Chapter 76
Planning to Enhance Student Learning Outcomes on Innovation Design Projects

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Abstract Design studio is the central learning environment for students in design schools. For the major design project, various topic selections can lead to dissimilar design journeys. This module was taught for the first time at one of the international universities in China campus in the 2015 spring semester. After completing the teaching, students suggested that more critiques help them to acquire design knowledge and manage their time more effectively. We adopted their suggestions. However, the learning outcomes in 2016 were not as good as those of the preceding year. To address this issue, we proposed Kolb's experiential learning cycle as a framework to develop assessment strategies for various design stages, and we argued that assessment strategies designed based on this framework enhance student learning outcomes. We illustrated how the stages of Kolb's model can be incorporated into the major design project and results presented in the paper.

76.1 Introduction

The design studio plays a crucial role in product design education because most students spend considerable time and effort learning in the design studio. Anthony [1] stated that the design studio provides students with their own space where they can draw, study, work, talk and even sleep. Therefore, the design studio has become the central learning environment for all design students in design schools. The most common module for teaching and learning at universities comprises lectures, assignments and examinations. However, teaching at the design studio is unique.

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Fig. 76.1 Major design project exhibition in 2015

The major design project (MAJ) involves sixteen weeks of teaching, followed by two weeks of design exhibition (Fig. 76.1) at one of the international universities in China campus. The students propose their chosen design topics first, which must be accepted by their lecturers based on the relevance of the topic to the module.

Various topic selections can lead to dissimilar design journeys. This module was taught for the first time in China campus in the 2015 spring semester. Students were asked to complete first a draft sketch and then present their final designs. Their presentations were marked by all product design staff, and oral and written feedback was provided to the students to help them to improve their final designs before the exhibition; most of the students used the feedback to refine their designs. The process of presenting work, receiving staff feedback, and revising designs is called critiquing [2], and it helped product design students gain design knowledge and experience from their lecturers. In general, most students achieved satisfactory outcomes and several students attained the first-class level. Figure 76.2 shows two good examples of students' design works, called Moving Design Studio and Invisible Studio.

After completing the teaching module, student evaluation of teaching (SET) and student evaluation of modules (SEM) surveys were obtained. After the first semester, students suggested that more critiques (feedback) help them to acquire design knowledge and manage their time more effectively. Although it increases staff's workload, all design lecturers agreed to provide more feedback and adopted the practice for the following year of MAJ teaching. Adding three more added critiques, which were delivered at different design stages, is shown in Table 76.1.

The student learning outcomes in 2016 were not as good as those of the preceding year, and none of the students achieved the first-class level. Therefore, there is a need to further improve this module, particularly because it is worth 60 credits and includes a public design exhibition. To address this issue, we propose Kolb's

Fig. 76.2 Good MAJ examples in 2015 (left: Moving Design Studio; right: Invisible Studio)

Table 76.1 Adding more design critiques for major design project 2016

Critiques	Design stages	Dates
1.	Topic selections—adding it in 2016	25 Feb 2016
2.	Sketching—adding it in 2016	17 Mar 2016
3.	Sketch model making	7 Apr 2016
4.	CAD modelling and engineering drawing—adding it in 2016	5 May 2016
5.	Final design	26 May 2016

[3] experiential learning cycle as a framework to develop assessment strategies for various design stages and we argue that assessment strategies designed based on this framework to enhance student learning outcomes. We illustrated how the stages of Kolb's model can be incorporated into the major design project.

76.2 Kolb's Experiential Learning Cycle (ELC) Model

76.2.1 Using Kolb's ELC to Improve Student Design Learning Outcomes

Learning is the process of creating knowledge through experience transformation [4]. In Kolb's ELC, learning takes place in four phases, as shown in Fig. 76.3 (next page). Kolb believes that in order to gain a complete learning experience, students must go through all four phases of the learning cycle. According to Kolb, these

