Exploring the Learning Problems and Resources Usage of Undergraduate Industrial Design Students in Design Studio

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Abstract. Design is a power weapon of modern companies. It is important to have excellent designers for the industry. The purpose of this study is to explore the learning problems, and the resources that students used to overcome problems in undergraduate industrial design studio courses. The survey with open type questionnaires was used to collect data. There were 189 undergraduate industrial design students from 3 universities participating in this study. The results demonstrated that the most difficulties design tasks included concept generation, design presentation, and design research. The learning resources used to solve the learning problems included 4 categories: people, object, method, and environment. This information can increase the understanding of the learning process of students, and provide the reference for teaching planning and the setting of the learning resources in design education.

Keywords: Industrial design, learning problems, learning resources, design studio.

1 Introduction

Design is a power weapon of the companies. It is important to have excellent designers for the industry. The essential feature of the design education is "learning by doing". Students learn design knowledge and skill through operating the real design problem. Based on the feature of the design education, the problems that students experienced and the resources used in the learning process may be different from those in other domains. But, there are few studies discussing the learning problems and learning resource in design education.

The purpose of this study is to explore the learning problems and the resources that students used to overcome problems in the undergraduate industrial design studio courses. The results can increase the understanding of the learning process of students, and provide the reference for teaching planning and the setting of the learning resources in design education.

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2 Literature Review

2.1 Design Professional Learning

Learning is the act or process of developing skill or knowledge [1]. Design is generally considered to involve abductive reasoning, which addresses ill-defined problems and uses a construction process to solve them [2]. Design knowledge is difficult to understand or to describe. It must be understood with reference to the problem context. It cannot be delivered by the traditional lecture pedagogy. The most used way is "learning by doing", such as the apprentice system, so design learning emphasizes working with actual problems to acquire professional knowledge and techniques [3]. Students need to acquire advanced knowledge through working with design problems in the real world. In the learning process, a teacher demonstrates and leads students to engage with a real design problem. Students try to observe, to understand, and to grasp the various methods and techniques through the process, to cultivate observation and decision-making capabilities, to explore their own talents, and finally to develop their own procedure and style of design. Therefore, the design process can be considered as a social process in which the result is constructed using various kinds of knowledge [4].

The main and most important teaching method of design education is studio [3] that has been in use for almost 100 years [5], especially in architectural and industrial design. The main distinguishing feature of studio pedagogy is the learning of the procedure and methods of design and the accumulation of experience through the process of solving actual design problems. The emphasis is on the presentation of design concepts and ideas, the critique and communication involved in the design process, and the learning of advanced design knowledge through reflection on design problems. Students go through the procedure of design to solve real or simulated design problems [6-8]. Through the studio, students are exposed to a number of learning experiences, focusing on two key aspects. The first is learning how to design by engagement with a process of designing or a suite of possible design methodologies. The second is to reveal knowledge about concepts and/or situations through the act of designing [9].

Design studio is the heart of most industrial design and architecture curricula. There are several factors associated with a successful design studio. The "studio teaching project (http://www.studioteaching.org)" supported by the Australian Learning & Teaching Council proposed that there are several key qualities or characteristics that play important roles in a typically successful studio program: 1) People: lecturers, tutors, technicians, members of the professional communities and student peers; 2) Facilities and Resources: space, equipment, technologies and materials; 3) Projects: areas of study, tasks and problems to be solved, especially those related to industry/profession; and 4) Time: the proportion of course time provided for studio and hours of access to facilities. Attoe & Mugerauer [6] also mentioned about the factors associated with teaching excellence in design studios, including three considerations: 1) the teacher as self (aspects of the teacher's own life that contributes to good teaching); 2) personal style (the way the teacher behaves); and 3) course format and implementation.

2.2 Learning Problems and Resources in Design Studio

The design studio is the place to practice and integrate the knowledge and skills that learnt from the surrounding courses. There are some people involved with the design learning process, for example, classmate, instructors, technician, and other experts. It also needs environments and settings to support the design learning process, such as the personal working space, workshops, library, etc. Learning the process of design is similar to designing. Both events involve spending certain periods of time thinking through the process and attempting to create some interesting results. Learners often have to explore and discover their own paths to gain the knowledge and skills [10]. The students faced a number of problems as they worked through their design process.

Learning Problems

The issues of students' learning problems or difficulties are complex and dependent on a range of factors, including course organization and development, the subject or topic being taught, teaching style, and students' expectations [11, 12].

