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Integrating a Cross-Reference List and Customer Journey Map to Improve Industrial Design Teaching and Learning in "Project-Oriented Design Based Learning"

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Abstract: To train students' practical ability in design, enterprise projects are often introduced into the industrial design courses of Chinese universities. However, such project-oriented learning activity (POA) is often not well designed. This not only makes it difficult to improve learning effectiveness, but also may bring the unpleasant learning experience to students. The learning experience and learning effectiveness are equally important, and they are mutually conditional and complementary. To consider both, POA needs to be elaborately designed. To this end, a variety of mature POA organization forms, such as project-based learning (PBL), design-based learning (DBL), and project-oriented design-based learning (PODBL), are discussed firstly. PODBL integrates and inherits the advantages of other learning models, and it has been preliminarily proved to improve the learning effectiveness of engineering design courses. Therefore, a cross-reference list was proposed for upgrading POA to PODBL. A lamp design course was developed based on this checklist and students were organized to study. The customer journey map tool was used to analyze the learning experience of students in the course journey, and the emotions and pain points were obtained, as well as some critical factors leading to a positive learning experience. Finally, to demonstrate the availability of the cross-reference list and critical factors, a baby strollers design project course was developed and participants were interviewed. The results show that the cross-reference list and critical factors could improve learning effectiveness and enhance the learning experience significantly.

Keywords: project-oriented design-based learning (PODBL); design-based learning (DBL); industrial design; project-based learning (PjBL); customer journey map; service design

1. Introduction

In order to improve the teaching level of the industrial design department and to train the students' design practice ability, Chinese teachers often introduce enterprise projects into the classroom and carry out research on them. These research projects can be put into two categories. The first is the reflective research based on practice. For example, Sun et al. (2015) discussed the process of introducing the project into the classroom based on the teaching case of garbage bin design [1]; Chen (2017) explored the methods, contents, and evaluation criteria of introducing an Internet music product project into the interface course [2]. The second is the comparative study on the organizational form of project teaching. For example, Li (2016) compared several project-oriented teaching modes in an industrial design classroom [3], and Jiang et al. (2015) discussed the project-based, interdisciplinary, and cooperative teaching mode [4].

The above project-based teaching activities and research were far away from the pedagogical discourse system and had not been supported by pedagogical theories and methods. This may be related to the fact that the professional teachers in the industrial design department have generally not received professional teacher education [5–7]. As a result, these teaching activities were often poorly designed. Wang (2019) referred to such activities as "project-oriented learning activities (POA)" and pointed out that they often take work output as the main goal [8], which deviates from the original intention of cultivating students' practical ability. Sometimes, they are also too limited by the time limit of a project, thus hindering students' exploration of real problems [9] (Fan and Xia, 2018). In a word, with current the POA in industrial design courses, it is difficult to improve the learning effect and may also bring unpleasant learning experiences to students. Therefore, the relevant issues need to be further studied in the context of pedagogy.

In pedagogical research, learning experience and learning effectiveness are equally important, and they are mutually conditional and complementary [10,11]. A pleasant learning experience can enhance the willingness to learn and make learning activities more sustainable and effective. In addition, addressing students' learning experiences in the evaluation of teaching quality can also better provide appropriate feedback for teaching improvement [12], thus improving students' learning effectiveness. The self-confidence and sense of achievement that results from learning effectiveness can also enhance the overall learning experience. To give consideration to both learning effectiveness and learning experience, POA needs to be meticulously designed.

In order to improve learning effectiveness, universities in Europe, America, and Australia have developed many widely recognized learning models, such as "problem-based learning (PBL)", "project-based learning (PjBL)" and "design-based learning (DBL)" [13–15]. Furthermore, problem-based learning, project-based learning, and design-based learning are integrated into "project-oriented design based learning (PODBL)" [16]. It is a project-oriented learning model that incorporates design activities through projects, and its effectiveness in engineering design education has been preliminarily verified [17,18] (Joordens et al., 2012; Chandrasekaran et al., 2014). According to Puente et al. (2011), the core of DBL in project-based environments is "the design of artifacts, systems and solutions" [19]. This is highly consistent with the research object "product, system, service and experience" of industrial design [20] (ICSID, 2015). Therefore, it can be considered that the application of PODBL in the teaching of industrial design should help to improve the learning efficiency.

Compared with the research on learning effectiveness, there is not so much research on improving learning experience. Jason et al. (2005) found that the combination of online and offline mode (blended e-learning) can improve students' learning experience more than complete distance learning or traditional classroom learning [21]. Maureen (2010) confirmed that podcasts can be used to provide effective formative feedback and enhance the learning experience of most students [22]. Awidi et al. (2019) found that refinements of components of the flipped design may further enhance the student learning experience in this flipped course [23]. Other similar studies also focused on the learning experience of online courses [24,25]. Although these studies provide ways to improve learning experience from different perspectives or stages, they have not yet clarified the definition and evaluation criteria of learning experience, nor put forward methods to improve learning experience based on the whole learning process. Therefore, it is difficult to improve learning experience of students in POA based on the above research. Hu et al. (2015) pointed out that the definition of learning experience refers to learners' perception, response, and behavior performance of many elements involved in learning process [26], such as learning environment, learning activities, and learning support services.

