” delivery. Over the internet of things, systems communicate and cooperate with each other and with humans in real time and via the internet of services; both internal and cross-organizational services are offered and used by participants of the value chain. Human benefits from internet by MOOC, websites on education, moreover to search for something unknown with webpages. On the opposite, this is an obvious big problem on education in case of the teachers teach as the above method, because maybe some of the knowledge has already been taught by students themselves. So in the industry 4.0 times what should be taught is also a problem faced all the teachers of engineering university.

According to the new criteria of Accreditation Board for Engineering and Technology (ABET) in 2000\cite{1}, based on my laser serious courses teaching process experience, in my opinion to an engineering university, the educators should focus on both science and technology and what skills and abilities an engineer should have. Further, engineering skill training by design thinking team works should be introduced as soon as possible.

Importance of Design Thinking Team Work

Work groups are the basic building block of any courses. The importance of developing team work skills in engineering students has been extensively documented in the literature. It has been validated
by industry itself and by the ABET in its requirements [2]. The main value of teams for courses is their ability to assemble and empower employees to use their talents to improve the courses.

Design thinking is a method for practical, creative resolution of problems, a form of solution-based thinking with the intent of producing a constructive future result, especially suitable to innovation. Here so called design is different from traditional design in Chinese. Traditionally, design is focus on the functions; designers function centered without consideration the populations of customer personal needs. Therefore, in order to develop team work skills in students effectively and efficiently, the task has to be thoroughly planned and implemented with design thinking methods. Moreover, in order to be creative, many skills need be trained, more mavericks, and less mutual admiration. One also has to adequately assess the development of these skills in the student, in order to determine the success of both the learning process and the education process the assessment results, if necessary. Development of team work skills in students was an important element in the relevant courses design.

Prepares of Team Works

Traditional lectures are the most common methods. Lectures require long attention spans, yet research has shown that concentration and knowledge recall decrease sharply after 10-15 min and that learner recall 70% of the material from the first 10 min of a lecture, whereas only 20% of the material presented from the last 10 min [3]. Incorporating active learning strategies into lectures has been suggested as a means to engage learners and counterbalance the inherent limitations of lectures. In Laser is the content intersection the following courses, “laser principles”, “laser technology”, “principles and technology of laser”, “photon-electronics”, and so on.

Students preferentially take in and process information in different ways as shown in Fig.1: by seeing and hearing, reflecting and acting, reasoning logically and intuitively, analyzing and visualizing, steadily and in fits and starts. Teaching methods also vary with multisensory ways in lectures process. It is dominant to exchange the roles between teacher and student in practice. This is student centered phase that is different from flipped classroom with applied design thinking methods.

Learning Styles Test. According to both teachers and students are the subjects in education process, the teachers must learn to know how the students learning methods are. Learning styles [4] test generally is referred to as the Felder-Silverman model for use by college instructors and students in engineering and the sciences, although it has subsequently been applied in a broad range of disciplines. After test, it gives degree from 1 to 11 to let the tester know his/her own styles that he/she maybe sensors or intuitors, visual or verbal, active or reflective, sequential or global. After test, the groups are formed with 4~6 persons, no more than 6 and each group may have a global student as leader.

To Establish Good Cooperation. Some of the baseline non-technical skills for team members recommended in the literature [5] are building trust and teamwork, training and coaching other people, leading problem-solving sessions, using group interaction tools, planning, communication and dealing with changes. Therefore, the development of teaming skills in students is of critical importance because it is expected that all course work will be done by teams of students. Thinking Pair Share method is helpful to establish good cooperation relations gradually. A serious of questions is ready to practice.

Rules of Courses - be Open and Creatives. Use active learning as much as you can! This is important during my experience of teaching. Because of wide applied internet, types of tools can be used in the classroom as shown in Fig.2. Team work as in Fig. 3 make the student to think is the most important thing, also powerful for motivating learning and for developing engineering skills. Further let students know mistakes are nothing but the keys of progress. The most important thing to an engineering undergraduate is to think. The iPhone’s story will help them to know the significance of mistakes.
Practice of Team Work Operation

Practice of Students

Project Chosen. Find out what the students know and what they want to know. This make they have the interest to learn as Towns said as Fig.4. What laser applications are in our daily life? This simple question has plenty of answers with laser printer, pointer, and so on. It is just a beginning. Second is which application and why it is attractive to student. The guys like medical and three-D printing field applications. Then is how laser is used, include the principles and techniques. The last step is flipped - let the student to do similar laser design or application.

