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# Learning problems and resources usage of undergraduate industrial design students in studio courses

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***Abstract:*** *Design students face certain learning problems and difficulties as they explore the design problems space. The purpose of this study is to understand those learning problems and the resources that undergraduate industrial design students need in studio courses. To collect the data, a questionnaire was designed according to the preliminary studies. A total of 334 students from 4 Taiwanese universities participated in the survey. The results demonstrated that the most difficult design tasks for students included concept generation, design presentation and design decision. The main problems that the students experienced included the cost issue in design presentation, time pressure in design documentation, inspiration in concept generation, digital modelling in design presentation and vertical (deep) thinking in concept generation. The causes of these problems were personal issues, resources and interactions with instructors and peers. The learning resources that the students used to solve their learning problems fell into four categories: people, object, method and environment. The information provided in this study can deepen the understanding of the learning process of students and provide a reference for teaching planning and the setting of the learning resources in design education.*

*Keywords: learning problems, learning resources, design education.*

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# Introduction

Today, design is a powerful weapon that companies use. Thus, it is important to educate excellent designers for the industry. The essential feature of design education is "learning by doing", especially in industrial design. Students acquire design knowledge and skills through operating real design problems.

Learning is the act or process of developing skills or knowledge (Arsham 2002), and understanding the learning process can improve education. A learning system includes many elements, such as instructors, learners, content and materials, and environment. Therefore, in order to understand the learning process, it is important to gain a holistic view from different viewpoints.

However, design students also experience learning problems. Due to the features of industrial design education, the problems that the students experience and the resources which they use in the learning process may differ from those in other domains. However, few studies have discussed the learning problems and learning resources in design education.

This study aims to reveal the problems of industrial design learning from the students' viewpoint, in order to explore these learning problems and the resources that the students used to overcome those problems in the undergraduate industrial design studio course. The results can deepen the understanding of the students' learning process and provide a reference for teaching planning and the setting of the learning resources in industrial design education.

# Literature Review

## *Design professionals' learning*

Design is generally considered to involve abductive reasoning, which addresses ill-defined problems and uses a construction process to solve them (Zimring and Latch Craig 2001). Design knowledge covers the body and relationship between object and subject. It is difficult to understand or to describe, and it must be understood with reference to the problem context. This knowledge also cannot be delivered by a traditional lecture course. The most common method of dissemination is "learning by doing", such as the apprentice system; thus, design learning emphasizes working with actual problems to acquire professional knowledge and techniques (Schön 1987). Accordingly, students need to acquire advanced knowledge through working with design problems in the real world. In the learning process, an instructor demonstrates and leads learners to engage with a real design problem. The learners try to observe, understand and 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, style and philosophy of design. Therefore, the design process can be considered a social process in which the result is constructed using various kinds of knowledge and which involves interaction and negotiation between participants (Bucciarelli 2001; Oak 2011).

The studio is the main and most important pedagogy of design education (Schön 1987) that has been in use for almost 100 years (Reimer and Douglas 2003), 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. Hence, learners go through the procedure of design to solve real or simulated design problems (Attoe and Mugerauer 1991; Budd, Vanka and Runton 1999; Forgber and Russell 1999). Through the studio, learners are exposed to a number of learning experiences which focus on two key aspects. The first is learning how to design by engaging with a process of designing or a suite of possible design methodologies. The second is evincing knowledge about concepts and/or situations through the act of designing (Smith, Hedley and Molloy 2009).

The 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 an important role in a typically successful studio programme: (1) People: lecturers, tutors, technicians, members of 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 the studio and hours of access to facilities. Attoe and Mugerauer (1991) also mentioned that the factors associated with teaching excellence in design studios include three considerations: (1) the teacher as self (aspects of the teacher's own life that contribute to good teaching); (2) personal style (the way the teacher behaves); and (3) course format and implementation.

## *Learning problems and resources in the design studio*

The design studio is the place to practice and integrate the knowledge and skills acquired from the courses in the programme. There are various people involved in the design learning process, for example, classmates, instructors, technicians and other experts. The design studio also requires an environment and setting to support the design learning process, such as a personal work space, workshops and library. Learning the process of design is similar to designing; both events involve spending certain periods of time thinking through the process and attempting to achieve some interesting results. Learners often have to explore and discover their own paths to gain knowledge and skills (Chang and Huang 2002). Furthermore, the students face a number of problems as they work through their design process.

### LEARNING PROBLEMS

The 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, the teaching style and the students' expectations (Chang et al. 2000; Pirrie, Hamilton and Wilson 1999).