Oliver et al. (2008) and Zerihun et al. (2012) further studied the evaluation of learning experience [11,12]. According to their research, the student learning experience evaluation can be carried out from five aspects (Figure 1). These five aspects can be used to evaluate learning experience. Naturally, they can also be used as the focus on improving learning experience. In summary, in order to improve the student learning experience in POA, these five aspects are worthy of attention. In addition, it is necessary to investigate the whole learning process with the help of systematic experience design tools.

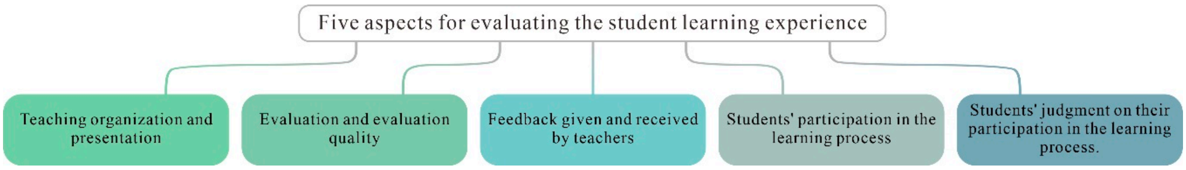

Figure 1. Evaluating learning experience.

In order to improve the learning effect and learning experience of industrial design courses simultaneously, a cross-reference list was proposed to facilitate POA upgrading to PODBL. A lamp design course was developed, and students were involved to analyze their experiences. The educational activities can be viewed as a service in their own right, and a customer journey map is the most commonly used visual experience design tool in the field of service design [27,28]. Hence, a customer journey map was used to analyze the behavior, emotion, and pain points of each stage of the lamp design course. The five aspects for evaluating learning experience proposed by Zerihun et al. (2012) were integrated into the customer journey map [12]. Finally, to demonstrate the availability of the cross-reference list and critical factors, a baby stroller design course was developed based on these factors and participants were interviewed. There are various pedagogical models to educate students to be an engineer, educator, economist, and scientist who is capable of facing the global problems articulated by the United Nations' 17 Sustainable Development Goals (SDGs). The PODBL model focuses on learner-centered, outcome-based, collaborative expertise knowledge curation for students during their learning process. The PODBL is underpinned by an explicit set of principles including sustainability through practice, which aligns with the SDGs at an organizational and individual level. By integrating a cross-reference list and a customer journey map to improve industrial design teaching and learning in PODBL, this research study explored the necessity of learners' sustainability in their learning process and how it helps their future.

The project-oriented design-based learning (PODBL) enhances positive effects on student content knowledge and their development of skills such as collaboration, critical thinking, creativity, innovation, teamwork, and problem solving. It is a challenging task for academic staff to implement a PODBL approach and integrate technology into projects in meaningful ways. PODBL creates a study environment that involves not only learning scientific knowledge and technological skills, it also involves learning the knowledge, established practices, beliefs, and professional values of the engineering culture that makes a student an engineer. The PODBL-unique learning principles, such as research-based learning, student-driven learning, outcome-based learning, analytical thinking, and collaborative-based learning, are constructively aligned and underpinned by constant engagement between the students, staff, community, industry, and government.

The rest of the paper is arranged as follows: in Section 2, the history and connotation of problem-based learning, project-based learning, design-based learning, project-oriented design-based learning, and customer journey map are reviewed. In Section 3, a cross reference list and a customer journey map containing critical factors leading to a positive learning experience are presented. In Section 4, the teaching experiment case is provided. Sections 5 and 6 are discussion and conclusion.

2. Literature Review

2.1. Problem-Based Learning and Project-Based Learning

Problem-based learning (PBL) originated from the teaching reform in medical schools of some North American universities in the 1950s and 1960s. At that time, teachers doubted the effectiveness of the traditional curriculum of "basic knowledge learning" plus "clinical practice". The Western Reserve University and McMaster University pioneered teaching reforms in their medical schools. Those educational institutions tried to put students in real situations related to medical practice from freshman year, where PBL was generated [29]. In 1972, Maastricht University introduced PBL and expanded it from the medical school to other departments [15,29]. In recent years, the concept of PBL has been constantly supplemented, developed, and improved. However, the core of PBL has not changed, where it is a student-centered learning method that emphasizes constructing knowledge and developing ability through cooperation and exploration in real situations.

Project-based learning (PjBL) is an inquiry-based learning pattern widely used in Denmark, the United States, the United Kingdom, Australia, and other countries. It was developed by rethinking the learning process [15]. It was first practiced in Roskilde University (1972) and Aalborg University (1974) [30]. It is generally believed that the theoretical basis of PjBL is the constructivism theory of learning [31], the pragmatic education theory [32,33], and the discovery learning theory [34]. When PjBL is implemented, the traditional teacher-centered instilling teaching mode is abandoned, and the student-centered and inquiry-based learning mode is advocated. Moreover, compared with the traditional education model, both PjBL and PBL pay more attention towards "what students learned" rather than "what teachers taught" [35]. However, there are also obvious differences between PjBL and PBL. The most typical difference is that the application of knowledge is emphasized in PjBL pattern, while the acquisition of knowledge is emphasized in PBL pattern [35]. In addition, in the PjBL pattern, special attention has been paid to the project. On the one hand, students complete the learning process and improve the learning effect by participating in projects [36]; on the other hand, teachers need to choose good projects and provide learning scaffolding to help students explore problems, build knowledge, and improve their competence [35].

