Enlightenment of Design Education in Purdue University: Research and Practice on Assessment Method in Project-Based Learning of Industrial Design Discipline

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Enlightenment of Design Education in Purdue University: Research and Practice on Assessment Method in Project-Based Learning of Industrial Design Discipline

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Abstract. Due to the characteristics of industrial design, the project-based curriculum learning method has been adopted by more and more universities. However, there is a lack of relevant research on the evaluation of course results in project-based learning. In practice, the single evaluation method for the final operation is usually adopted, often with the subjective nature of the teacher, which has many disadvantages. Learning from the evaluation method of Purdue University's industrial design specialty, through the project-based learning practice of the Department of Industrial Design in Huazhong University of Science and Technology, a combination of periodic assignments evaluated by teacher and final assignments evaluated by experts was used to obtain a more objective score. This method has achieved good teaching results. This research is expected to promote the improvement of the evaluation method of the design discipline curriculum.

1. Introduction

Project-based learning (PBL) is a form of contextual learning[1]. PBL is gradually adopted by more and more majors in higher education institutions with its vivid teaching method, scientific and reasonable teaching process, and teaching objectives of positively facing the market[2]. In the professional course teaching of industrial design, PBL has become a common used teaching method. In the professional curriculum, practical topics were frequently introduced in the teaching procedure to guide students to understand the design concept, experience the design process, and latter achieve the purpose of learning.

PBL is a model for organizing learning around projects[3]. The method let students acquire knowledge in the process of solving problems through challenging and complex topics[4]. In China, some scholars gave specific teaching paths and methods starting from the background of social needs to improve students' practical ability[5-6]. They also proposed that PBL is a learning method that emphasizes student-centred learning, interdisciplinary, collaborative learning, independent inquiry, and practice[7]. However, there is a lack of relevant research on the assessment of course performance in PBL currently.

In the actual course teaching of colleges and universities in China, due to the differences in the characteristics of specific courses, from the theoretical teaching courses to the design courses, the performance assessment method are different. The scores of most professional courses in other majors are based on the score of the examination, and the final score is obtained in combination with the usual scores. While in the industrial design discipline, PBL is utilized in professional courses, and many

professors evaluate students' performance based on the design work or design report of the final class operation as the sole score. This method may cause two problems: First, from the student's point of view, the final design work is the only work needs to be provided, it is easy to cause the phenomenon of being lazy and rushing to work hard before submitting assignments, so the learning effect is poor. Secondly, because the preferences and standards of different people are different, the scores given by the teacher will have different degrees of personal subjectivity and cannot give objective results.

2. Method

In the industrial design courses of many American universities, PBL methods are also adopted. By observing the teaching procedure of many design courses, as a visiting scholar at Purdue University, the assessment methods were generalized. The evaluation mode is diversified (see Table 1). In assessment of product design courses such as "Problems in Industrial Design", presentation is of importance, and professors including visiting scholars are invited to participate in the evaluation of the results of the presentation. Some teachers also use the method of exhibition of course works, such as "Information Visualization" to evaluate students' performance. At the end of the term, students are required to exhibit their design works, and the effect of the exhibition will be the most important factor to evaluate their performance.

Table 1. Assessment methods of 5 courses in Purdue University.

	Courses	Assessment items	Ratios	Remarks
1	**Interactions Design Studies**	Mobile phone interface design	20%	Independent assignments
		Personal website design	30%	
		Interactive information visualization design	20%	
		Laboratory cooperation project	30%	PBL mode, Group assignments
2	**Information Visualization Design**	Course participation	10%	PBL mode, Including both independent assignments and group assignments
		Classwork	20%	
		Design project results exhibition	70%	
3	**Human Factors in Engineering**	Test 1	25%	Three exams, with each 25% weight
		Test 2	25%	
		Final examination	25%	
		Assignments	25%	
4	**Design Cognition and Learning**	Weekly class discussion	20%	Focus on class discussion and after-school thinking
		Weekly after class feedback	10%	
		Summary	20%	
		Course project research	30%	
		Final course feedback	20%	
5	**Problems in Industrial Design**	presentation	100%	PBL mode Several professors attend the presentation to evaluate

According to the above analysis, PBL mode was utilized in Huazhong University of Science and Technology. Participators are junior students with the major of industrial design. During the procedure of the course, both independent assignments and group assignments are required. In addition, a new assessment method with a combination of periodic assignments evaluated by teacher and final assignments evaluated by experts is used to obtain a more objective score for students.