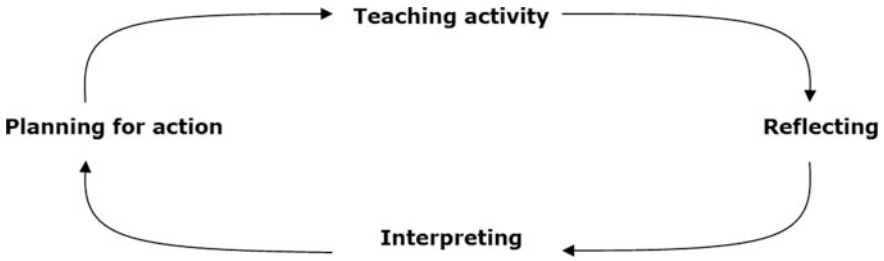

Fig. 76.3 Four stages of Kolb's experiential learning cycle. *Source* Kolb [3]

learning styles are the product of two pairs of variables, and they are *doing with watching, thinking and feeling*. Each phase of Kolb's ELC can be mapped to these variables. Everyone has a preferred learning style, but everyone will react to various learning styles to some extent and need stimulation [5]. Kolb's ELC offers the opportunity to complete each learning style, and a specific stage may match one's learning style preferences. Some of the criticisms of Kolb's model are that learning does not usually occur in consecutive, ordered steps, but that the steps overlap [6]. However, these criticisms are not sufficient to exclude the contributions from Kolb's model. Therefore, this paper adopted Kolb's model as a framework to enhance students' learning outcomes in the major design project.

The framework in this project contains four stages: reflecting, interpreting, planning for action and teaching activity. (1) Reflecting: review the experience from different perspectives, e.g. from own observations and based on feedback from others; (2) interpreting: form, reform and process ideas into logical theories, coming to an understanding. Relate the ideas to the wider context, e.g. existing literature; (3) planning for action: using the new formed ideas and theories to make decisions, problem-solving and plan subsequent teaching activities; (4) teaching activity: involvement in new experiences—the doing part. Teaching here embraces all aspects of teaching such as lecturing, supervision, tutoring small groups, assessing and module convening [7].

76.2.2 Reflecting

All teaching staff agreed that both the design process and design outcome learning are equally critical for the MAJ, because good design process produces great design outcomes. We taught the module twice, in the spring semesters of 2015 and 2016, although all teaching staff exerted great efforts to provide feedback for the five design stages of student presentations (Table 76.1), the student learning outcomes worsened in 2016, evidenced by no one achieving the professional (first-class) level.

The second-year learning outcomes of the MAJ indicated that the teaching method (more student work presentations) we applied in 2016 was problematic. After carefully reviewing each student's design process, we determined that over the course of the sixteen-week project (divided into five small design projects) students only had approximately three weeks between two design stages. Thus, although we provided more oral and written feedback, students did not have time to refine their designs and simply copied their draft sketches for the final designs.

The MAJ is a project-based module in the design studio for students' final semester study and is the final project of the Bachelor of Engineering degree programme. As noted earlier, this module comprises one project, which develops and later showcases the design skills of the students at the end-of-course exhibition. Through practical design work, the students grapple with the problems of managing various constraints and producing cohesive design proposals. Moreover, the project provides students with details about design solutions and the manufacturing of their product.

We collected student feedback through the 2015 and 2016 SET/SEM surveys and a series of interviews. Three students who had already graduated volunteered to participate in the interviews. Notably, we found some correlations in the SET/SEM responses; for example, both of the SET/SEM received a *neutral* score in 2015 and an *agree* score in 2016. As discussed earlier, the module requirements are very challenging for students because they need to (1) resolve complex problems as part of an open design brief, by employing the skills and knowledge they have gained from the programme; (2) demonstrate their ability to design a product, considering all aspects of its requirements in detail; (3) manage a complex and substantial design project over a lengthy period of time; and (4) present complex ideas, products and systems in an appropriate way, suitable for the target audience and correctly formatted.

Most students complained that they did not have enough experience to choose their design topics. Unlike other modules, lecturers provided the design briefs so that inappropriate topic selections resulted in less successful design outcomes and marks; however, even after selecting a suitable topic, students were still required to determine an appropriate solution using 3D forms to solve the problems they had defined in their research. Overall, students appeared to be unsatisfied with this learning experience. Additionally, based on SET/SEM comments from 2015, more design critiques during the design processes were encouraged. In response, we increased the number of design critiques from two (mid-review and final-review) to five and provided more staff feedback; on this portion, students' satisfaction levels increased slightly in 2016.

To further improve our teaching methods, four questions were asked during the interview.

Q1: Did you find that our teaching plan (research → sketching → sketch models → CAD modelling → prototype → poster → design report → final presentation → design exhibition) encouraged you to focus on the design process and to achieve superior design outcomes, or do you think students should choose their own ways to complete the projects because different design topics require different methods?

