Adoption of Project Based Teaching in Mechanical Drawing and CAD Course

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Abstract. Project based teaching is a practice-oriented educational procedure that is led by the instructor based on practical usage and targeting at students. It is originated from the practical demand of a career by identify typical projects and cases as the syllabus in the curriculum. The learning process of the curriculum is highly interactive between the faculty and the students. This methodology would encourage the active participation of the students throughout the whole learning process while proactively building their knowledge base, which is a new conceptual model in teaching and learning.

1. Introduction

In 1998, instructors from Shanghai Medical Instrumentation College (SMIC) made the very first attempt to integrate the CAD Computer Drawing Course into the Mechanical Drawing Course through a major redesign of the syllabus by selective deletion and reduction of the current course content. Based on the basis of mastering the basic concepts, the emphasis was focus on the development of students’ capabilities in understanding the drawings, sketch the draft drawing, traditional pencil based drawing and computer based drawing.

Students would take four periods every week, with two periods of lecture and another two periods of lab session, where a number of drawings are required to be complete on computers. Through one year’s learning and training, the improvement is significant on the student side. Demonstrated by their capability to successfully complete hundreds of industrial CAD blueprints going through the review/revision process and the drawing process in their sophomore year. Many students were hired by employers for their CAD skillset in employment, and some were even entrusted to undertake key projects.

In 2000, the Mechanical Drawing Course was formally renamed as Mechanical Drawing and Computer Drawing Course. In 2003, Mechanical Drawing and Computer Drawing Course was rated as Premium Quality Course in Shanghai. In support of this initiative, Mechanical Drawing and Computer Drawing Textbook and Problem set (with Supplement CD) authored by the all members of teaching and research section was published by Tsinghua University Press. After the three colleges merged into an undergraduate college in 2015, two bachelor's degree programs the Biomedical Engineering and Clinical Engineering Application also adopted the applied project based teaching in Mechanical Drawing Course. In July of 2016, Project Tutorial for Mechanical Drawing and Computer Drawing Textbook, Problem set and Supporting Software designed for undergraduate degree was authored and published by Shanghai Jiaotong University Press.

2. Project Based Teaching

About ten years ago, the Ministry of Education proposed the "Excellence Engineer Nurturing Program (Zhuoyue Jihua)". Under the current circumstances, the further update of the teaching concept, the enhancement of the curriculum system and further improvement and innovation of the teaching practices are required. Empower the students with stronger spatial ability, three-dimensional modelling capability, planar representation capability and computer aided design capability. This enables the students to acquire the basic and innovative capability to analyze and solve practical problems in the professional field after they have received the follow-up education.
Thus meet the demand from job market which possess the quality of professional ethics and discipline, teamed with advanced professional skills.

2.1 Integration of the Course Content

This course utilizes project based teaching with a single stage gearbox as the vehicle teamed with a number of assignment driven tasks. The complete teaching process consists of eight projects, as shown in Figure 1. Each project has a list of specific tasks. The project based teaching was first implemented in class of 09 medical device manufacturing and maintenance discipline, testing technology and application, and rehabilitation technology disciplines. The eight projects were completed in two semesters, and during the adoption the "task-driven" is the key that is associated with lead by action. Each project has several tasks, arranged in steps from easy to complicate. After the tasks are assigned, students will conduct the corresponding activities in the training room in groups with 4 in each as the basic unit. In these projects, the teachers will identify some industrial drawings and assign to students for practice, so that they can gain hands on experience and knowledge on their disciplines as early as possible and plan early for the future professional careers.

![Figure 1. The Main content of the Project Teaching of Mechanical Drawing and Computer Drawing.](image)

2.2 Project Implementation

The total number of periods of the course is 104, including 52 periods of classroom teaching; 52 periods of laboratory practice, and an additional 50 periods of extracurricular time for students to perform mapping. Teaching and training venue is an integrated educational base support lecture, laboratory and mapping. The mapping include single stage gearbox, wooden model and etc. The laboratory practice includes problem sets, industrial drawings, and requires to complete the CAD drawing from sketching. During the mapping training session experienced engineers are brought in as coach to students. The whole mapping process is closely integrated with the instruction content, complementing each other, such as the project one is the fundamentals of AutoCAD. The goal of the project is to teach students to draw simple two dimensional components with CAD technology. But why draw? In this project, students are allowed to disassemble the single stage gearbox, which demonstrates that the production and assembly process of these parts requires drawings, so that students understand the necessity of drawing. In project 3, how to read a drawing associated with the mapping of the wooden model. The practice of creating planar drawing by surveying the model
and imagining the spatial shape from the planar drawing and identify the correct wooden model further improves the dimensional cognition capability from the students. After completing a project, students should complete the corresponding work report based on the requirements of the assignment, including information inquiry, plan definition, plan optimization, plan implementation and self-assessment. Students are paired in group usually with 4 per group. The groups will complete the project together, while the work report can be completed independently after the group discussion. The class representative organizes the team leader to score the work report submitted by the classmates, and the teacher will do the final review and judgement. Such a mechanism is designed to fully mobilize the students' enthusiasm. In a group of 4 the students take turns to be the team leader, which strengthen the self-management of the students and nurture their responsibility and working attitude.

