INTEGRATED ACTIVE LEARNING IMPLEMENTATION IN CDIO PRACTICAL COURSE FOR MASSIVE POPULATION

Min Chen, Mingyuan Xie, Dingyu Yang

Department of Optoelectronic Technology, Chengdu University of Information Technology, Chengdu, Sichuan, 610225, China

ABSTRACT

In CDIO standards, the 7th and 8th are "Integrated Learning Experiences" and "Active Learning", which are most important for undergraduate laboratory courses. This paper describes an approach undertaken by the course of Synthesis, Characterization & Processing of Materials (SCPM) to integrate teamwork and self-management into its Project-Based Learning (PBL) for achieving these two standards. This represents a pragmatic approach in CDIO practical course when massive students are simultaneous in the same class.

PBL is an effective way to practice active learning and develop teamwork skills. In SCPM course, a long-running professional project is set and a serial of CDIO stages and relevant tasks are designed. The project is implemented in student's teams. In each team, the students work together from the beginning to the end of the project. Student's teams carry out the project independently. Our approach will help students improve CDIO skills during active learning process and foster teamwork skills through long-time cooperating within one team.

But in many laboratory courses like SCPM, many students participate in the class and are divided into many teams, which carry out the project simultaneously. How to manage the teams effectively at the same time? Self-management is the answer. In a student's team, there are a team leader and 3-4 team members and the membership is changed in every project stage. The leader is responsible for the management of project and the outcome of the relevant stage. So, all the team members are the manager and the partner, and can manage themselves well very. Moreover, student's teams can compete with each other. This is helpful to the active implement of the project.

In this paper, we present the objectives, contents, innovative design, implementation process, the results achieved after CDIO implementation. The learning outcomes are verified from student's surveys.

KEYWORDS

Integrated design, Active learning, PBL, Teamwork, Self-management, Standards 7 and 8

INTRODUCTION

In CDIO context, there are 12 standards to assess the outcomes of engineering education. The 7th and 8th standards are "Integrated Learning Experiences" and "Active Learning", which can only be achieved through a long-running learning process [1]. For the curriculum in our university, there are several comprehensive professional experimental courses in the 6th and 7th semesters, such as the course of Synthesis, Characterization & Processing of Materials (SCPM). These experimental courses always last for 2~3 months, and require students to

apply knowledge to solve professional problems. Many engineering skills (such as communication skills, teamwork and other technical and professional skills [2]) can be truly practiced in the courses. Based on our several-year CDIO practices, it is found that this kind of laboratory course is most suitable to achieve the 7th and 8th standards by an integrated active teaching model.

For the integrated active learning, Project Based Learning (PBL) is the best choice. PBL is one of the key approaches to carry out comprehensive engineering training, in which the students take the initiative to be involved in the whole process of PBL and experience the gradually changing problems in the process [3]. PBL is also an effective way to practice active learning. It encourages the students to think, analyze, and solve problems by applying knowledge, skills and experiences [4]. Moreover, PBL can develop teamwork skills very well [5]. Therefore, we used PBL teaching model in the course of SCPM to foster the skills of comprehensive knowledge application and teamwork skills through a comprehensive professional project. The undergraduate students carry a long-time cooperation to make a team effort rather than individual effort and ability. The course goals were realized by the integrated learning experiences and the active learning

Actually, the number of students participating in the comprehensive laboratory courses is massive. Usually there are about 20 students. The students are divided into several teams and carry out the project simultaneously. How to manage the teams effectively at the same time? Self-management is the answer. This is our idea of integrating teamology into PBL in order to foster the skills of inner-team. Furthermore, the competition is introduced into PBL. The student's teams can compete with each other in learning process. This is helpful to the active implement of the project.

This paper describes an integrated design and active learning taken by the course of SCPM, which integrate teamwork and self-management for achieving the CDIO 7th and 8th standards. We present the objectives, contents, innovative design, implement process, the results and learning outcomes achieved after CDIO practice.

INTEGRATED DESIGN AND INNOVETION OF SCPM COURSE

The course of Synthesis, Characterization & Processing of Materials is in the 7th semester, and will last for 2 months when 4 classes are arranged for every week. There are one comprehensive professional project named "Design and Preparation of Semi-conductor of TiO_2 Thin Films" is designed in classes. In this long-running course project, a serial of CDIO stages and relevant tasks are set according to the needs of experiment [6], as shown in Table 1. As we see, students can have their own ideas and experimental design in every stage so long as they are able to complete the relevant task. When they do the works step by step, they will experience the whole process of C-D-I-O training.