In particular, design students experience some learning problems and difficulties when they explore the design problems space. Yang, You and Chen (2005) investigated the difficulties faced by industrial design students and their career guidance needs and found that the students encountered the following problems: (1) high learning pressure and frustration; (2) a heavy workload, depriving them of extra-curricular activities and leisure time; (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. In addition, Mawson (2007) compared the workplace practices of six experienced

designers and investigated their experience of a teaching practicum designed to help secondary school students develop design skills. The results revealed that the students faced two types of problems. First, they experienced technical problems related to the skills needed to produce the product. The second type of problem was related to the nature of the materials and the tools needed to do the job. The teachers also identified three basic problems with their experiences. One was the students' antipathy towards, and ignorance of, the design element in the technological process. Another was the students' lack of practical experience. A further problem was the 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 various media and formats, which 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 (*Learning Resources* 1999).

Learning the process of design is similar to designing (Chang and Huang 2002). The design students need some resources to solve the learning problems and difficulties they encounter, as well as to solve the design problems with design resources and knowledge. Some of the design resources used to solve the design problems may also be the same resources for solving the learning problems.

Little research has discussed the design learning resources or even the study method. Brown et al. (1996) developed a learning resource questionnaire to gather information on the learning resources used by students. These resources may include not only lectures, tutorials and courseware, but books, hand-outs, notes and discussions with other students. They regarded this information as important to teaching staff in assessing and increasing the value of the resources for students by ensuring their effective integration into a course.

With regard to the design learning resources, Chiu (2010) investigated students' knowledge sources and knowledge sharing in the design studio, the definition of design knowledge resources is similar to the design learning resources in this study. The results demonstrated that the top four knowledge resources requested by juniors were books and magazines, studio-mates, schoolmates and the Internet. In the same order, 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 critiques. In terms of the percentage of knowledge gain, books and magazines were 25%, the Internet was 23%, studio-mates were 20% and auditing desk crits was 15%.

The research of You, Yang and Liao (2007) explored industrial design students' learning attitudes in Taiwan. Some results of the study also related with the learning resources, including the following: (1) while learning design, students want teachers to share their design experiences with them; (2) they tend to ask classmates or friends for help when they encounter difficulties; (3) they devote a great deal of time and emphasize creative thinking and model-making during the design process; and (4) their design concepts mostly come from their life experiences.

## *Summary*

The main method for design education is the studio, where students obtain design knowledge through the design process by operating real design problems. Design students face some learning problems and difficulties in the design learning process, and they try to use some learning resources to solve these problems, such as seeking and gathering the resources to solve the design problems. However, little research has discussed the learning problems and learning resources in the design education domain. This paper shall explore the learning problems and learning resources to increase the understanding of the learning process of design students.

# Methods

A survey was conducted to investigate the learning problems that students encounter and the learning resources that they use to solve the learning problems in industrial design studio courses. The main research questions were as follows:

- What do students consider to be the most difficult design tasks?
- What are the major and most common problems that students experience?
- What are the issues that cause the learning problems?
- What kind of resources do students use to overcome the problems?

## *Subjects*

The survey respondents were 334 undergraduate industrial design students from 4 universities in Taiwan. There were 114 male and 220 female students. The subjects' attributes are shown in Table 1.

***Table 1. The attributes of the subjects.***

| | | Year of core course | | | Gender | |
|---|---|---|---|---|---|---|
| **University** | **Total** | **2** | **3** | **4** | **Male** | **Female** |
| U1 | 61 | 20 | 24 | 17 | 22 | 39 |
| U2 | 99 | 40 | 30 | 29 | 29 | 70 |
| U3 | 84 | 34 | 29 | 21 | 32 | 52 |
| U4 | 90 | 30 | 29 | 31 | 31 | 59 |
| Total | 334 | 124 | 112 | 98 | 114 | 220 |

On average, the students spent 23.17 (SD = 18.15) hours per week on their design learning projects. Per day, they slept for 5.82 (SD = 1.43) hours and spent 5.80 (SD = 3.28) hours surfing the Internet, on average.

## *Data collection and analysis*

The data were collected using the abovementioned survey. The survey was designed according the results of a preliminary study (Chen and Tang 2011) that formulated the categories and items of the learning problems and resources. The survey questions were in three parts: (1) the learning problems that the students experienced in each design task; (2) the resources that the students used to solve the problems in each design task; (3) the basic information of the subjects.

It took about 20–30 minutes for the participants to complete the questionnaire. All the data were entered into an MS Excel datasheet, then sorted and checked. Finally, SPSS software was used to statistically analyse the data.

# Results

## *The difficulty of design tasks*

The results regarding the difficulty of the design tasks are shown in Table 2. The students reported that the top 3 most difficult design tasks were *concept generation* (75.7%), *design presentation* (38.6%) and *design decision* (37.7%).

