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Digital Transformation of Education: Design of a "Project-Based Teaching" Service Platform to Promote the Integration of Production and Education

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Abstract: The integration of production and education represents a common paradigm for vocational education development globally. In this study, project-based teaching serves as a crucial pedagogical model. However, the manifestation of this model in Chinese undergraduate vocational institutions has yet to reach the desired state of integration. The objective of this research is to advance the concept, service model, and platform framework for project-based teaching service design through empirical research by utilizing the Double-Diamond process of service design. The aim is to address service pain points for stakeholders against the backdrop of project-based teaching with the integration of production and education, thereby enhancing service qualvrtity. Five critical areas were identified, leading to the proposition of service concepts such as platforms for information communication, fund management, teaching management, auditing/evaluation management, and promotion management. The effectiveness and recommendation levels of the digital service concepts were validated via a Net Promoter Score survey involving 100 stakeholders. This research features targeted discussions and suggestions regarding a conceptual digital service platform. The five service concepts derived from this research may serve as specific digital designs for applications and evaluations of project-based teaching.

Keywords: digital service platform; integration of production and education; sustainability; project-based teaching; user-centered design; stakeholder

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1. Introduction

1.1. Integration of Production and Education

According to Etzkowitz (2004) [1], although there was a strict boundary between universities and the industrial sector in the past, today, the relationship between higher education and the industrial sector has become more direct and ubiquitous. The integration of production and education is a common research subject in international vocational education and is a common pursuit in the development of vocational education in many countries [2]. In China, the integration of production and education is a requirement for vocational education from the perspectives of industrial development and local economic development in the context of the current deep industrial transformation. Moreover, the integration of production and education can also provide strong support for the development of the connotations of vocational education and for the progress of industry and technology. It is not only that this is a scientific and practical approach to the development of talent that keeps pace with the times, but it also contains important content and provides a path for implementation in order to build a modern vocational education system in China [3].

In the integration of production and education, "production" can be understood as "production" or "learning how to do", which is an important form of practical education;

"education" refers to "educational teaching", which generally refers to practical teaching activities and content; "integration" is a requirement for the interaction between the two aspects, and this is an organic combination of "productive learning", "learning production", "productive teaching", and "teaching production". This is the fundamental requirement for combining theory and practice. The integration of production and education refers to the cooperation and fusion between the industrial sector and the educational field, with the aim of improving the practicality of education and industrial development [4]. Against this background, project-based teaching is an important organizational form that is used to implement specific collaborative projects that integrate production and education. In comparison with that in developed Western countries, higher vocational education in China has had a relatively late development, and the development of project-based teaching models has also lagged behind [5]. At present, most of the newly transformed vocational universities in China are still in the initial stage of the integration of production and education; their talent development models are still at a low level, and, thus, they have not reached the ideal state of the deep integration of production and education [6].

1.2. Project-Based Teaching

Project-based teaching is a "behavior-guided" teaching model that has been vigorously promoted in German vocational education since the 21st century. This teaching method, which focuses on "projects" and is guided by industry, is a process of organizing students to actually participate in the design, implementation, and management of projects, and teaching can be completed during the project implementation process. It is a teaching method that focuses on the professional behavior of modern enterprises, and it emphasizes the development of students' comprehensive abilities [7].

In the field of education, "project-based teaching" can be understood as an open teaching activity in which the teachers of a project team place students in a specific time and environment, and the students engage in a specific activity through their ideas, actions, and social experiences in order for their self-management abilities to be cultivated during this process. In this context, the "project" refers to the construction and growth periods of a system or task, and "project-based teaching" has the connotation of an operational mechanism built around the project cycle. One feature of "project-based teaching" is the maximization of the project objectives, which means that all educational resources should be concentrated and integrated into a single project. As the project progresses, the students become direct participants in it, grow through practice, and improve their skills and abilities. The second feature of "project-based teaching" is motivation. Universities can utilize "project-based teaching" to consolidate special funds, motivate teachers to be more dedicated to teaching and research, and use this as a starting point to enhance the enthusiasm and comprehensive development of students in the process of developing their self-management abilities. Overall, "project-based teaching" can motivate teachers' enthusiasm, promote the deep exploration and development of "project-based teaching" with full dedication from teachers, and directly improve the learning effect, knowledge mastery, and application level of students during the process. As a result, the development and improvement of students' self-management abilities can be ultimately achieved.