The final grade of the course is calculated as follows:

$$F= (S_1R_1+ S_2R_2+\ldots\ldots+SnRn) +SR \quad (1)$$

F is the final score of students, S_1, S_2, …S_n are scores of periodic assignments, R_1, R_2, …R_n are ratios of assignments, which are decided by the teacher according to the difficulty of the assignment. S is the score of final assignment, R is the ratio.$R_1+R_2+……+R_n+R=100$. (According to the characteristic of the major, in practice, n is less than 3.)

3. Practice teaching process

3.1. Participant

In this paper, 104 students of Huazhong University of Science and Technology attend the course *Product Design II*. They are junior students at the time.

3.2. Introduction of the course

Product Design II is a professional advanced course based on the course of *Product DesignI*, and is an important subject core course of industrial design. Through the design theory guidance and design topics in the course, students learn to understand and master the basic theory of product design, design procedures, design methods and main performance methods of design. The proposition design exercises of this course are mainly based on the design of mechanical equipment such as digital equipment. Through the comprehensive design training of the course, students can understand and familiarize with the methods of electromechanical product design, understand related materials and processing techniques, and further improve performance techniques. The course also provides an in-depth explanation of the integrated design of product design methods, enabling students to master the methods of coordinating and solving several problems, such as products and markets, individual and overall products, product details and overall, product serialization, etc. in actual design, and improving students' practical design practices. The objective of the course is to improve students' ability of using design methods, and to cultivate their ability of observing, analysing, solving problems, in addition, comprehensive modelling and design capabilities are also focused.

3.3. Course arrangement and grade assessment

During the procedure of the course, there are 56 lessons in total. According to the syllabus requirements, there are 3 assignments, including 2 periodic assignments and 1 final assignment. The 2 periodic assignments are the basis of the final assignment. Each assignment accounts for a certain percentage of the course grade. In the follow-up course, PBL methods are adopted. The teacher specifies several topics, for students to choose, and set the deadline of the final closing assignment. Then students set up their design team (no more than 5 students in each group), and develop their own schedules according to the deadline. Later they combine the knowledge acquired in the course with the previous courses, and complete the final complete design report for presentation within the specified time.

In the final assessment of students' grades, the periodic assignments evaluation mode and the final assignment evaluation mode are combined. According to the formula (1) described above, the final scores of the course is calculated as follows:

$$F=S_1* 15\%+ S_2* 15\% +S*70\% \qquad (2)$$

F is the final score of the student, S_1 is the first assignment result, S_2 is the second assignment result, and S is the course completion result. Among them, S_1 and S_2 embody the staged results of the course. The class teacher scores the knowledge points according to the actual operation. S is the result of the graduation work and adopts the expert evaluation mode. In this course, the proportion of each grade is set by the instructor according to the amount of work and difficulty. In the course evaluation method of the course, since S_1 and S_2 respectively examine the material process structure and product brand recognition (PI) concept, it is easier for the teacher to evaluate the mastery of the theoretical knowledge points and give objective scores. S is a comprehensive large-scale work performance, thus the single class teacher is subjective in evaluation, and the proportion of the score is also high,

therefore the expert evaluation is adopted. The model can obtain more reasonable and objective scores for students. (See Table 2)

Table 2. Course composition and assessment method.

Course composition	Periodic assignments assessment		Final assignment assessment
Assignments	Assessment 1	Assessment 2	Assessment 3
Ratios	15%	15%	70%
Rating person	Teachers of the course		Experts (Including teacher of the course, professors, post graduate students, industrial designers, mechanical engineers, etc.)
Objective of assignments	Basic theory of the course		PBL method
Examination point	Mastery of specific knowledge points		Comprehensive design capability

In the final course, the final assignment was presented by students and evaluated by experts. Experts were consist of 10 members, including 2 teachers of the course, 3 professors from design major, 3 graduate students, 1 mechanical engineer, and 1 professional industrial designer. The teachers and graduate students have more experience in design research, and can evaluate the students' assignment from the perspective of research; the invited mechanical engineer is the chief engineer of the designated project and has a good understanding of the product, especially experienced in the structural process; the invited professional industrial designer is also the designer of the project, who not only understand the project but also had many practical design project experience before. A comprehensive evaluation by such a professional team can evaluate students' works from different perspectives, can lead to more objective scores. In addition, through the experts' comments after the presentation, students can better understand their own advantages and disadvantages, so as to obtain the views of experts from different background, then they can have a clearer direction in the future learning. Therefore, this evaluation procedure is also a valuable additional learning opportunity for students.