***Table 2. The most difficult design tasks for students. (DR: Design Research, CG: Concept Generation, DDec: Design Decision, DP: Design Presentation, DDoc: Design Documentation.)***

| | | Design Tasks | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DR | | CG | | DDec | | DP | | DDoc | |
| Category | Item | N | % | N | % | N | % | N | % | N | % |
| Gender | Male | 45 | 39.5 | 81 | 71.1 | 41 | 36.0 | 35 | 30.7 | 14 | 12.3 |
| | Female | 57 | 25.9 | 172 | 78.2 | 85 | 38.6 | 94 | 42.7 | 16 | 7.3 |
| Course | Basic Product Design | 40 | 32.3 | 98 | 79.0 | 41 | 33.1 | 57 | 46.0 | 11 | 8.9 |
| | Product Design | 32 | 28.6 | 87 | 77.7 | 47 | 42.0 | 40 | 35.7 | 13 | 11.6 |
| | Senior Design Project | 30 | 30.6 | 68 | 69.4 | 38 | 38.8 | 32 | 32.7 | 6 | 6.1 |
| Total | | 102 | 30.5 | 253 | 75.7 | 126 | 37.7 | 129 | 38.6 | 30 | 9.0 |

### GENDER

According to the male students, *concept generation* and *design research* were the top two most difficult tasks, and according to the female students, they were *concept generation* and *design presentation*.

Chi-square tests were conducted to test the homogeneity of the proportions between genders. The results indicated that the male students (39.5%) regarded the *design research* task as more difficult than the female students (25.9%), and the female students (42.7%) regarded the *design presentation* task as more difficult than the male students (30.7%).

### CORE COURSE

Regarding the core course, the results suggested a decreasing trend in *concept generation* and *design presentation* from year 2 to year 4. The students in the third year product design course regarded *design decision* and *design documentation* as more difficult than the students in the second year basic product design and fourth year senior design project courses. However, there were no significant differences between the core courses.

## *The design learning problems*

The result of the frequency and percentage of the learning problems that the students experienced are presented in Table 3. The main problem that the students frequently experienced was associated with the cost of *design presentation* tasks, with 59.8% of the students responding that they always encountered this problem. Further, 58.0% responded that they had experienced time pressure with regard to *design documentation*; 54.2% always encountered digital 3-D modelling problems in *design presentation* tasks; and 51.2% frequently experienced vertical thinking problems in *concept generation* tasks.

***Table 3. The learning problems that the students experienced in each design task.***

| | | Never | | Few | | Always | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| **Task** | **Problems** | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** |
| Design Research | Data collection | 13 | 3.9 | 201 | 60.2 | 120 | 35.9 | 334 | 100.0 |
| | Data sorting | 48 | 14.4 | 218 | 65.3 | 68 | 20.3 | 334 | 100.0 |
| | Data analysis | 18 | 5.4 | 226 | 67.7 | 90 | 26.9 | 334 | 100.0 |
| | Data Presentation | 45 | 13.5 | 198 | 59.5 | 90 | 27.0 | 333 | 100.0 |
| | Understanding of the design theme | 42 | 12.6 | 212 | 63.5 | 79 | 24.0 | 334 | 100.0 |
| | Selection of the design direction | 15 | 4.5 | 178 | 53.3 | 141 | 42.2 | 334 | 100.0 |
| | Target setting | 26 | 7.8 | 198 | 59.5 | 109 | 32.7 | 333 | 100.0 |
| Concept Generation | Lateral thinking | 15 | 4.5 | 173 | 51.8 | 146 | 43.7 | 334 | 100.0 |
| | Vertical thinking | 15 | 4.5 | 148 | 44.3 | 171 | 51.2 | 334 | 100.0 |
| | Concept presentation skills | 28 | 8.4 | 162 | 48.5 | 144 | 43.1 | 334 | 100.0 |
| | Inspiration | 8 | 2.4 | 135 | 40.4 | 191 | 57.2 | 333 | 100.0 |
| | Form & Style | 22 | 6.6 | 179 | 53.6 | 133 | 39.8 | 334 | 100.0 |
| | Reference information | 59 | 17.8 | 203 | 61.1 | 70 | 21.1 | 332 | 100.0 |
| Design Decision | Decision-making ability | 32 | 9.6 | 193 | 57.8 | 109 | 32.6 | 334 | 100.0 |
| | Quantity of concept | 32 | 9.6 | 162 | 48.5 | 140 | 41.9 | 334 | 100.0 |
| | Quality of concept | 16 | 4.8 | 154 | 46.1 | 164 | 49.1 | 334 | 100.0 |
| | Criteria for evaluation | 40 | 12.0 | 189 | 56.6 | 105 | 31.4 | 334 | 100.0 |
| | Evaluation method | 55 | 16.5 | 193 | 58.0 | 85 | 25.5 | 333 | 100.0 |
| Design Presentation | Digital modelling | 18 | 5.4 | 135 | 40.4 | 181 | 54.2 | 334 | 100.0 |
| | Physical modelling | 19 | 5.7 | 182 | 54.7 | 132 | 39.6 | 333 | 100.0 |
| | Graphic | 62 | 18.6 | 170 | 51.1 | 101 | 30.3 | 333 | 100.0 |
| | Oral | 52 | 15.6 | 151 | 45.2 | 131 | 39.2 | 334 | 100.0 |
| | Organization & logic | 49 | 14.8 | 190 | 57.4 | 92 | 27.8 | 331 | 100.0 |
| | Cost | 26 | 7.8 | 108 | 32.4 | 199 | 59.8 | 333 | 100.0 |
| Design Documentation | Data collection | 83 | 24.9 | 180 | 54.1 | 70 | 21.0 | 333 | 100.0 |
| | Organization & structure | 52 | 15.6. | 211 | 63.2 | 70 | 21.0 | 333 | 100.0 |
| | Layout & editing | 44 | 13.2 | 181 | 54.4 | 108 | 32.4 | 333 | 100.0 |
| | Time | 26 | 7.8 | 114 | 34.2 | 193 | 58.0 | 333 | 100.0 |
| | Cost | 64 | 19.4 | 110 | 33.3 | 156 | 47.3 | 330 | 100.0 |