1.3. Research Questions

Although various universities have recognized the importance of integrating production and education and some have also explored or made breakthroughs at certain "points", the overall participation in the integration of production and education is still lacking in scale, level, and intensity. Some projects are superficial, and the quality of talent development cannot meet the requirements of industries and enterprises. Related systems and mechanisms require further improvement. Vocational universities have not established a management system and long-term operating mechanism that are compatible with the integration of production and education, and project-based teaching is still a weak point in vocational education. Notably, research investigating the actual demand for project-based

teaching and analyses of the stakeholders thereof are underrepresented, as are studies on the service pain points and deficits during the process.

Therefore, to face the challenges in project-based teaching against the background of the integration of production and education, it is necessary to explore the interests and requirements of the stakeholders and the sore points in services in a profound and systematic manner, and relevant solutions should be proposed. In this study, the main research questions are as follows:

(1) What are the interests and requirements of the stakeholders in project-based teaching?;
(2) What are the sore points in services for the stakeholders in project-based teaching?;
(3) What kind of services do the stakeholders need in project-based teaching in order to solve the existing problems?

2. Literature Review

2.1. Current Research Status of Project-Based Teaching

At present, the academic research on project-based teaching mainly focuses on three aspects.

First, there is empirical research on the attitudes and perceptions related to project-based teaching [8–10]. For example, Cano and Arya (2023) [9] investigated the opinions of undergraduate students on participating in university–community collaboration projects. According to Alamri (2021) [8], the BPBL method can enhance the use behavior, intention, and academic performance of students, and it allows the sharing of knowledge and information as well as discussion. Therefore, it is recommended for students to use the BPBL method for educational purposes, and they are also encouraged to do so through their studies at universities.

Second, there is practical research related to project-based teaching [11–19]. For example, Imbaquingo and Cárdenas (2023) [11] investigated the effectiveness of project-based learning (PBL) in improving the English reading skills of ninth-grade students in a school. Tong and Wei (2020) [12] proposed a new universal teaching model—project-based blended learning (PBBL)—and described teaching experiments in which PBBL was applied. Liu et al. (2019) [13] found that pre-service teachers can enhance their ability to design information-based teaching through project-based learning so as to improve their teaching abilities.

Third, there is research on mechanisms, models, and influencing factors related to project-based teaching [2,20–27]. Cui and Xing (2010) [26] pointed out that issues such as the cooperation mechanism and system, willingness for cooperation, and benefit distribution are the main factors restricting cooperation. Li et al. (2012) [27] pointed out that poor communication channels, weak cooperation abilities, significant cultural differences, and insufficient policy support are important factors affecting the cooperation between universities and enterprises. According to D'Este and Patel (2007) [20], the integration of production and education is more frequently employed in joint research, patent licensing, consulting and contract research, training, and derivative enterprises. The empirical research of Liu et al. (2015) [21] showed that internal factors, coupling factors, and external environmental factors of the integration of production and education all have a significant impact on the four models of production–education integration in application-oriented undergraduate colleges, but the degree of influence varies.

According to an analysis of the literature, it was found that there have not been abundant achievements in project-based teaching models from the perspective of service design. On the one hand, there are limitations in the research. Project-based teaching involves multiple stakeholders, while most available research was conducted only from the perspective of a single stakeholder and objectively analyzed that stakeholder's demands while failing to analyze, summarize, and conclude upon the sore points of other stakeholders during the process of project-based teaching. The problems of other stakeholders were not addressed, and no relevant solutions were proposed. On the other hand, there is a lack of design practice. There are various issues related to the connection between courses and projects, quality evaluations, and other aspects in project-based teaching. In most research in this field, this issue was only discussed in theory, with theoretical suggestions being

provided. However, there has been no in-depth exploration or design practice. Therefore, there is a research gap in terms of putting design methods into practice.