Among the scores of the course completion assignments, 10 members of experts responded from four aspects according to the course objectives, including the content (30%), quality (40%), attraction (20%) and integrity (10%) of the student's presentation, and then the scores of each group were rated. The scoring projects are designed according to the course content requirements and convenience of scoring.

After the presentation, the scores obtained by each group are input into the EXCEL software, and the average score of the expert group is obtained, thereby the score S of students in the formula (2) obtained. Combine the scores of S1 and S2 given by the teacher, and use formula (2), the final score of students generated.

4. Results and discussion of teaching practice

4.1. Result of PBL

From the teacher's point of view, PBL method requires the instructor to have overall control during the course, thus the higher demands on the class teacher are required.

During the process of course learning, the use of PBL methods, combined with practical topics, allow design results to be practically adopted, and mobilize the initiative of students greatly from passive learning to active learning. Students are grouped by themselves, and their design progress is arranged according to the strengths and weaknesses of their respective members. Cooperation and division of labor are carried out within the group. The teacher's guidance is more targeted and effective. Judging from the quality of the final design reports submitted by the four classes in two years, the level of submitted work is significantly better than in previous years.

From the perspective of the completion report submitted by students, all students expressed that they learned a lot through the PBL method course. The following is an excerpt from the course completion of some students:

"From receiving this topic to previous research, analysis, summary, positioning, sketching, solution determination, modelling to the final report, this is a very complete design process for me. The relevant analysis and knowledge we have learned are also applied throughout the design, and I gained a deeper understanding of the theoretical knowledge learned in the classroom through practice."

"In the process of doing my homework, I encountered many difficult problems. From the unclear idea in the beginning to the in-depth design through the guidance of the teacher, our team got the final design through five design stages. We experienced the happiness of design. This process allows us to learn a lot."

"In the process of project design, we have learned a lot from the previous research, the various analysis in the medium term, to the later modelling and rendering. After the design experience, we have made the design process clearer. The final design of the program is the results of many revisions and discussions, and we benefit from the course a lot."

4.2. The effect of evaluation method

From the point of view of the class teacher, it is easy to give a reasonable score for the evaluation of the stage work because the knowledge of the work is clear. In the comprehensive design of PBL, the experts give scores according to the scoring items and various scores, which makes the individual's performance subjectively small and has good operability.

From the student's point of view, the entire course of the learning process has a phased goal, and the student's mental state can remain active because of the staged homework scoring. After learning that the final assignment will be presented and the final results will be judged by experts, students feel the pressure and get a lot of motivation, therefore the enthusiasm for completing the coursework is well mobilized. The combination evaluation model can achieve more fair and appropriate results, and also play a very good role in mobilizing students' enthusiasm for learning.

5. Conclusion

In the course of industrial design, the use of PBL method allows students to learn actively. The evaluation method of course performance can be improved from a single class operation evaluation method to a combination of stage work and final class work evaluation. In the evaluation of the course work, the mode of expert evaluation is more effective than the class teacher, so that it can get objective and fair results and better mobilize students' initiative. The teaching and evaluation method lead to good effect, and it has good operability to spread.

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References

[1] K. Koedinger, A Corbett. (2006) The Cambridge Handbook of the Learning Sciences. Ed. R K Sawyer. New York: Cambridge University Press.

[2] Sun, Q. Q., Sun, H. C. (2015) Exploring the realization process of project-based teaching in industrial design——Taking the collection of rainwater and semi-automatic cleaning bins as an example. Journal of Inner Mongolia Normal University(Educational Science), 28: 152-154 (in Chinese)

[3] Jones, B. F., Rasmussen, C. M., Moffitt, M. C. (1997) Real-life problem solving: A collaborative approach to interdisciplinary learning. Washington, DC: American Psychological Association.
[4] Thomas, J. W., Mergendoller, J. R. (2000) Managing project-based learning: Principles from the field. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans.
[5] Du, H. B., Hu, H. Q. (2014) Exploration of a new model of industrial design project-based teaching. MEIYUAN, 1： 9-12 (in Chinese)
[6] Lv, W. L., Huang, Y., Liu, F. (2011) Primary discussion of project teaching methodology reform in environment design. ZHUANGSHI , 2: 139-140(in Chinese)
[7] Long, R., Cao H., Li, J. (2014) The Research and Practice of Product Design in a Guiding Robot. In: 2014 the 3rd International Conference on Industrial Design and Mechanics Power (ICIDMP2014).