To identify any difference due to gender and core courses, the data were re-coded from the normal scale to an interval scale, thus converting “Never” as “0”, “Few” as “1” and “Always” as “2”. Table 4 presents a summary of the test results. The results indicated that the female students significantly and frequently experienced problems related to the selection of the design direction in *design research*, vertical thinking and

concept presentation skills in *concept generation*, quality of concept and criteria for evaluation in *design decision* and digital modelling in *design presentation* task.

The third year product design course students experienced problems with the selection of the design direction in *design research* tasks more so than the fourth year senior design project course students. The third year students also encountered vertical thinking problems in *concept generation* tasks more often than the second year students in the basic product design course.

***Table 4. The results of the test of differences by gender and course with significance level .05. (F: Female, M: Male, 2: second year basic product design course, 3: third year product design course, 4: fourth year senior design project.)***

| Task | Problem | Gender | Course |
|---|---|---|---|
| Design Research | Selection of the design direction | F > M | (3, 2) ≥ (2, 4) |
| Concept Generation | Vertical thinking | | (3, 4) ≥ (4, 2) |
| | Concept presentation skills | F > M | |
| Design Decision | Quality of concept | F > M | |
| | Criteria for evaluation | F > M | |
| Design Presentation | Digital modelling | F > M | |

## *Issues that caused learning problems*

Five issues developed based on the preliminary research (Chen and Tang 2011) were listed and presented in a multiple choice format to determine the main issues that caused the learning problems. The issues related to the learning problems that the students experienced included *personal* (67.3%), *resources* (40.1%), *interaction with instructors* (28.9%), *interaction with peers* (19.4%) and *others* (2.8%).

Table 5 summarizes the results of the problems caused by the issues in each design task. A chi-square test was conducted to test the homogeneity of the proportions between design tasks. The results revealed that there were significant differences between the design tasks in terms of each issue.

***Table 5. The results of the issues that caused learning problems in each design task. (DR: Design Research, CG: Concept Generation, DDec: Design Decision, DP: Design Presentation, DDoc: Design Documentation.*** p < .05)***

| | DR | | CG | | DDec | | DP | | DDoc | | Test of homogeneity | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Issues** | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** | $X^2$ | *df* | *p* | |
| Personal | 1735 | 64.9 | 1637 | 70.0 | 1304 | 65.1 | 1686 | 72.1 | 1285 | 64.1 | 53.009 | 4 | .000 | *** |
| Resources | 1031 | 38.6 | 1122 | 48.0 | 724 | 36.1 | 884 | 37.8 | 795 | 39.7 | 81.549 | 4 | .000 | *** |
| Interaction with instructors | 884 | 33.1 | 812 | 34.7 | 808 | 40.3 | 472 | 20.2 | 307 | 15.3 | 454.760 | 4 | .000 | *** |
| Interaction with peers | 589 | 22.0 | 542 | 23.2 | 405 | 20.2 | 411 | 17.6 | 261 | 13.0 | 91.062 | 4 | .000 | *** |
| Others | 79 | 3.0 | 58 | 2.5 | 43 | 2.1 | 67 | 2.9 | 70 | 3.5 | 7.862 | 4 | .097 | |

Figure 1 below shows the radar chart of the percentages corresponding to the issues in each design task. *Personal* was the main issue that caused learning problems,

especially in the *design presentation* and *concept generation* tasks. The *resource* issue's proportion of *concept generation* was significant higher than in other tasks. The proportion of *interaction with instructors* in *design decision* tasks was significantly higher than in other tasks. In *design decision* tasks, the proportion of *interaction with instructors* was also higher than the *resource* issue.