The project is carried out in student's teams. There are always 4 teams in one class and one team has 4~5 students. Student's teams implement the project independently. In one team, all students work together and cooperate with each other from the beginning to the end of the project. In the integrated design of SCPM, the mapping of CDIO syllabus to the course and the assessing standards are shown in Table 1.

As we mentioned above, the students are massive in the course. In order to manage the student's teams effectively at the same time, we propose a management method by students themselves. In a team, there are a team leader and 3-4 team members. The leader is

responsible for the management of project and the outcome of relevant stage [7]. The members must participate in the teamwork and help the leader to reach the team goals. But the membership must be changed in every project stage. So, all the team members are the manager and the partner, and they have to do a good job for themselves. This leads to an excellent self-management in a team. The only thing what the teacher can do is to design the project and assess the outcomes of the teams. The teamwork skills are shown in Table 1 and the self-management method is scheduled as Table 2.

Table 1. Design of PBL in SCPM course

CDIO Stages	Tasks	Weeks	Weight-ing	Assessing Standards	CDIO Syllabus
Conception of Experiment	Investigating: 1) Structure and properties of TiO_2 thin films 2) Application of TiO_2 thin films in solar cells 3) Mechanism and advantages of Sol-gel method for TiO_2 thin films 4) Budget of the experiments	Done before class	10%	Feasibility and validity of the conception of project	Professional skills- Comprehensive knowledge application; Design of experimental process; Sample preparation and measurement; Data handling and Analysis Teamwork skills- Project management and implement; Team cooperation; Team communication
Design of Experiment	Designing: 1) Experiment steps 2) Experiment parameters 3) how to obtain TiO_2 thin films with high quality	1	10%	Reliability and rationality of designed process	
Preparation of Materials	Operating: 1) Learn operation methods of the instruments 2) Prepare Sol-gel samples 3) Prepare TiO_2 thin films 4) Improve the quality of TiO_2 thin films	3	40%	Quality of prepared samples and cooperation ability of team members	
Measurement of Material Properties	Measuring: 1) Structural characterization of TiO_2 thin films by X-ray diffraction 2) Optical absorption properties of TiO_2 thin films measured by UV-Vis spectrometer 3) Morphological properties of TiO_2 thin films measured by Atomic Force Microscopy	2	20%	Operation ability of instruments and measurement results of TiO_2 thin films	
Analysis of Experimental	Analyzing: 1) Structural properties of	1	10%	Validity of data handling	

	2) Film thickness and optical energy gap of TiO_2 thin films by UV-Vis spectra 3) Surface properties and particle size of TiO_2 thin films by AFM images.				
Summary and Presentation on Project	Summarizing: 1) Experimental report according to team implement process 2) Make a presentation for team works 3) Forecast about the obtained TiO_2 thin films	1	10%	Team report quality and replying performance	

Table 2. Management of PBL in SCPM course

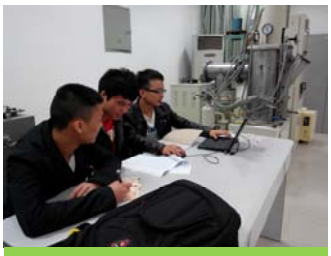
CDIO Stages	Project Goals	Task for Team-leader
Conception of Experiment	Planning step: 1) To understand the meaning of the project through investigating 2) To obtain the idea about the project 3) To expect the results of the project	The 1th leader- Repose for organizing team, dividing the project work and writing project plan
Design of Experiment		The 2th leader- Repose for organizing the discuss about the design of experiment and make decision
Preparation of Materials	Implement step: 1) To carry out the works 2) To achieve the expected results of the project	The 3th leader- Repose for organizing the experiment and control ling the progress
Measurement of Material Properties		The 4th leader- Repose for organizing the measurement of the structure and property of the sample
Analysis of Experimental Results		The 5th leader- Repose for organizing the discuss and analysis of experimental results
Summary and Presentation about Project	Assessment step: 1) To finish report of project 2) To participate the assessment 3) To plan the potential application of the project according to the needs of enterprise or industry	All team members cooperate together to finish the summary works

Moreover, competition is introduced into PBL. Student's teams can compete with each other while they do the same project. The winner will get extra scores in the course. This is helpful to the active implement of the project and to improve the interest of learning.