PBL and PjBL are often combined as POPBL, which refers to problem-oriented and project-based learning [37,38], while others refer to project-oriented and problem-based Learning [39,40]. In recent years, more researchers have used PBL to cover these two learning patterns (problem-based learning and project-based learning), who have argued that PBL is a problem-based, project-organized learning method [14,41–43]. To avoid confusion, this article continues to use the abbreviations PBL and PjBL, respectively. In fact, after years of development, PjBL now generally contains a challenging and open driving problem (or question) [8].

2.2. Design-Based Learning

Design-based learning is a teaching and learning approach similar to problem-based learning [19]. Kolodner et al. (1998) first proposed the concept of "learning by design" and then further proposed a "learning by design's cycles" model [44,45]. Later, Nelson (2004) further proposed design-based learning (DBL) [13]. His "design based reverse thinking learning model" has been widely used in primary and secondary education in the United States in recent years, and its effectiveness has been recognized [46]. However, the experience of primary and secondary schools cannot be directly applied to higher education [19].

In higher education, Eindhoven University of Technology was the first institution to introduce DBL, which integrated the PBL model from Maastricht University [47] and the problem-oriented and project-based learning model (POPBL) from Aalborg University [19,48]. DBL inherited some of the main principles of PjBL and PBL, such as being "student centered", "problem driven", "project organized", and "providing scaffolding where appropriate" [8,49]. Singapore University of Technology and Design is another one of the universities to have integrated DBL into teaching. It proposed a system consisting of four layers of design. The first layer is design in a course; the second layer is the design between courses; the third layer is designed to span different majors and grades; and the fourth layer design is the full simulation of extracurricular practice [50]. It can be seen that DBL not only refers to the students' learning through exploration and design in the project, but also includes the design of the whole school's teaching system and learning process.

Similarly, the School of Engineering at Deakin University has further developed the DBL concept with a new curriculum model named project-oriented design-based learning (PODBL). Through this model, design and project became the basis of its undergraduate course, replacing the traditional approach based on textbooks, lectures, and exams [13,51,52]. PODBL consists of seven steps: (1) problem/project presentation; (2) identification of learning issues; (3) individual/team research; (4) design development; (5) modeling or building; (6) testing or evaluation; and (7) product delivery. Among them, 5 and 6 can only rely on local learning, while other steps can rely on cloud (off-campus) learning and local (on-campus) learning [51]. It can be said that PODBL is a learning method integrating PjBL and DBL, and a teaching mode suitable for industrial design courses.

2.3. Customer Experience and Customer Journey Map

Customer experience was first valued in the field of marketing [53]. In the early stage of development, customer experience research was obviously influenced by early consumer decision-making process models [54,55]. These models generally studied all stages of a consumer's experience, such as problem identification, search, purchase, and after-sales use [56], also known as "pre purchase stage: customer decision journey" [57], "purchase stage: customer purchase journey" [58], and "post purchase stage: customer use journey". These provided the foundation for thinking holistically about the customer experience [55].

Subsequently, customer experience has been further developed in the field of Internet product design and service design. Many mature visual customer experience design tools have also been developed and widely used, the most famous of which is customer journey map. The basic matrix structure of the customer journey map was first constructed by Shaw. Its horizontal structure is customer behavior process, the vertical structure is customer experience content, and the middle structure is customer experience in each stage of the behavior process [59]. In recent years, the matrix structure of Shaw has been further developed. For example, the Effective UI company created a customer journey map for consumers to purchase and install broadband services in 2010, highlighting the customer's emotional experience and purchase decision-making process. It contained "customer portrait", "customer journey", "emotional experience at each stage", "suggestions for improvement", and so on. The emotional experience is represented as an emotional curve [60]. Risdon created a customer journey map for European Railway in 2011. Its typical structure was "Customer Journey + Interaction Behavior + Experience Demand analysis + Enterprise Opportunity Analysis". Multiple graphs are embedded in the analysis of interaction behavior [61,62]. Kate Kaplan (2016) surveyed 48 UX practitioners and the survey results show that the customer journey map generally includes three areas: the lens contains descriptions of users and scenarios; the experience contains each stage, as well as users' behaviors, ideas, and emotional reactions in each stage; the insights mainly refers to opportunities for improvement [63].

Although there is no complete consensus on the customer journey map, it is generally believed that the basic elements of a customer journey map include the customer journey, customer behavior, emotions, contact points, pain points, and opportunities for improvement [60] (James, 2016). Through the customer journey map, researchers can conduct systematic analysis to find out all the touch points in the whole service process, as well as the curve formed by the customer's emotional changes of each contact point and the pain points of the customer, and propose multidimensional improvement points at each touch point to improve the customer experience more comprehensively.

To sum up, PODBL is a model that can improve the learning effectiveness of engineering design, and there are a large number of POAs that have not been well designed in the industrial design courses of Chinese universities, it is a valuable thing to develop a cross reference list that can facilitate POA upgrading to PODBL. In addition, the customer journey map, one of the most popular visual experience design tools, can also be used to enhance the learning experience in the PODBL process.