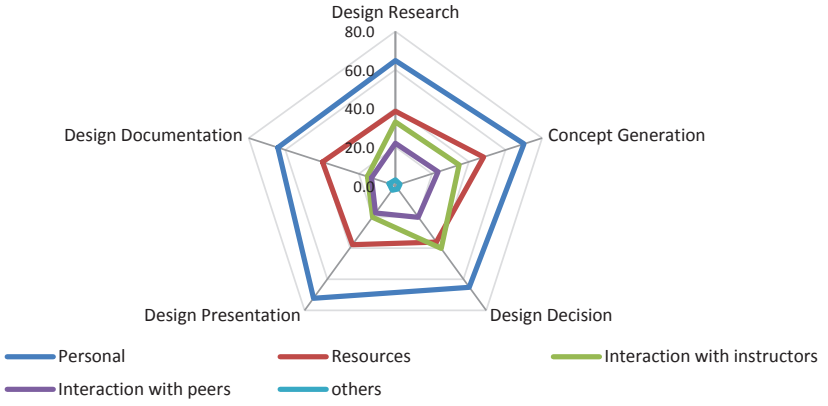


*Figure 1. The radar chart of the issues caused learning problems in each design task.*

Table 6 presents a summary of the analysis results for the issues by gender. There were some significant differences related to gender. The proportion of male students' learning problems caused by *resources* and *interaction with peers* issues were significantly higher than they were for the female students. The proportion of *personal* issues was significant higher among the female students than the male students.

***Table 6. Analysis of the issues that caused learning problems by gender. (* p < .05, ** p < .01, *** p < .001)***

| | Male (M) | | Female (F) | | Test of homogeneity | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Issues** | **N** | **%** | **N** | **%** | $X^2$ | *df* | *p* | | **Post test** |
| Personal | 2517 | 64.4 | 5130 | 68.9 | 23.843 | 1 | .000 | *** | F > M |
| Resources | 1635 | 41.8 | 2921 | 39.2 | 7.141 | 1 | .008 | ** | M > F |
| Interaction with instructors | 1106 | 28.3 | 2177 | 29.2 | 1.128 | 1 | .288 | | |
| Interaction with peers | 823 | 21.0 | 1385 | 18.6 | 9.809 | 1 | .002 | ** | M > F |
| Others | 92 | 2.4 | 225 | 3.0 | 4.226 | 1 | .040 | * | F > M |

The analysis results of the issues by core course year are shown in Table 7. The proportion of *personal* issues in the second year basic product design and third year product design courses were significantly higher than in the fourth year senior design project course. In terms of the *resources* issue, the proportion for the third year product design course was significantly higher than for the second year basic product design and fourth year senior design project courses. The proportions of interaction with instructors and interaction with peers for the fourth year senior design project course were significantly higher than for other courses.

***Table 7. The results of the issues that caused learning problems by course. (BPD: Basic Product Design, PD: Product Design, SDP: Senior Design Project. * p < .05, ** p < .01, *** p < .001)***

| | BPD (2) | | PD (3) | | SDP (4) | | Test of homogeneity | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Issues** | **N** | **%** | **N** | **%** | **N** | **%** | $X^2$ | *df* | *p* | | **Post test** |
| Personal | 2977 | 70.0 | 2584 | 68.5 | 2086 | 62.6 | 50.312 | 2 | .000 | *** | 2 > 4; 3 > 4 |
| Resources | 1630 | 38.4 | 1632 | 43.2 | 1294 | 38.8 | 23.136 | 2 | .000 | *** | 3 > 2; 3 > 4 |
| Interaction with instructors | 1163 | 27.4 | 1052 | 27.9 | 1068 | 32.1 | 22.919 | 2 | .000 | *** | 4 > 2; 4 > 3 |
| Interaction with peers | 649 | 15.3 | 763 | 20.2 | 796 | 23.9 | 90.743 | 2 | .000 | *** | 3 > 2; 4 > 2; 4 > 3 |
| Others | 142 | 3.3 | 76 | 2.0 | 99 | 3.0 | 13.541 | 2 | .001 | ** | 2 > 3; 4 > 3 |

## *Design learning resources*

The learning resources that the students used to solve the learning problems comprised 4 categories: *people* (27.9%), *object* (24.7%), *method* (29.4%) and *environment* (18.0%). Figure 2 shows the percentages of the learning resource categories and items. The *people* resources include instructors, peers, technicians, experts, family, friends and others. The *object* resources include the Internet, books and magazines, existing products, tools and equipment and others. The *method* resources include brainstorming, discussion, observation, interviews, practice, computer-aided and others. The *environment* resources include library, workshops on campus, processing factories off campus, shops and department stores and others.