Design students faced some learning problems and difficulties when they explored in the design problems space. Yang, You, & Chen [13] investigated the difficulties faced by industrial design students and their career guidance needs. Focus group interview was used to collect the data. The participants included freshmen, seniors, graduates of senior high schools, and vocational high schools, with or without a design background. The problems students encountered were: 1) high learning pressure and frustration; 2) heavy workload depriving them of extra-curricular activities and leisure; 3) competition among classmates influencing peer relationships; 4) high costs of materials resulting in financial pressure; 5) feeling of uncertainty and worries about the future; and 6) insufficient interaction between faculty and students. Mawson [14] compared the workplace practice of six experienced designers and investigated their experience on teaching practicum in developing design skills with secondary school students. They found students faced 2 types of problems. The first were technical problems related to the skills needed to produce the product. The second type of problems related to the nature of the materials and the tools needed to do the job. The teachers also identified three basic problems with their experience. One was students' antipathy towards and ignorance of the design element in the technological process. Another was the lack of practical experience. A further problem was entrenched traditional views of technical education in the schools that were not congruent with the approach of the relatively new technology curriculum.

Learning Resources

Learning resources are defined as information, represented and stored in a variety of media and formats that assists student learning as defined by provincial or local curricula. This includes but is not limited to, materials in print, video, and software formats, as well as combinations of these formats intended for use by teachers and students [15].

Learning the process of design is similar to designing [10]. The design students need some resources to solve the learning problems and difficulties, as well as to

solve the design problems with design resources and knowledge. Some design resources used to solve the design problems may also be the design learning resources for solving the learning problems.

Little research discusses about the design learning resources, even the study method. Brown, Doughty, Draper, Henderson & Mcateer [16] had been developed a learning resource questionnaire to gather information on the learning resources used by students. The resources may include not only lectures, tutorials and courseware, but books, handouts, notes and discussions with other students. They regarded this information is important to teaching staff in assessing and increasing the value of the resources to students by ensuring their effective integration into a course.

About the design learning resources, Chiu [17] has been investigated the students' knowledge sources and knowledge sharing in the design studio, the definition of the design knowledge is similar as the design learning resources in this study. The results demonstrated that the top four knowledge sources requested by juniors were books and magazines, studio-mates, schoolmates, and the Internet. The top four knowledge gain sources were books and magazines (40%), studio-mates (22%), schoolmates (12%), and the Internet (9%). The top four knowledge sources requested by seniors were books and magazines, the Internet, studio-mates, and auditing desk crits. In terms of percentage of knowledge gain, books and magazines were 25%, the Internet 23%, studio-mates 20%, and auditing desk crits 15%.

The research of You, Yang & Liao [18] explored the industrial design students' learning attitudes in Taiwan. Some results of the study also related with the learning resources, including: 1) while learning design, students aspire for teachers to share design experiences with them; 2) they would ask classmates or friends for help when encountering difficulties; 3) they devote much time and place emphasis on creative thinking and model-making during the design process; 4) their design concepts mostly come from their life experiences.

The main method for design education is studio, where students learn design knowledge through the design process with operating real design problems. Design students faced some learning problems and difficulties in design learning process, and tried using some learning resources to solve the problems just like searching and gathering the resources to solve the design problems. But little research discusses the learning problems and learning resources in design education domain. This paper tries to explore the learning problems and learning resources to increase the understanding of the learning process of design students.

3 Methods

A survey was conducted to explore the learning problems and the learning resources that used to solve the learning problems in industrial design studio. The main questions in this study include:

1. What are the most difficult tasks of the design process in design learning project?
2. What are the major problems that students experience in the each tasks of the design learning projects?
3. What kinds of the resources are used by students to overcome problems?

3.1 Subjects

The participants in this study were 189 undergraduate industrial design students from 3 different Universities in Taiwan. The subjects' attributes are shown as in Table 1.

Table 1. The subject numbers and percentages of school, gender, and year

	School			Gender		Year	
	U1	**U2**	**U3**	**Female**	**Male**	**2nd**	**3rd**
Frequency	42	127	20	116	73	88	101
Percentage (%)	22.2	76.2	10.0	61.4	38.6	46.6	53.4

3.2 Data Collection and Analysis

The data were collected using questionnaire survey. There are 3 categories questions in the questionnaire: 1) the learning problems that students experience in each design tasks; 2) the resources that students use to solve the problems in each design tasks; 3) the basic information of the subjects. For exploring the questions, open type questions were used in category 1 and 2 to collect the data. Both quantitative and qualitative data analyses were performed. First, descriptive statistics of the students responses were computed. Next, the content of problems and resources was coded. Finally, the content coding also was calculated and tested.