2.3 Assessment Method

The examination is the guidance for the students' learning. The assessment content directly determines what the students learn, and the assessment method directly guides the students on how to learn. In fact, the content and methods of assessment to some extent illustrate on the kind of talents we train. The past practice of a single exam decides all does not reflect the true capability and level of the students, nor can it objectively evaluate the teaching results of the instructor, and it will also result in some students to cram for a good final exam grade in the last few days while ignore the process of the learning. Recite rather than learn the knowledge, on side exercise only the memory but hampers the development of thinking, which will impact the goal of cultivating the students with quality, skill and creativity. Therefore, the reform in the content and methodology of the assessment are the crucial parts in the educational reform.

Mechanical Drawing and Computer Drawing course focuses on skills. Instructors are not instilling pure theoretical knowledge in class, but should pay attention to the training of students' ability of drawing and decipher drawings. It is a highly skilled technical course. At the same time, in order to respond to the excellence engineer cultivating plan (ZhuoyueJihua) proposed by the Ministry of Education and to meet the demand of cultivating high-quality and highly skilled personnel, a specific assessment standard has been formulated: total semester grade = usual grade × 30% + [CAD drawing score (or board Figure scores) + final exam scores + project (work report scores)] × 70%. This kind of assessment increases the teacher's attention to the students' daily learning. In the teaching process, measures can be taken in a timely and effective manner. At the same time, the subjective initiative of students' learning is mobilized, passive learning turns into active learning, and students are actively involved. In the teaching activities, it has achieved good results.

3. Teaching Innovations

The project based instruction method adopted in this course has begun both in China and abroad, but there are few cases in which CAD technology is integrated. We believe that after a series of project based training, students' CAD skills and freehand drawing skills have been greatly improved.

Here are some teaching innovations:

(1) The synergy between Industry, Learning, Medical and Research. The mechanical drawing and computer drawing learning process from the students is combined with the instructor’s research effort. The industrial production blue print of the enterprise is an integral part in the student practical training programs.

(2) The three in one combination of the teaching, training, surveying and mapping rooms. The students' theoretical study and practical skills training are carried out at the same time. “Hands-on for everyone” achieved the goal of improving students' practical skills. The project teaching base is shown in Figure 2.
(3) The teaching is in line with multiple certificate systems such as CAD certificate. After one year of training, more than 95 percent of freshmen have passed the examination and obtained the junior or intermediate certificates issued by the “National CAD Network Center”

(4) CAD skill training is uninterrupted throughout three years of "a consistent system", highlighting the professional skills from students, which are mainly reflected by 2 periods of weekly computer lab for first year students, typical mechanism training by example for second year students, and Graduation design for third year students.

(5) Teaching is combined with professional medical instruments and pharmaceutical instruments. Mechanical drawing incorporates the connotation of biomedical engineering.

(6) Streamline the teaching content, highlight the practical implementation. The course combines freehand drawing, manual drafting, drawing and computer aided drafting, and further optimizes the approach for assessment. Pay attention to the teaching process rather than the test results.

4. Achievement

Through years of teaching practice, Mechanical Drawing and Computer Drawing course has yield good results and gained remarkable achievements.

4.1 Teaching of Teachers

(1) Formulated the curriculum standards, overall curriculum design, and curriculum unit design for project-based teaching.

(2) Improved the training content, course questionnaire bank and assessment criteria for each project.

(3) Established a three-dimensional model library and formulated work orders and work reports.


(5) Producing mechanical aid software with mechanical drawing and computer drawing project tutorial, published by Shanghai Jiaotong University Press, edited by Zhu Peiqin;

(6) Authorization of mechanical drawing and computer drawing teaching courseware and surveying and drawing courseware.
4.2 Benefits for Students

Project based teaching benefits students. In 2014, students from class participated in the National 3D Digital Innovation Design Grand Prix and won the Grand Prize in Shanghai. They participated in the national competition on behalf of the Shanghai Area and won the first prize, second prize and third prize. Since 2011, the Shanghai Municipal Education Commission, the Shanghai Engineering Graphics Society and various universities have jointly organized the “Shang Tu Bei” Shanghai University Students Advanced Mapping Competition. This competition is the touchstone for testing the mechanical drawing and CAD teaching of students and teachers. The students have harvested six first prizes in the two-dimensional group, ten in the second prize. In three-dimensional group, they harvest three awards in first prize, five in the second prize, and numerous first prizes and second individual prizes.