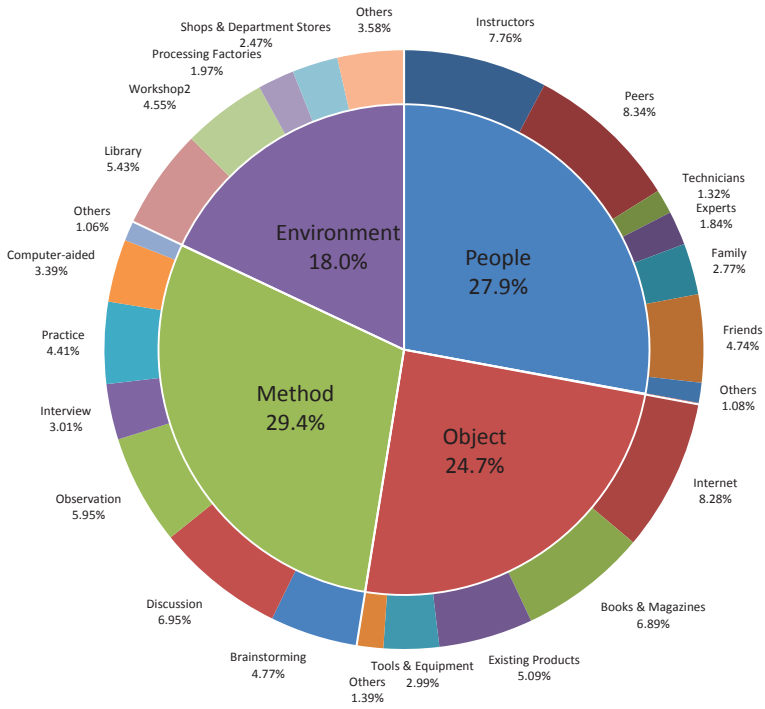


*Figure 2. The learning resource categories and items.*

Table 8 presents a summary of the frequency and percentage of each resource. The results indicated that peers (58.7%), the Internet (58.2%) and instructors (54.6%) were the most used learning resources for solving the learning problems. The top 3 resources that the students used in *design research* tasks were the Internet (68.8%), peers (62.4%) and instructors (59.7%); in the *concept generation* tasks, they were the Internet (69.6%), peers (63.9%) and instructors (63.1%); in *design decision* tasks, they were instructors (66.8%), peers (58.4%) and discussion (57.8%); in *design presentation* tasks, they were peers (58.4%), practice (48.5%) and instructors (45.1%); and in *design documentation* tasks, they were peers (48.2%), the Internet (47.3%) and books and magazines (40.3%).

***Table 8. The categories and percentage of the learning resources in each design task. (DR: Design Research, CG: Concept Generation, DDec: Design Decision, DP: Design Presentation, DDoc: Design Documentation.)***