2.2. Service Design

Service design is an activity that effectively plans and organizes people, infrastructures, communication, materials, and other related factors involved in a service so as to improve the user experience and service quality. The aim of service design is to design and plan a series of services that are easy to use, satisfactory, reliable, and effective for the customers, and this has been widely used in various service industries. Service design can be both tangible and intangible, as it integrates people with other factors, such as communication, the environment, behaviors, and materials, and a people-oriented concept is implemented throughout the whole process. Service design can have various processes. Some works divided the processes based on design thinking, some studies described the design process by referring to specific steps of design practice, and, in some other works, the design process was divided to highlight the details of service design [28].

The Double-Diamond model, which is a design-thinking model that was initially proposed by the British Design Council in 2004 [29], is fundamentally rooted in identifying the correct issues and discovering the corresponding solutions [30]. As a standardized method for design processes [31], it enjoys broad application in product design, interaction design, service design, and user experience design. This model emphasizes problem analysis as the foundation for the creation of solutions for clients, outlining four main stages across two adjacent diamonds. The two diamonds represent spaces for problems and solutions. Within each space, an initial divergent stage expands the space, followed by a convergent stage that narrows it down. This model's distinctiveness lies in its systematic division of human-centered design into two continuous divergent–convergent stages, as depicted in Figure 1 [32].

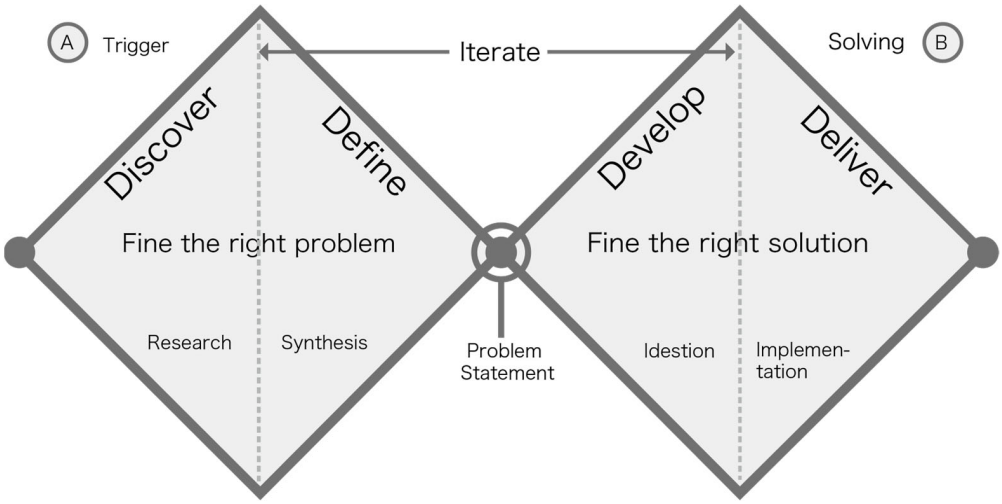

Figure 1. Double-Diamond model (reillustrated by the authors) [32].

A review of the research literature and practical reports of pioneers [33–39] in the field of service design revealed the Double-Diamond model to be conducive for handling complex processes, gaining insight into user demands, and aiding in solution identification. For example, Vuong (2022) [37] sequentially applied the four stages of the Double-Diamond design method to create user personas, customer journeys, information architecture, and user flows, and carried out UX and UI design for a photography service application. Zhang et al. (2019) [38] adopted the Double-Diamond design method to design wearable guidance devices for the visually impaired, thus realizing human-centric innovation while ensuring technological and economic feasibility. Therefore, this research employed the Double-Diamond model for its investigation.

In service design, the design process used in the Double-Diamond model can be roughly divided into four steps:

1. Discovery: First, an understanding of the problem or challenge is gained, the relevant information that should be obtained is confirmed, a plan for how to conduct research is created, and research is carried out to obtain results;
2. Definition: The problem is defined and the key issues are identified. At this stage of "definition", the Double-Diamond becomes convergent, suggesting the definition of the problem in a clear and concise way. The definition of the problem is the guiding principle for the design team, and it can provide guidance for creating prototypes and testing solutions;
3. Conception: Various possible solutions are conceived. At this stage, preliminary research on the design is carried out, and the design team begins to develop prototypes of solutions. A "solution module" should be constructed at this stage, which means that all possible prototypes are tested as feasible solutions. This step not only ensures the best results from a design perspective, but also helps provide practical and efficient solutions for the end users;
4. Delivering solutions: The potential solutions are turned into usable solutions, they are verified one by one, the most suitable products are output, and prototypes are created.