Students A and C stated that the strict teaching plan was appropriate and helped them to manage their time, whereas Student B suggested that it could be optional for students to choose their own methods. They all agreed that students with more design experience should be allowed to develop their own design processes, but that students with limited design experience should follow the assigned teaching plan. In addition, Student A provided some constructive comments for improving the design stages, especially in the early design phase:

> Before research, the students should define their own brief: what problem they want to solve? This problem should be better described in one sentence; a good topic should be brief and clear. (student A)

> Our research phase is lack of effective methodology. Some students did it too general (simply conduct on-line survey on the particular question they've already knew/expected the answer) some too specific without proper summary or categorise the user. (student A)

Q2: Did you find that meeting different tutors helped you receive more useful feedback on your design project, or would you have preferred the more traditional route of one supervisor who guides you throughout the design process?

All the students agreed that the feedback from various tutors was helpful. However, Student A also recommended that every student selects one tutor to be a primary supervisor, because too many directions from different tutors can sometimes be confusing. Student B thought that receiving several different suggestions from supervisors would help the students to develop their critical thinking skills:

> They should have the ability of analysing the feedbacks, pick up the useful suggestions. For the suggestions that they do not agree with, give the reasons. (student B)

Q3: Did you find that a formal review and mark at every design stage was useful in terms of time management, or would you have preferred a review and mark only at the final presentation stage?

All the students agreed that a mark at every stage was better and fairer. However, they also suggested that the proportion of marks should be adjusted for different design stages, with the final stage being worth the most marks.

> For an industrial designer in commercial world, design process (especially marketing research) is as important as the final result. A good research with accurate product positioning always leads to a good design solution. While 60% mark in the final stage ensures that students will always need to refine their design, to the end of project instead of making no improvement in the late stage. (student A)

The reflections from staff and student perspectives have been useful for identifying several areas that could be further improved. In particular, we discovered how various strategies for assessing the design stages may impact students' final design outcomes and their learning experiences.

76.2.3 Interpreting

In this section, we focus upon two aspects of my teaching plan that arose from the reflecting stage: the purposes of using different design media and applying strategies for design critiques.

First, we reviewed the relevant literature related to design to make sense of our reflections and to improve teaching quality. Contemporary design practice encompasses a range of visual representations, including sketches, CAD models, manually sketched models and physical models. Designers use these media for multiple purposes, such as to create artefacts that reduce cognitive load or as triggers that facilitate the communication of ideas and exploration of design problems. Romer et al. [8] found that the two most frequently used design media in both the design industry and design schools are sketching and CAD modelling. Sketches are ambiguous but allow designers to explore alternatives, while CAD models accurately specify the dimensions of objects and their relationships with each other. When Ibrahim and Rahimian [9] compared traditional sketching, CAD modelling and mixed media (combined sketching and CAD modelling) to assess their influence on design cognition and activities, they found that mixed media design environments improved the quality of the design process, as well as the quality of the ultimate product design. Based on these findings, we recommend that students adopt mixed media to generate their solutions and produce better outcomes; moreover, with this strategy, we will not need to ask students to complete individual sketching and CAD modelling presentations in the MAJ 2017.

A creative design process is optimally defined by its output; as scholars, and the interview results herein, have indicated creative design processes produce great design outcomes [10]. Teaching student's creative design processes is a common goal of most product design courses worldwide, and therefore, having a complete understanding of the processes that lead to creative designs is of great interest to academics, designers and design researchers. In earlier descriptions of creative engineering design, Buhl [11] described design as a linear sequence involving the following steps: (1) preparation, (2) synthesis, (3) analysis, (4) evaluation and (5) presentation. Similarly, Isaksen et al. [12] described the creative approach to problem-solving as a linear sequence of (1) framing a problem, (2) exploring data, (3) generating ideas, (4) developing solutions and (5) appraising tasks.

The development of creative design processes was traditionally viewed as a sequence of activities that began with the formulation of a problem, leading to the synthesis of solutions [13]. However, design problems are often ill-defined [14], meaning that there is no definitive formulation for the design outcomes. Thus, creative designers must constantly generate design alternatives to redefine uncertainties. In practice, a designer develops and redefines both the formulation of a problem and his or her ideas for solutions, iterating between the design processes and requirements until the final outcome is achieved. According to our discussion about students' learning experiences and the design critiques in 2016, students' design processes were linear, which results in less creative design outcomes. One

strategy for adopting a suitable design critique to address this problem was encouraging students to consider our design feedback for refining their previous designs, because creative design requires fluctuation between design problems and solutions.