4 Results

4.1 Basic Information

The students spent on average 30.63 (SD = 19.48) hours per week for their design learning projects. They slept 5.47 (SD = 1.04) hours and spent 4.85 (SD = 2.50) hours surfing on Internet every day on average.

4.2 Learning Problems

Table 2 shows the percentage of each design task that students experienced with years, gender, and schools. The results show that the top 3 difficulties design tasks that students responded were *concept generation* (82.5%), *design presentation* (40.7%), and *design research* (34.4%). The chi-square tests were conducted to test of homogeneity of proportions between years, gender, and schools. The result indicates a significant difference between schools (X^2 = 16.361, df = 8, p = 0.037 < 0.05). The top 3 tasks that students experienced problems of U1 were *concept generation* (73.8%), *design presentation* (54.8%), and *design decision* (50.0%); of U2 were *concept generation* (85.8%), *design research* (37.8%), and *design presentation*

(36.2%); of U3 were *concept generation* (80%), *design research* (40%), and *design presentation* (40%). The U1 students seem to face more problems than U2 and U3, especially in *design decision* task. But U2 and U3 students seem to have more problems in *design research* and *design documentation*. However, no significant difference in gender (X^2 = 3.052, df = 4, p = 0.549 > 0.05) and year (X^2 = 2.676, df = 4, p = 0.613 > 0.05).

Table 2. The percentages of problems that students faced in terms of year, gender, and school; and the results of the chi-square tests

Resource	Year		Gender		School			Total
	2nd	3rd	Female	Male	U1	U2	U3	
Design Research	34.1	34.7	32.8	37.0	21.4	37.8	40.0	34.4
Concept Generation	89.8	76.2	81.9	83.6	73.8	85.8	80.0	82.5
Design Decision	34.1	28.7	33.6	27.4	50.0	25.2	30.0	31.2
Design Presentation	39.8	41.6	40.5	41.1	54.8	36.2	40.0	40.7
Design Documentation	15.9	7.9	14.7	6.8	2.4	15.0	10.0	11.6
X^2	2.676		3.052		16.361			
df	4		4		8			
P Value	0.613		0.549		0.037*			

Note: percentage = number of responses / number of subjects.
* p < 0.05.

The learning problems students responded were coded and divided into three categories: 1) *personal* (89.6%); 2) *resources* (6.1%); and 3) *interaction and communication* (4.3%). The *personal* problems included capabilities, thinking, technique and skills, experiences, personality, knowledge, and others issues. The *resource* problems were money (cost), time, technical support, equipment, and related courses. The *interaction and communication* problems were occurred with instructors and peers. Table 3 presents the percentages of the problem categories in each design tasks.

The top 3 major problems of design research task were *personal* thinking (49.3%), capabilities (14.3%), and experiences (8.5%); of concept generation were *personal* thinking (53.7%), capabilities (10.1%), and experiences (9.4%); of design decision were *personal* capabilities (31.0%), thinking (23.1%), and *interaction and communication* with instructors (9.9%); of design presentation were *personal* capability (38.2%), technique and skills (30.3%), and personality (6.8%). The *personal* capabilities (60.2%), thinking (9.7%), and technique and skills (7.1%) were the top 3 problems in design documentation tasks.

Table 3. The percentages of the problem categories in each design tasks

Problem\Task	Design Research	Concept Generation	Design Decision	Design Presentation	Design Documentation
Personal	**92.1**	**92.5**	**83.3**	**88.0**	**91.7**
Capability	14.3	10.1	31.0	38.2	60.2
Thinking	49.3	53.7	23.1	3.1	9.7
Technique & Skill	10.2	7.8	8.0	30.3	7.1
Experience	8.5	9.4	6.8	3.3	2.0
Personality	2.0	1.8	4.4	6.8	2.0
Aesthetics	1.8	4.1	4.9	1.9	2.2
Knowledge	4.1	3.3	2.6	2.0	1.7
Other	2.3	2.5	3.2	3.1	7.1
Resource	**5.6**	**2.7**	**3.0**	**11.6**	**6.9**
Money (Cost)	0.7	0.5	1.8	4.4	0.6
Time	0.7	0.3	0.6	3.1	1.4
Technical Support	0.1	0.1	0.2	2.8	2.3
Equipment & Tool	0.3	0.3	0.0	2.3	0.9
Related Course	0.0	0.1	0.2	0.8	0.3
Other	4.0	1.9	0.3	1.3	2.5
Interaction & Communication	**2.3**	**4.8**	**13.7**	**0.3**	**1.4**
Instructor	2.1	3.0	9.9	0.3	1.2
Peer	0.1	1.9	4.4	0.0	0.2

Note: percentage = number of responses / total number of responses in task category.