3. Materials and Methods

3.1. Research Process and Methods

Figure 2 illustrates our research framework, which is composed of the following components: Phase 1: Discovery—this stage employs a literature review and user interviews to delineate stakeholders in project-based teaching and understand their interests; Phase 2: Definition—by utilizing user journey mapping and the KJ method [40], this phase explores negative points and opportunities for stakeholders during the implementation process; Phase 3: Development—this stage refines design concepts, service models, and prototype designs by using design workshop methods, such as brainstorming, mind mapping, and prototyping; Phase 4: Delivery—to validate the effectiveness and recommended levels of the design concepts and service feature points, this research phase applies the Net Promoter Score survey method.

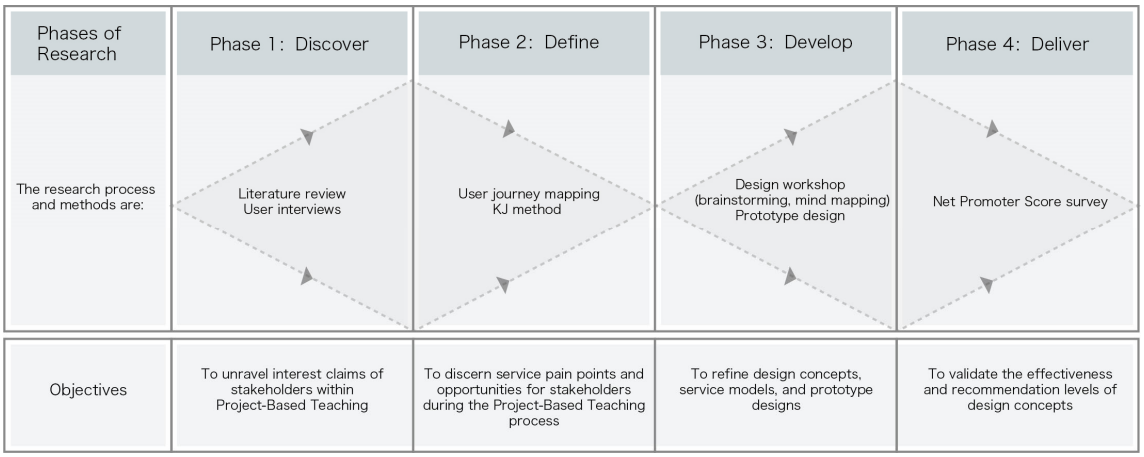

Figure 2. Research framework.

3.2. Discovery Stage

3.2.1. Literature Collection

In order to investigate the current studies on production–education integration and project-based teaching, we reviewed the existing literature and relevant websites related to project-based teaching. The literature review was conducted from March to May 2022. We checked studies that were published over a period of 10 years (2011–2021), focusing on

the latest data. Moreover, in databases such as those of CNKI (China National Knowledge Infrastructure), MDPI, Scopus, Web of Science, and DBLP, we searched for terms such as "integration of production and education", "university-industry cooperation", "university-industry practice platform", "role of vocational education integration mechanism", and "project-based teaching". We sorted out relevant concepts and data to support our research on the topic.

3.2.2. User Interviews

In order to understand the most realistic situations, we interviewed the stakeholders of project-based teaching. In our study, the interviews were mainly conducted in two stages. The first stage was a pre-interview, which took place in early June 2022 and lasted for ten days, involving seven people. The information obtained in these interviews helped improve the interview outline. The second stage involved more formal interviews, which lasted for 23 days from mid-August 2022 to mid-September 2022 and involved 13 people (as shown in Table 1). Due to the epidemic, all participants were interviewed online (Tencent Meeting), and the formal interview time was generally around 30 min. We intended to smoothly investigate the situation and relevant problems of the process from their own perspective concerning "projects" and "project-based teaching". An outline of the interview questions is shown in Table 2.

Table 1. Information of the respondents of the official interviews.