Research in cognitive psychology has revealed that uncertainty is central to solving complex problems [15]. Indeed, uncertainty is essential in the earliest stages of problem-solving because how a problem is initially discovered and structured is a vital precursor to its solution [16]. Design tasks are particularly concerned with ill-structured or wicked problems, because the solutions are unknown throughout the design process; thus, exploring different ideas under uncertain conditions is a natural occurrence and uncertainty becomes a tool to help a designer explore alternatives. During the early design stages, a designer also engages with the iterative design process of evaluation to gain valuable insights into the boundaries of the original problem [17]. This echoes Student A's response to the first interview question: '…*Some students did it too generally (simply conducted online survey on a particular question they already knew or expected the answer to)*…'. In short, the proper MAJ brief must contain some uncertainty to produce design alternatives; otherwise, students may merely reproduce one idea for their final designs. To avoid this situation, we would suggest that students present their potential topics during the first design review. Subsequently, all of the staff's oral and written feedback will be provided and, guided by that feedback, students can make informed choices of topics.

76.2.4 Planning for Action

In this section, we provide an overview of a refined MAJ teaching plan for use during the 2017 module based on a reflection of our experiences, the input from students and the ideas described in the literature. The aim of this project is to enhance students' design outcomes through suitable design critiques and marking criteria. Too many design critiques may deconstruct the major design project into several small design projects which curtail the students' time to consider our feedback. To provide more time for the students, the subsequent timetable identifies three possible design critiques: research insight and design thinking, 1:1 sketch modelling, and design outcome, and a timeline for their implementation (Table 76.2).

Table 76.2 Timetable of design critiques for MM3MAJ in 2017

Critiques	Design stages	Dates
1.	Research insight and design thinking	23 Feb 2017
2.	1:1 sketch model	6 Apr 2017
3.	Design outcome	18 May 2017

Table 76.3 Marking criteria for research insight and design thinking

Criteria	Research insight and design thinking	Percentages (%)
1.	Propose design problems	10
2.	Potential design solutions	10

In 2016, we found that giving students only a few weeks to complete their sketching presentations was insufficient. They were not connected to their topics, and many students eventually modified their topics or changed design directions. Based on the findings [17] and as discussed earlier, the creative design process must oscillate between the design problem and solution; in short, students need to present their topics and potential solutions at the same time (Table 76.3), a problem that requires more time to accurately flesh out. Using mixed media (both sketches and CAD models) [9] to develop the concept solutions is also recommended, because it has been demonstrated to help designers to achieve better design outcomes.

We also suggest adding a marking criterion for students who address staff's comments about refining their projects, because this is particularly beneficial (Table 76.4). All the staff agreed that 1:1 sketch models play a key role in product design because they enable users to test ergonomics and confirm working principles before mass production.

As suggested by Student A, we propose that the design outcome presentation weigh 60% of the total 60-credit module mark (Table 76.5), which reflects the assumption that students do and should expend more effort on their final design. Novel ideas implemented throughout the designing process are encouraged; however, the students must also prove that the final design fully and appropriately solves the topic.

Table 76.4 Marking criteria for 1:1 sketch model

Criteria	1:1 Sketch model	Percentages (%)
1.	Address staff's comments by refining and improving previous designs	10
2.	Solve problem using 3D physical models	10

Table 76.5 Marking criteria for the design outcome

Criteria	Design outcome	Percentages (%)
1.	Address staff's comments by refining and improving previous designs	10
2.	CAD model rendering	10
3.	Manufacture details	10
4.	Design creativity	10
5.	Poster design for exhibition	10
6.	Design report	10

Table 76.6 Three-year student learning outcomes

	2015	2016	2017
Student no.	20	17	25
Average mark	64	59	63
Standard deviation	7.2	9.8	12.1
No. of first class	4	n/a	3

76.3 Results of Teaching Activity and Conclusions

We were excited to present a refined teaching plan for MAJ and were confident that it facilitated a superior learning experience and improved design outcomes from students' learning (Table 76.6). Three MAJ students reached the first class design outcomes in 2017. Their project topics are called GreenBox, Fidget Pen and OneWork. This framework proved that Kolb's experiential learning cycle is useful to enhance students' learning outcomes for the major design project because students can focus on potential design topics and have enough time to refine their final designs based on staff feedback. The different design tools such as sketching or CAD modelling can use at any time as long as they can progress their design processes. The ethical application of the project has been approved by the university research group.

76.4 Acknowledgements

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