ACTIVE LEARNING EXPERIENCES

Guiding by the integrated design of course and self-management model, students have carried out an active learning during SCPM course, and their skills about knowledge application and teamwork have been fully practiced. The process of their learning and the outcomes of teams are shown in Figure 1. This kind of learning is met the needs of the CDIO 7th and 8th standards.

a) Investigating report of experimental conception



b) Designing experiment

c) Preparing materials

d) Papared sample

e) Recording experimental data

f) Analysis of experimental results

g) Presentation about project

h) Experiment report

Figure 1. Active Learning in CDIO practice course

STUDENT SURVEY AND FEEDBACK

The student survey [8] conducted at the end of the courses is shown in Table 3 and the resulting distribution chart shown in Figure 2. It can be seen that the overall student reaction to the project was strongly positive.

Table 3. Student survey results table

Questions	Answer options for the course of SCPM
1	There are obvious different learning process between SCPM and other laboratory courses.
2	I like the active learning during SCPM course.
3	I understood the learning model and the management method before class well.
4	My team carried out the required investigation and made the experiment plan before beginning of class independently.
5	All members of my team performed active learning during the course.
6	All members of my team contributed to the project equally.
7	I thought more and did more in this teaching model.
8	I practiced the comprehensive application of professional knowledge.
9	I practiced the skills of team-management and team-cooperation.
10	I am interesting in SCPM course.

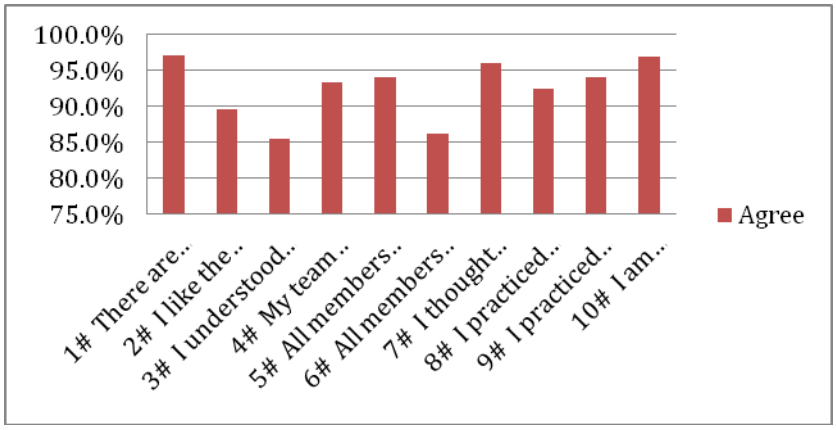


Figure 2. Student survey results

CONCLUSIONS

The active learning in the course SCPM integrated teamwork and self-management into its PBL process. This not only is one kind of effective CDIO practices, but also represents a pragmatic approach in CDIO practical course for massive population. This experience gave students the opportunity to develop comprehensive professional skills and teamwork skills, and achieved the 7th and 8th ones in CDIO standards effectively.

Feedback from students has been positive and appreciative. Analysis of questionnaire responses revealed that the teaching model encouraged students to think more and do more by themselves. Improvements derived from students' feedback will be included in the future. We hope these kinds of CDIO practice can basically develop student's engineering abilities.

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BIOGRAPHICAL INFORMATION

Min Chen is a Professor in Material Science and the associate dean in the Department of Optoelectronic Technology at Chengdu University of Information Technology. She works on topics related to engineering education reform in the department, and focuses on the curriculum design and the improvement of teaching and assessment in recent two years.

Prof. Mingyuan Xie is the dean of Chengdu University of Information Technology. Her current research focuses on implementing of CDIO engineering education model in the University.

Dingyu Yang is an associate Professor in Material Science. He is the manager of the course of Synthesis, Characterization & Processing of Materials. He ensures the design of the course to be achieved by using appropriate pedagogies. He does the day-to-day management and operation of the course, including curriculum review, student feedback, etc.

Corresponding author

Prof. Min Chen
Chengdu University of Information Technology
No. 24, 1 block, Xuefu road
Chengdu, Sichuan, 610225, China
86-28-85966385
minchen@cuit.edu.cn