Review. Here a review is a profession evaluation of books, journals, news etc. on lasers. In addition to a critical evaluation, the students may assign the work a rating to indicate its relative merit, even to review current events, trends, or items in the news. In team work first stage, students do work individually. One can easily find the reports have different section, from presentation to details of contents. The whole process is review, team work, peers assessment, then feedback to group. After peers’ assessments, the contents depth becomes deeper.

Peers Assessment. The practice is employed to improve students' understanding of course materials as well as improve their metacognitive skills. Listen to others voice, which makes students not only learn from each other, also open the vision of the students. During the past two years, over 400 persons made peer assessments. To avoid the partner giving high score directly, some questions are designed. For example, the students should first list the team members and evaluate each one to team participation on following scale: poor, average, excellent. This score is not the final. The second is another four questions to sure the quality of team work. These questions are: i. Teams are willing to
listen to and respect each other’s ideas and input; ii. Team members are helpful towards each other; iii. Conflicts among team members are resolved efficiently and constructively; iv. There is a dominant member in your group that has excess control over all other members. The students may choose items never, sometimes, often, always.

**Teachers Operations**

**Design Thinking – from Education to Student Centered.** There is a mismatch between teachers and students -- everybody has a preferred learning style, also one teaches the way he/she learn, further expect students to be like him/her! Design thinking is an effective method to solve the mismatch conditions. The aim of design thinking is to transfer function phase - education to solution phase – student centered. But each student has his/her own personality and student number is several tens, even about two hundred. The empathy as the results of exchanging of roles makes one to be creative.

**Multiple Teaching Activities.** Imagine one wants to teach students the forming of laser. Besides lecturing, what other learning activities you might want to consider to address several learning styles? In my opinion, this implies that one may use multiple activities, e.g. TPS, minute question, flash video and demo labs to demonstrate the resonator’s function. There are large amount of resources of lasers, a video and demo lab are presented except of lecture.

**Flipped Classroom.** According to the laser techniques applications, students are interested and they may watch online lectures, collaborate in online discussions, or carry out research at home and engage in concepts in the classroom with the guidance, which let student to spend more time on engaging learning activities. With the advent of technology that can more easily facilitate content delivery, there are now more ways for learners to access knowledge. The lecture is less essential to content delivery than it once was.

*Students report*

The students prefer courses that have online components. This is a project in general courses.

**Results of Engineering Skills Training**

By the practice of both students and teachers, nine non-technical skills are listed in Tab.1. Design thinking embodies in project chosen and design thinking two different sections and plays a dominant role in engineering skills training.

Table 1. Engineering Skills Trained by Design Thinking in Laser Serious Courses Except of Mathematics, Science & Technology.

| Operation | Student Project Chosen Review Peers assessment | Teacher Design thinking Teaching activity Flipped classroom Students report |
|-----------|-----------------------------------------------|------------------------|--------------------------|-----------------------------|---------------------------|
| Non-technical Skills | | | | | |
| Design and conduct experiments, a system, component, or process to meet within realistic constraints | X | X | | | X |
| Use the techniques and modern tools necessary for engineering practice | X | X | X | X | X | X |
| Identify, analyze, formulate, and solve engineering problems | X | X | X | X | X | X |
| Function on multidisciplinary teams | | X | X | X | | |
| Communicate effectively | X | X | X | X | X | X |
| Possess the broad education necessary to understand the impact of engineering solutions | X | X | X | X | | |

234
Summary

According to ABET criteria, engineering skills and abilities should be trained life-long; the undergraduate is only part of it. In this article, we introduced our practice experience of team work in laser serious courses. From the preparation to both the teachers and the students’ practice, some efforts were achieved. In my opinion, the combination of team work and design thinking benefits the students to improve their skills – both technical skills and non-technical skills greatly.

Acknowledgement

This research was financially supported by the reform in education of Beihang University.

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