3. Design Methodology

First, according to the aforementioned review on PBL, DBL, and PODBL, especially the PODBL model [16], this study emphasized the differences between general POA and PODBL from eight aspects such as "basic principle", "criteria for selecting projects", and "stage and duration of projects", and formed a comparison table (Table 1). It should be noted that the "never before seen" challenges in the Nelson model were not included [13]. This is because they were used more in primary and secondary education, but in higher education, it seems difficult to define "never before seen" challenges. In more cases, the difficulty lies not in "never before seen", but in the fact that "design" and "design evaluation" are almost ill-structured problems [64], and students need more scaffolding to solve such problems.

Table 1. A cross-reference list for project-oriented learning activity (POA) to project-oriented design-based learning (PODBL).

Items	POA	PODBL
Basic principle	In practice, students should further deepen their understanding of the theory and exercise their practical ability.	Students learn hands-on practical knowledge through projects facilitated with design activities.
Criteria for selecting projects	Authenticity.	1. Consistency (Is it consistent with the learning objectives?); 2. Authenticity; 3. Exemplary.
Stage and duration of project in the course	The project is arranged after the theory class and skill class, which is the last practice link; and the project duration is short.	The project runs through the whole learning process; the project lasts for a long time.
Learning issue	There is often no clear driving issue (easily reduced to a work-driven business).	There is one or a series of driving issue (with a clear learning problem or question) that is consistent with the teaching objectives.
Multidisciplinary cooperation	There is usually no multidisciplinary collaboration.	There is usually multi-disciplinary collaboration.
Learning scaffolding	No or very little.	Yes. Teachers/facilitators provide learning scaffolding in time.
Course evaluation criteria	Whether the product is approved by the enterprise or the customer.	1. Whether students have grown in the program. 2. Whether the product is approved by the enterprise or the customer.
Student autonomy	Students have few choices, and low sense of participation and responsibility.	Students have many choices, strong sense of participation and responsibility.

In order to verify the usability of Table 1 and explore the critical factors to enhance the student learning experience, a lamp design course was developed according to the cross-reference list. Previously, this course was the "Modular design course" of the Department of Industrial Design of Wuhan University of Science and Technology. Class CL1 (32 students) was invited to participate in the course. In addition, two teachers, two teaching supervisors, and two enterprise technicians also participated in the course [65]. The specific settings of the course are as follows:

(1) Basic principle: the subject of the course is "PODBL model: the lamp design based on modular design method". In the course, students are the center of the teaching activities and complete theoretical and practical learning by themselves. Teachers are the designers of the course, and cooperators and service providers of learning activities.

(2) Criteria for selecting projects: according to the Table 1, a lamp design project of an enterprise in Changed City, Hunan Province was selected. The enterprise has developed a cube module. The module can add bulbs, batteries or switches, and other parts. The company expects an industrial design team to design these modules into competitive lamp products. After the evaluation of the teacher team, the project meets three criteria: (1) It is consistent with the learning objectives of the original curriculum. Students can understand the principles and advantages of modular design in this activity and master the design method of modular division and modular combination. (2) It's an authentic project. (3) It is exemplary, and the experience gained from completing the project can be migrated to other modular product design activities.

(3) Stage and duration of project in the course: the project ran through the course for two months.

(4) Learning issue: the driving issue set in this project was as follows: "how to use cube as a basic module unit to design unique, creative, and competitive lamp products?"

(5) Multidisciplinary cooperation: experts from the enterprise technology department were invited to give lectures on the internal structure and connection structure of the module.

(6) Learning scaffolding: a large number of books and online literature on "modular design" were provided, as well as 3D printing equipment.

(7) Course evaluation criteria: the cultivation of students' ability is put in the first place and students have plenty of time to explore and design in the context of the project.

(8) Student autonomy:

(8.1) Students printed many cubic unit modules and developed their designs based on them.

(8.2) Students set their own design theme and style, and designed a series of works (Figure 2).

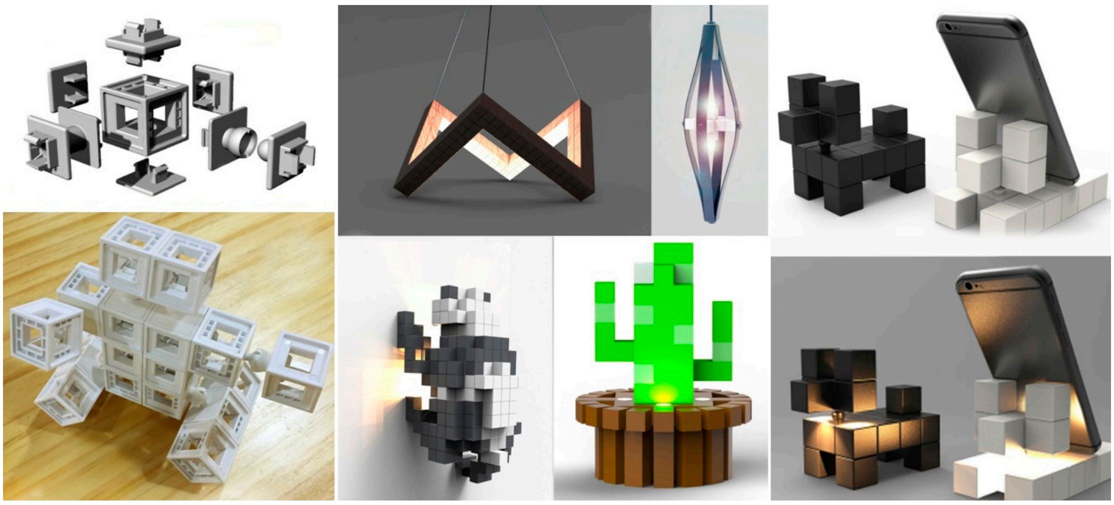

Figure 2. Basic module unit and some design works of modular lamps.