| | | | | Design Tasks | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | | DR | | CG | | DDec | | DP | | DDoc | |
| Categories | Items | N | % | N | % | N | % | N | % | N | % | N | % |
| People | Instructors | 6198 | 54.6 | 1594 | 59.7 | 1475 | 63.1 | 1339 | 66.8 | 1055 | 45.1 | 735 | 36.7 |
| | Peers | 6662 | 58.7 | 1667 | 62.4 | 1494 | 63.9 | 1170 | 58.4 | 1365 | 58.4 | 966 | 48.2 |
| | Technicians | 1056 | 9.3 | 227 | 8.5 | 238 | 10.2 | 212 | 10.6 | 248 | 10.6 | 131 | 6.5 |
| | Experts | 1470 | 12.9 | 329 | 12.3 | 373 | 16.0 | 313 | 15.6 | 281 | 12.0 | 174 | 8.7 |
| | Family | 2211 | 19.5 | 490 | 18.3 | 551 | 23.6 | 326 | 16.3 | 456 | 19.5 | 388 | 19.4 |
| | Friends | 3783 | 33.3 | 1024 | 38.3 | 918 | 39.3 | 581 | 29.0 | 721 | 30.8 | 539 | 26.9 |
| | Others | 862 | 7.6 | 182 | 6.8 | 181 | 7.7 | 111 | 5.5 | 169 | 7.2 | 219 | 10.9 |
| Object | Internet | 6612 | 58.2 | 1837 | 68.8 | 1628 | 69.6 | 1152 | 57.5 | 1047 | 44.8 | 948 | 47.3 |
| | Books & magazines | 5503 | 48.5 | 1391 | 52.1 | 1453 | 62.1 | 972 | 48.5 | 879 | 37.6 | 808 | 40.3 |
| | Existing Products | 4058 | 35.7 | 1046 | 39.1 | 1214 | 51.9 | 813 | 40.6 | 540 | 23.1 | 445 | 22.2 |
| | Tools & equipment | 2385 | 21.0 | 461 | 17.3 | 560 | 24.0 | 381 | 19.0 | 624 | 26.7 | 359 | 17.9 |
| | Others | 1111 | 9.8 | 166 | 6.2 | 141 | 6.0 | 177 | 8.8 | 323 | 13.8 | 304 | 15.2 |
| Method | Brainstorming | 3806 | 33.5 | 1031 | 28.6 | 1172 | 50.1 | 728 | 36.3 | 463 | 19.8 | 412 | 20.6 |
| | Discussion | 5550 | 48.9 | 1589 | 59.5 | 1305 | 55.8 | 1159 | 57.8 | 827 | 35.4 | 670 | 33.4 |
| | Observation | 4747 | 41.8 | 1216 | 45.5 | 1331 | 56.9 | 890 | 44.4 | 704 | 30.1 | 606 | 30.2 |
| | Interview | 2398 | 21.1 | 677 | 25.3 | 623 | 26.6 | 517 | 25.8 | 301 | 12.9 | 280 | 14.0 |
| | Practice | 3521 | 31.0 | 547 | 20.5 | 738 | 31.6 | 451 | 22.5 | 1135 | 48.5 | 650 | 32.4 |
| | Computer-aided | 2624 | 23.1 | 706 | 26.4 | 594 | 25.4 | 335 | 16.7 | 556 | 23.8 | 433 | 21.6 |
| | Others | 847 | 7.5 | 114 | 4.3 | 114 | 4.0 | 116 | 5.8 | 225 | 9.6 | 278 | 13.9 |
| Environment | Library | 4334 | 38.2 | 1220 | 45.7 | 1157 | 49.5 | 769 | 38.4 | 588 | 25.1 | 600 | 29.9 |
| | Workshops | 3630 | 32.0 | 879 | 32.9 | 804 | 34.4 | 687 | 34.3 | 764 | 32.7 | 496 | 24.8 |
| | Processing factories | 1570 | 13.8 | 376 | 14.1 | 356 | 15.2 | 277 | 13.8 | 322 | 13.8 | 239 | 11.9 |
| | Shops & stores | 1969 | 17.3 | 516 | 19.3 | 654 | 28.0 | 368 | 18.4 | 221 | 9.5 | 210 | 10.5 |
| | Others | 2857 | 25.2 | 639 | 23.9 | 514 | 22.0 | 456 | 22.8 | 660 | 28.2 | 588 | 29.3 |

Figure 3 presents a bar chart of the percentage of the resources used in each design task. The top 2 types of resources that the students used in *design research* tasks were *object* (36.7%) and *method* (30.0%); in *concept generation* tasks, they were *object* (42.7%) and *method* (35.8%); in *design decision* tasks, they were *object* (34.9%) and *method* (29.9%); in *design presentation* tasks, they were *object* (29.2%) and *people* (26.2%); and in *design documentation* tasks, they were *object* (28.58%) and *method* (23.7%). There was a similar pattern of usage in the resource types. The students used the most resources in *concept generation* tasks and the fewest in *design documentation* tasks. The students used the *object* type resources the most and the *environment* type resources the least.

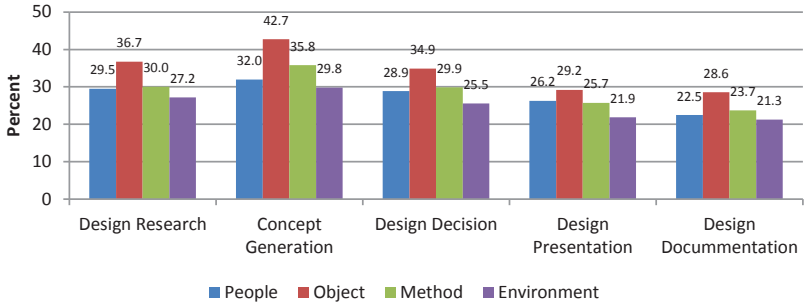


*Figure 3. The proportions of learning resources used in each design task.*

Figure 4 shows a comparison of the proportions of the learning resources used by gender. The results suggested that the male students used more resources to solve the learning problems than the female students did, especially in the case of *environment* resources.

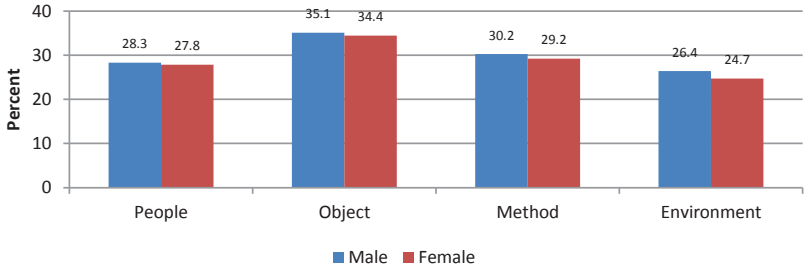


*Figure 4. The proportions of the learning resources used by gender.*

Figure 5 presents a bar chart of the proportions of resources used in different types by core courses. The results illustrated that the students progressively relied on the *people* type resources from the second year to the fourth year core courses, and their usages of *object* type resources gradually decreased as the course year increased.