4.3 Learning Resources

The learning resources that students responded were divided into 4 categories: the *people* (47.3%), *object* (30.5%), *method* (22.6%) and *environment* (3.2%). Table 4 shows the percentages of resource categories between years, gender, and schools. The chi-square test indicates a significant difference between year (X^2 = 13.189, df = 3, p = 0.004 < 0.01), and schools (X^2 = 223.417, df = 6, p = 0.000 < 0.001). It seems that the 2nd year students depend on the *people* resources more, while 3rd year students begin trying to use *object*, *method*, and *environment* resources to solve the learning problems more. The U1 seems to use the *object* and *method* resources more often than others schools, and U2 & U3 seems to depend on the *people* resource more. However, there is no significant difference in gender (X^2 = 4.111, df =36, p = 0.250 > 0.05).

Table 4. The percentages of learning resources categories in year, gender, school; and the results of the chi-square tests

Task	Year		Gender		School			Total
	2nd	3rd	Female	Male	U1	U2	U3	
People	48.9	46.0	46.7	48.3	40.5	50.8	43.9	47.3
Object	29.5	31.3	31.2	29.4	32.9	29.6	29.4	30.5
Method	21.9	23.3	22.6	22.7	32.2	18.5	22.0	22.6
Environment	2.7	3.5	2.8	3.7	3.8	2.5	5.5	3.2
X^2	13.189		4.111		223.417			
df	3		3		6			
P Value	0.004**		0.250		0.000***			

Note: percentage = number of responses / total number of responses in task category.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5 shows the resource categories used in each design task. The chi-square test indicates a significant difference between design tasks ($X^2 = 241.371$, df = 12, p = $0.000 < 0.001$). The *people* resource was most used in each task, especially in design decision. Students used the *people* and *object* as main resources for solving the problems in most design tasks, but used *method* (25.0%) more than *object* (21.0%) resources in design decision task.

Table 5. The percentages of learning resources categories in each design task

Resources\Task	Design research	Concept generation	Design decision	Design presentation	Design documentation
People	44.5	40.5	56.7	50.2	44.9
Object	35.1	34.0	21.0	25.9	22.8
Method	20.5	26.1	25.0	22.8	18.5
Environment	4.0	3.9	1.6	4.0	2.2

Note: percentage = number of responses / total number of responses in task category.

5 Concluding Remarks

The purpose of this study was to investigate the learning problems that students faced and the resources used for undergraduate industrial design students in studio courses. The results indicate that 1) the *concept generation* was the most difficulty design task since 82.5% students experienced the problems; 2) the main problems were related with students' *personal* issues; 3) the *people* resource was most used for solving the problems, especially in *design decision* task; 4) different schools had significant difference between their learning problems and resources usage. These findings are consistent with previous studies [13, 17, 18]. Several additional findings and reflections are elaborated below.

The Capabilities and Thinking Styles of Students

The research results indicated that students experience lots of problems related to their capabilities and thinking styles. There were 22.6% students using *methods* to solve the problems, and 47.3% using *people* resources. Design studio is the core course of the design education, so students need to implement the knowledge and techniques learned from the supporting courses. The curriculum design may influence the performance [19]. Are the supporting courses appropriately arranged to support the core course? Do students really learn the abilities? Do they know how to apply the abilities learnt? These questions will significantly related to the problems students will encounter.

Resources Setting and Supporting

The students responded they faced problems related to *resources* setting, such as money (cost), time, technical support, equipment, and *interaction* with instructors. Reviewing the answers found that some issues were related to students themselves, for example, the time management skill. However, there were some related to facilities and the technical support, such as the workshops and processing machines. Therefore, design learning is similar to apprentice system that students learn design through doing the design with instructors' guidance. The instructors' support is important [18, 20]. In this study, some students seem to have problems to interact with instructors. Some of them had different opinions with instructors, especially in design decision. It is important to guide students dealing with conflicts and making decisions.

Design professional learning is a complexity issue. This study is an exploratory research, and therefore the findings were not very conclusive. Future research will provide more details to provide insights regarding to learning problems and resources usage.

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