At the end of the course, each student was interviewed for about 20 min. The interview included two open-ended topics: (1) In the seven stages of PODBL, which instructional design makes you have a positive experience? (2) Which instructional design makes you have a negative experience? Next, students, teachers, and experts from the enterprise further discussed the key factors that might eliminate negative experiences and lead to positive ones. Finally, all the factors were sorted out and the student learning journey map was drawn. In the map, the factors that lead to a negative experience were marked in magenta. For critical positive factors, those related to five aspects for evaluating learning experience (Figure 1) were marked in yellow, while others were marked in black (Figure 3). In addition, some specific suggestions have also been adopted, such as online pre-lecture assignments, because those could ensure that students would have already had exposure to and critically thought about the material to be expanded upon during class or lab sessions [66]. These critical positive factors were initially accepted by students. Finally, the importance of these factors was qualitatively represented by the vertical height in the figure.

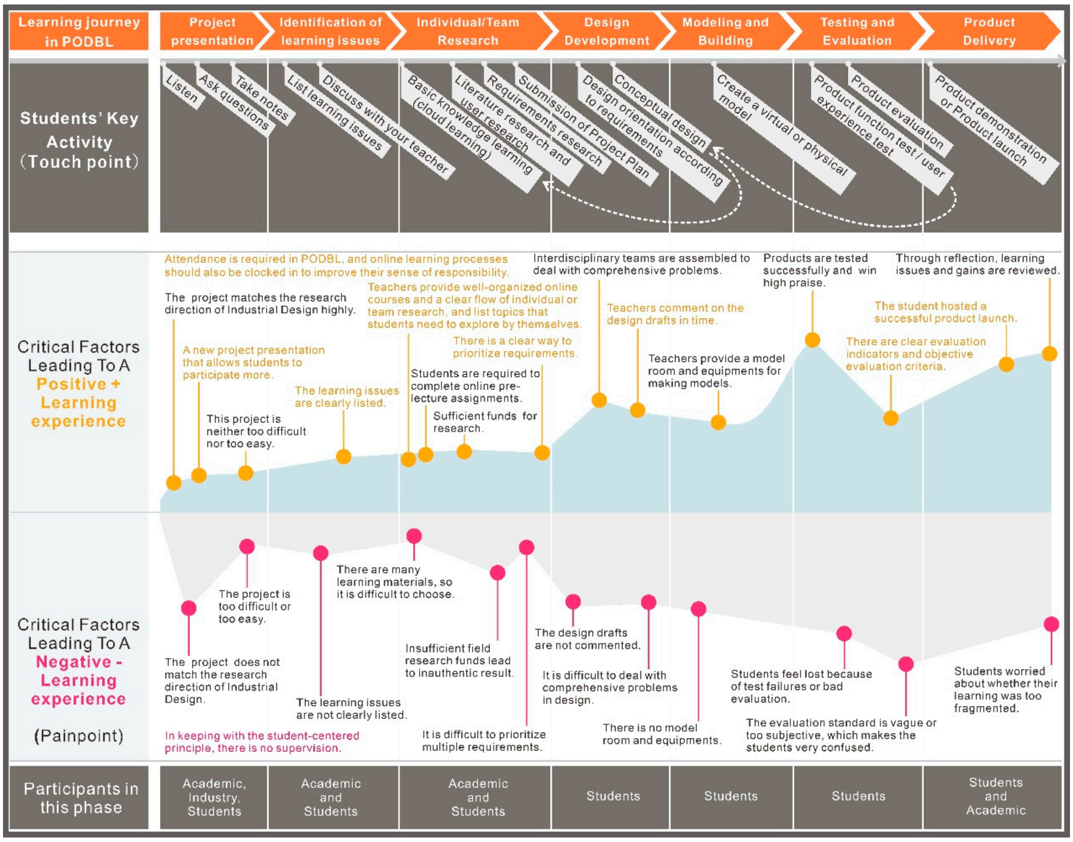

Figure 3. Students' learning journey in PODBL.

It should be noted that what we need to improve is the overall experience, not the experience of a single touchpoint. Even if people are satisfied with each touchpoint, they may not be satisfied with the whole journey [67]. That is to say, not every negative experience needs to be addressed. Some negative experiences may be necessary in the learning process, for example, people may feel confused due to the lack of creativity or feel lost after the product test fails. These negative emotions maybe not bad things. Sometimes it can stimulate students' morale. In other words, we were mainly trying to find out the negative experience caused by the problems of education service itself and sought suggestions for improvement.

4. Case Study of Teaching Experiment

4.1. The Design of Teaching Experiment

The design of the teaching experiment is referred in Table 1 and the critical factors leading to positive learning experience in Figure 3 can improve learning effectiveness and learning experience. Two classes CL_1 (32 students) and CL_2 (33 students) were invited to participate in the teaching experiment for a whole semester. CL_1 was the class that participated in the modular lamp course before. It should be noted that there was no significant difference in the average scores of the two classes in previous courses. In addition, four teachers, two teaching supervisors, five staff of the stroller enterprise, and one user experience designer participated in this experiment. The students in each class were divided into six teams to complete the project, with 4–5 students in each team.