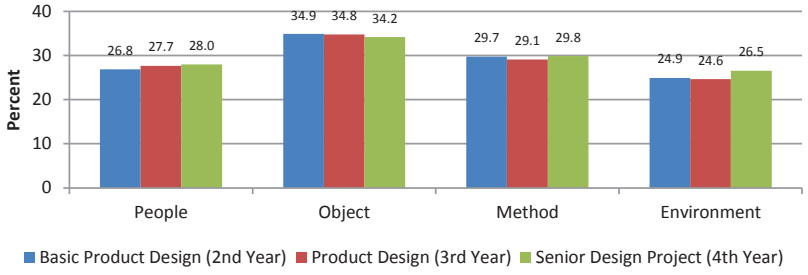


*Figure 5. The analysis of the usage proportion of learning resources by core course.*

## *Summary*

The results revealed that the students experienced learning problems within the learning process, especially in *concept generation* tasks. The learning problems were mainly caused by *personal* issues, and they relied on *people* resources to help them solve their problems. There were several differences between genders and among core courses in terms of the learning problems, issues and resources usage.

In terms of gender, both the male and female students regarded *concept generation* as the most difficult task. However, the male students regarded *design research* as a more difficult task than the female students did. Moreover, the female students regarded *design presentation* as more difficult than the male students did, especially in digital modelling. The proportions of males who had problems caused by *resources* and *interaction with peers* issues were significantly higher than among the female students. The proportion of female students who had *personal* issues that caused problems was significantly higher than among the male students. Overall, the male students seemed to use more resources to solve their problems, especially with regard to *environment* resources.

Concerning the core courses, there was a decreasing trend in the proportions of students who regarded *concept generation* and *design presentation* as difficult tasks from second year to fourth year. The students in the third year product design course significantly and frequently experienced problems in the selection of the design direction in *design research* tasks as compared to the fourth year senior design project course students. The third year students also experienced vertical thinking problems in *concept generation* tasks more so than those in the second year basic product design course. In the fourth year senior design project course, the proportion of problems caused by *personal* issues was the lowest, but the proportions of issues associated with *interaction with instructors* and *interaction with peers* were higher than other courses. The students progressively relied on *people* resources from second year to fourth year, and gradually decreased their usage of *object* resources as the course year increased.

# Concluding remarks

The purpose of this study was to investigate the learning problems that undergraduate industrial design students experienced and the resources they used in core courses with studio pedagogy. The results illustrated that (1) *concept generation* was the most difficult design task for the students; (2) the main learning problems that the students frequently experienced were cost problems within *design presentation* tasks, time pressure in *design documentation* and digital modelling in *design presentation* tasks; (3) the top two main issues causing learning problems were *personal* and *resources*; (4) the top two resources that the students used for solving the learning problems were *method* and *people*. These findings are consistent with those of previous studies (Chiu 2010; Yang, You and Chen 2005; You, Yang and Liao 2007). Several additional findings and reflections are elaborated below.

### Gender issue

The results indicated that there were significant differences between the males and females in terms of the difficulty of design tasks, learning problems and resources usage. The proportion of female students in the industrial (product) design domain gradually increased from 48.11% in 1998 to 61.06% in 2011 in Taiwan (Ministry of Education 2011). Therefore, it is worth studying the issues concerning the education and career development of female designers.

PEOPLE ISSUE

The learning problems in *design decision* tasks were mainly caused by *personal* and *interaction with instructors* issues. Furthermore, the students preferred to solve these problems by relying on *people* resources, such as instructors and peers. Design practice can be seen as a social process that involves interaction and negotiation between participants (Oak 2011). In the design studio, students have to interact and negotiate with the instructor to propose solutions to design problems. Thus, the instructor plays an important role in students' learning process (Attoe and Mugerauer 1991). Consequently, the quality and quantity of the design instructors in studio courses should be considered.

PERSONAL ISSUE

Most of the students regarded *personal* issues as the main issues causing their learning problems. These *personal* issues were related to personal talent and abilities (Chen and Tang 2011). The results indicated that the students lack confidence in their talent and abilities acquired from their other courses. It is important to enhance students' confidence and to make sure that the students have really learnt the knowledge and skills that their courses are designed to impart. Further, the students must learn how to use this knowledge and skills to ensure the integrity of their design projects. However, students seem to ignore design methods.

Design professionals' learning is a complex issue. This study attempted to explore the learning problems and resources from the learners' viewpoint. The findings can deepen the understanding of the design learning process. They could also be applied in teaching and future research. However, there is a continuing need for an adequate theoretical basis for the practical application of design education.

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