4.3 Grade Comparison

The project based teaching has started from the class of 2009 in medical instruments, and it has been 9 years. First, compare the final scores of the classes of 2009, 2010, and 2011 medical instruments that have been implemented with project-based teaching with those of the class of 08 medical instruments who have not implemented project teaching.

Table 1. Compares the Final Results of Students Before and After Project-Based Teaching.

<table>
<thead>
<tr>
<th>Grade Class</th>
<th>Excellent</th>
<th>Good</th>
<th>Satisfactory</th>
<th>Pass</th>
<th>Fail</th>
<th>Average Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>08 MedIns</td>
<td>9</td>
<td>32</td>
<td>51</td>
<td>14</td>
<td>11</td>
<td>70</td>
</tr>
<tr>
<td>117 students</td>
<td>7.69%</td>
<td>27.35%</td>
<td>43.59%</td>
<td>11.97%</td>
<td>9.40%</td>
<td></td>
</tr>
<tr>
<td>09 MedIns</td>
<td>12</td>
<td>39</td>
<td>27</td>
<td>6</td>
<td>25</td>
<td>69.6</td>
</tr>
<tr>
<td>109 students</td>
<td>11.01%</td>
<td>35.78%</td>
<td>24.77%</td>
<td>5.50%</td>
<td>22.93%</td>
<td></td>
</tr>
<tr>
<td>10 MedIns</td>
<td>8</td>
<td>63</td>
<td>48</td>
<td>6</td>
<td>9</td>
<td>72.37</td>
</tr>
<tr>
<td>134 students</td>
<td>5.97%</td>
<td>47.01%</td>
<td>35.82%</td>
<td>4.48%</td>
<td>6.72%</td>
<td></td>
</tr>
<tr>
<td>11 MedIns</td>
<td>16</td>
<td>45</td>
<td>16</td>
<td>3</td>
<td>6</td>
<td>77.1</td>
</tr>
<tr>
<td>86 students</td>
<td>18.60%</td>
<td>52.33%</td>
<td>18.60%</td>
<td>3.49%</td>
<td>6.98%</td>
<td></td>
</tr>
</tbody>
</table>

It can be seen from Table 1 that the “Excellent” rate of 09, 11 medical instruments students is higher, the “good” rate of 09, 10, 11 is much higher than that of 08 medical instrument students, and the rate of unqualified (“Fail”) medical instrument students is higher than that of 09 which is not satisfactory. Reasons can vary, but main reason is that teachers are just beginning to adopt this teaching method. There may be many nuances that need improve and problems need to fix, such as the students not paying enough attention to this teaching mode, and the work report is not being done properly. All these issues may ultimately leads to unqualified results. Now after years of practice, the teaching process has been continuously revised, and the students' performance has been greatly improved. It can be said that the mechanical drawing project based teaching has not only stimulated the students' enthusiasm for learning but also inspired the instructors' teaching enthusiasm.

5. Conclusion

Project based instruction put focus on the students and highlights the subjective status of the students. This teaching method has the following characteristics:

1. With the introduction of projects and new knowledge, the motivation and interest of students' learning is stimulated.
2. Turning the textbook oriented instruction into the "project" oriented instruction can trigger curiosity to mobilize enthusiasm and cultivate communication and cooperation skills. Mechanical drawing start from the real objects, and students can gain hands on experience and use it to further strengthen their skills.
(3) Transforming the classroom centered education into practical experience centered education, so that students can memorize even better. Once they learn, they master. Different projects present students with different scenarios, expanding their horizons and enhance their self-confidence for future employment.

(4) Project teaching transformation the teacher into “Dual Qualified Teacher”, where they morph into guides and moderators. Behaviorally speaking, students have the opportunity to independently plan their work, and there is also need for them to conduct collaborative cooperation. Thus it cultivates the students' ability to work independently and collaborate;

(5) It can realize the teaching method of imparting theoretical knowledge and cultivating practical skills, that is, the integration of “teaching, learning, and doing”;

(6) The teaching method of “teaching, learning and doing” is not only suitable for vocational teaching, but also suitable for undergraduate, as learning theoretical knowledge and the cultivation the practical skills for students are the eternal teaching goals.

The project teaching of "Mechanical Drawing and Computer Drawing" with the characteristics of medical engineering is brand new. A great man once said, "We can cross the river by feeling the stones". This pilot is still not perfect, its theoretical teaching and the implementation of the practices are yet to further polish. In the future, it is necessary to summarize what we have learned in this experiment, to formulate reasonable and effective theoretical teaching and practice, improve the training program, and finally achieve the purpose of improving students' innovative ability.

Acknowledgement

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References