Class CL2 was the control class, and its teaching followed the traditional way. The teachers first taught four courses—design research, computer-aided modeling, product design method, and product design practice. At the end of the fourth course, the teachers arranged the baby stroller design project for the students as an exercise. Students needed to complete the project within four weeks. During this period, students reported to the enterprise twice according to the development progress of the enterprise and modified and improve the design scheme according to the opinions of the enterprise.

Class CL1 was the experimental class. Their courses were redesigned according to Table 1 and the critical factors leading to positive learning experience in Figure 3, as follows:

(1) Basic principle: the four courses taught by teachers were integrated into one student-centered course, which was called "PODBL course: the baby stroller design based on the real-life scenario".

The critical factors leading to a positive learning experience: teachers recorded teaching videos of the theoretical and technical courses and uploaded them to the cloud platform of the campus network. This was convenient for students to study independently and watch repeatedly. In addition, whether online or offline courses, attendance was also required, and students should complete some corresponding homework.

(2) Criteria for selecting projects: a baby stroller design project was selected. The project was a real development project of an enterprise in Hanchuan City, Hubei Province. After the evaluation of the teacher team, as the stroller design is a common product, it was an exemplar. In addition, to complete this project, the ability (competence) that students have was basically consistent with the teaching objectives of the above four courses, which included: (1) students can grasp the methods of user demand research and analysis; (2) students can master a 3D design and rendering software; (3) students can master the process and general method of product design; (4) students can learn the evaluation method of product scheme; (5) students can learn the basic process and method of product exhibition layout.

The critical factors leading to a positive learning experience: The baby stroller design project highly matched the industrial design professional direction and curriculum learning objectives and the difficulty of the project was moderate.

(3) Stage and duration of project in the course: the project ran through a semester, replacing the original four courses.

(4) Learning issue: the driving problem of the project was as follows: "How to design a competitive baby stroller with unique creativity, beautiful shape, convenient folding, and considering the manufacturability and recyclability in a competitive environment around the real user requirements?"

The critical factors leading to a positive learning experience: The driving questions were clear and could gather participants' attention.

(5) Multidisciplinary cooperation: In addition to the students of the Department of Industrial Design, two graduate students from the Department of Mechanical Engineering were invited to assist all teams in completing the design of mechanical moving components. Moreover, an IBM user experience designer was invited to participate in the testing and evaluation of products.

The critical factors leading to a positive learning experience: compared with the previous lamp design projects, people from other disciplines were more involved, especially in the specific design stage.

(6) Learning scaffolding:

(6.1) In the early stage of the project, the teachers recorded the course "IDEO design thinking" to explain the design process for the students. In addition, the teachers also guided the students to observe and study the behavior of people using the stroller in their life;

(6.2) After the requirements were listed, the teachers explained the M-S-C-W method and the KANO method to help analyze the requirements. Students were encouraged to compare the advantages and disadvantages of the two methods and chose them reasonably;

(6.3) The exhibition site and 3D printing equipment were provided.

The critical factors leading to a positive learning experience: Supports were provided at all stages. In addition, the exhibition also stimulated the enthusiasm of students (Figure 4).

Figure 4. PODBL course: the baby stroller design based on the real-life scenario.

(7) Course evaluation criteria: This activity put the ability training of students in the first place. Students had plenty of time to explore and design in the context of the project.

(8) Student autonomy:

(8.1) The students identified the scene of using the stroller through literature and field research. For example, they looked for young parents with children in residential communities, and then investigated their needs through various methods;

(8.2) The students visited the stroller factory and were familiar with the manufacturing process;

(8.3) Students designed and stated their own plans;

(8.4) After the design, students made models and displayed boards, and arranged a baby stroller design exhibition. Some young mothers and managers of the baby stroller enterprise were invited to visit and give opinions. These opinions also stimulated students to reflect and modify their designs.

The critical factors leading to a positive learning experience: the conditions for making the model and detailed product evaluation criteria were provided. The people involved in the evaluation design were diverse, including real users, manufacturers, and marketing staff.

4.2. The Evaluation of Learning Effectiveness/Learning Experience

Learning effectiveness is mainly evaluated by learning output and ability cultivation, while learning experience is mainly evaluated by making a questionnaire based on five evaluation elements of students' learning experiences [12]. Four types of participants, or shareholders, were interviewed. Some questions needed to involve several types of people, while others only focused on one type of person. All interview questions are shown in Table 2.

Table 2. Questionnaire and participants.

Objectives	Questions	Participants
Availability of Table 1	1. Is Table 1 easy to understand?	Teachers
	2. According to Table 1, is it easy for a POA upgrade to a PODBL?	Teachers
Learning effectiveness	3. Is the overall design level of students' works in the experimental class better than that in the control class?	Teaching supervision, enterprise personnel
	4. Compared with the control class, does the experimental class improve students' ability more significantly? If so, which of the following? (please select four or less) (A) Autonomous learning ability (B) Ability to solve design problems (C) Interdisciplinary communication ability (D) Expressive ability (E) Project management capability (F) Prototype testing capability (G) Critical thinking	Teachers, the students in the experimental class
Learning experience	5. Is the learning experience of the PODBL course (stroller design) better than that of the traditional design course?	The students in the experimental class
	6. Is the learning experience of the stroller design course better than that in the lamp design course?	The students in the experimental class
	7. Is the teaching organization of the stroller design course more attractive than the traditional one?	The students in the experimental class
	8. Is the presentation of the stroller design course more attractive than the traditional one?	The students in the experimental class
	9. Is the design evaluation objective and fair in the stroller design course?	The students in the experimental class
	10. Compared with traditional courses, did students put forward more questions during the course of stroller design?	Teachers
	11. In the process of supervisors' observation, were the total number of offline interactions between students in the experimental class significantly higher than that in the control class?	Teaching supervision
	12. In the course, you may be an audience member, participant, or moderator. What proportion (such as 10% to 100%) can they account for respectively?	The students in the experimental class, the students in control class

5. Discussion

After sorting out the interview data, the following results were obtained.

All six teachers pointed out that, in general, the transformation list in Table 1 was easy to understand and also made it easier to transform POA into PODBL. Some teachers claimed that the "student-centered" principle in PODBL was very similar to the "user-centered" design principle, and that the "participatory learning" mode emphasized by PODBL was very similar to the "participatory design" mode widely spread in the design industry in recent years. These made it very easy for industrial design teachers to understand PODBL. One teacher pointed out that his previous understanding of students' participation in the classroom was just "question and answer" interaction. Through these PODBL courses, he has a deeper understanding of participatory learning.

The results of the interview on learning effectiveness included the evaluation of learning outcomes and the views of teachers and students on the ability cultivation. Two teaching supervisors and five enterprise personnel rated the students' stroller works, giving 1–5 points, and the works and raters were anonymous. After removing the extreme data, the average value was calculated. The total average value of the 24 works in the control class was 3.7, while the total average value of the 24 works in the experimental class was 4.1. The distribution of the scores of each group in each score segment is shown in Figure 4. In view of "PODBL has significantly improved students' ability", teachers have given priority to (A), (B), (C), and (E). Students chose (A), (B), (C), and (D) more (Figure 5). According to Figures 5 and 6, PODBL significantly improved learning effectiveness.

In the interview of learning experience, most people thought that the learning experience of PODBL is good. In total, 90.6% of students thought that the learning experience of PODBL was better than that of the traditional course, and 84.3% of students thought that the learning experience of the baby stroller course was better than that of the lamp design course. Additionally, 78.1% of the students pointed out that the teaching organization of the PODBL course was more attractive than the traditional course; 87.5% of the students thought that the presentation of the PODBL course was more attractive than the traditional course. Overall, 96.9% of the students thought that the evaluation of the design results of the PODBL course was very objective and fair. All the four teachers agreed that the students put forward more questions in the PODBL stroller course, thinking and designing more actively. This was consistent with the records of feedback of teaching supervision and students. The teaching supervisor listened to one course, respectively, in the design development/design practice stage of the experimental class and the control class, and counted the number of interactions between teachers and students. Teachers and students interacted 67 times in the experimental class and 38 times in the control class. When students evaluated the proportion of class time as an audience member, participant, and moderator, the results of the two classes were as shown in Figure 7. It was obvious that students in the experimental class thought that they were more involved.

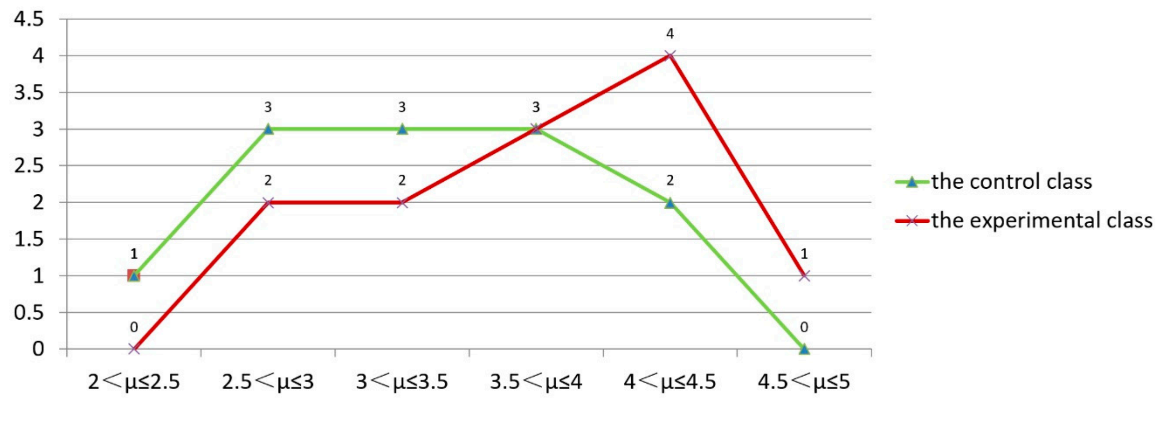

Figure 5. Score distribution.

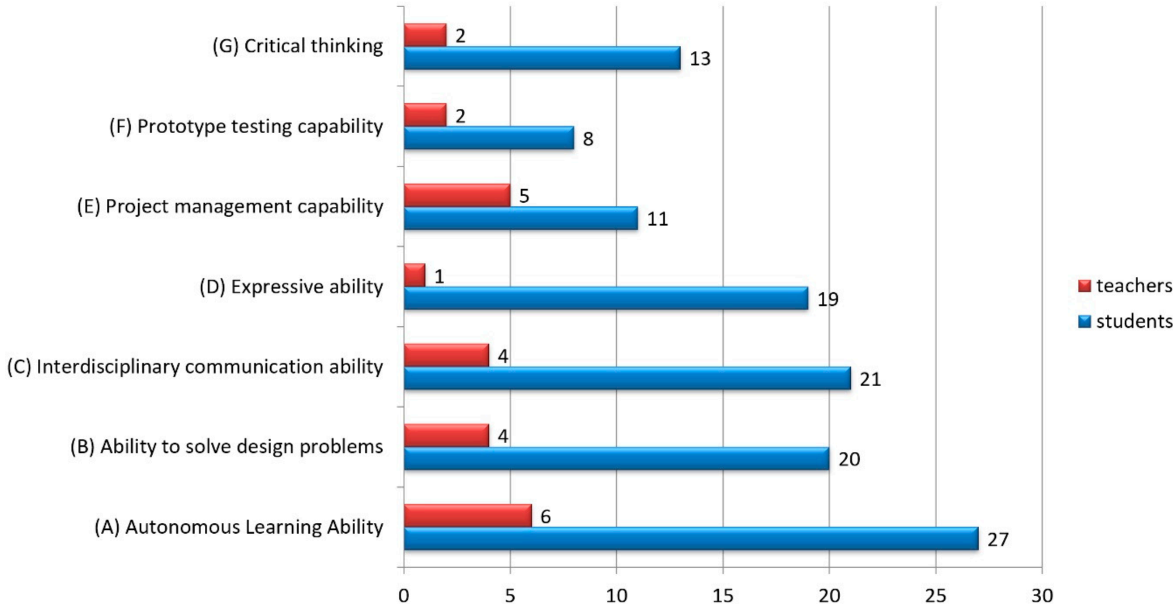

Figure 6. Teachers and students' views on PODBL cultivation ability.

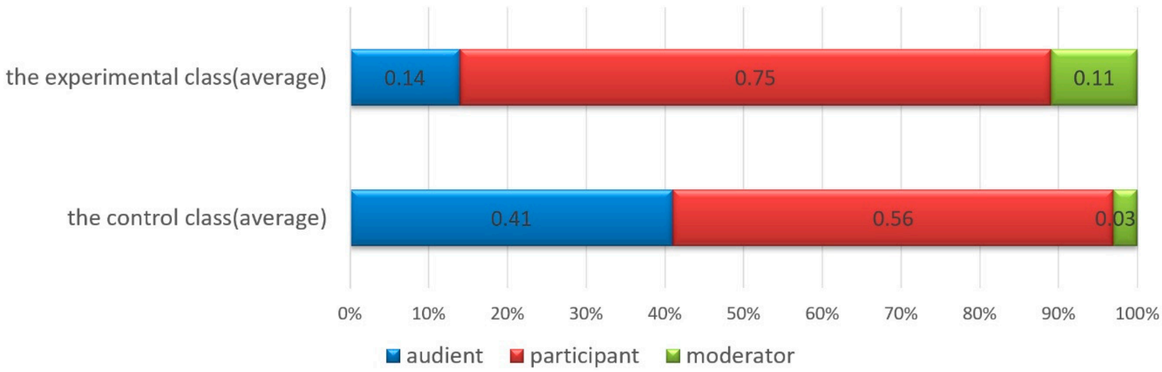

Figure 7. Proportion of time spent as audience member, participant, and moderator.

In general, the POA to PODBL cross-reference list was easy to use from the feedback of all participants. Moreover, when the critical factors leading to positive experience were adopted, the learning effectiveness and learning experiences of students in the PODBL course were better than those of ordinary courses. The learning experience was better than the PODBL courses that have not adopted these key recommendations.

6. Conclusions

In order to improve the learning effectiveness and learning experience of students in an industrial design class of China, this study analyzed the differences between POA and PODBL, and proposed a cross-reference list of POA to PODBL. Then, according to the list, a course was designed, and students were organized to study. Then, the student learning experience was analyzed by using the customer journey map tool, and the critical factors leading to positive learning experiences were obtained. These critical factors, together with the previous cross-reference list, were used to develop a baby stroller design course. Finally, through interviews with participants, it was preliminarily confirmed that they can improve learning effectiveness and learning experience.

It needs to be pointed out that the POA to PODBL comparison table proposed in this study is just a shortcut—a way to enable teachers that have not received specialized teacher education to master PODBL quickly. To further master PODBL, you need to have a certain understanding of DBL, PBL, and PODBL.

In addition, more teaching experiments and samples are needed to prove the effectiveness of the method presented in this paper, especially its effectiveness in the broader design curriculum, for example, teaching experiments can also be carried out in the IT design curriculum. In the future, in addition to popularizing this method in more classes, the research could also explore more ways to improve learning effectiveness and learning experience, such as the application of game-based learning or a persuasive design model in PODBL. This approach can lead to the sustainability of the PODBL model in enhancing the learning effectiveness of engineering design courses in order to improve the teaching of industrial design and also facilitate the students' design practice capability.

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