No.	Age	Gender	Role	Institute
1	36	Male	College teacher a	A university in Jiangsu province A
2	47	Male	College teacher b	A university in Jiangsu province B
3	44	Female	College teacher c	A university in Jiangsu province C
4	21	Female	College student a	A university in Jiangsu province A
5	20	Male	College student b	A university in Jiangsu province A
6	21	Male	College student c	A university in Jiangsu province B
7	22	Male	College student d	A university in Jiangsu province C
8	56	Male	College dean	A university in Jiangsu province A
9	49	Male	College assistant dean	A university in Jiangsu province A
10	44	Female	College assistant dean	A university in Jiangsu province B
11	38	Male	Project manager	A company in Jiangsu province A
12	48	Male	General manager	A company in Jiangsu province B
13	43	Female	Project manager	A company in Jiangsu province B

Table 2. Outline of the interview questions.

1	What role do you play in the project-based teaching process in the context of the integration of industry and education?
2	Can you introduce your interests and needs in the project-based teaching process in the context of the integration of industry and education?
3	What is your opinion on project-based teaching?
4	What is your final opinion?

In post-interviews, we identified four principal categories of stakeholders in the "project-based teaching" process: project providers (companies), project managers (university administrators), project leaders (university teachers), and project practitioners (university students). What service pain points and deficiencies might these four key stakeholders encounter within the context of the integration of production and education in the "project-based teaching" process? For these queries, we employed the Double-Diamond model as a tool and progressed to the "Definition" phase.

3.3. Definition Stage—Opportunity Analysis

3.3.1. User Journey Mapping Tool

In this study, a customer journey map for stakeholders was created based on the common issues identified in the literature and according to the interviews with the stake-

holders. A customer journey map is used to visualize invisible experiences in order to identify complexity and relevant issues. By drawing high-quality user journey maps for different stakeholders (enterprises, universities, teachers, students, etc.), we were able to identify the negative points and positive points in the behaviors of different stakeholders in the project-based teaching process, identify related problems, and link their direct/indirect interactions with the route toward identifying potential negative points and positive points for solutions. These user journey maps can be used to address the negative points for the users and improve the user experience.

3.3.2. Summarization of Negative Points of Services

We defined the service-related issues around the derived touch points by using the KJ method [40] to group and classify the relevant issues in order to prepare for the later determination of opportunities for the development of service design strategies for the system. The main issues that we summarized included the lack of information and communication platforms, funding management platforms, teaching management platforms, auditing/evaluation management platforms, and publicity/promotion management platforms, which are presented in detail in Section 4.2.

3.4. Development Stage—Conception and Strategic Planning

3.4.1. Conception and In-Depth Concepts

In this study, a design concept workshop (as shown in Table 3) was established to collect various ideas. Two service designers, two school administrators, two teachers, four students, and two relevant personnel from a cooperative enterprise participated in the workshop (as shown in Table 4). According to their respective experiences, relevant issues and service points in the process of project-based teaching were identified via brainstorming. The participants wrote their suggestions for improvement on a memo on a work board. Cards were used to divide the opinions with the same goals into the same groups. Moreover, the ideas gathered in the design concept workshop were reprocessed to match the opportunity points and design strategies, and a systematic conceptual scheme of service design was formulated.

Table 3. Workshop-related information.

Target	Determining sustainable service design solutions
Agenda	Transforming problems into solutions and building a service system
Method Used	Brainstorming and mind-mapping methods
Result	Formation of a systematic service design scheme

Table 4. Information of the workshop participants.

Participants	Career	Age	Sex	Institute
SD1	Service Designer	27	Male	A university in Jiangsu province A
SD2	Service Designer	29	Female	A university in Jiangsu province A
Ua1	University administrator	56	Male	A university in Jiangsu province A
Ua2	University administrator	49	Male	A university in Jiangsu province A
Ut1	University teacher	34	Female	A university in Jiangsu province C
Ut2	University teacher	30	Male	A university in Jiangsu province D
St1	Student	20	Male	A university in Jiangsu province A
St2	Student	21	Male	A university in Jiangsu province A
St3	Student	21	Female	A university in Jiangsu province A
St4	Student	22	Female	A university in Jiangsu province A
Ep1	Enterprise personnel	42	Male	A company in Jiangsu province C
Ep2	Enterprise personnel	38	Male	A company in Jiangsu province D

3.4.2. Construction of a Service Framework Prototype

In this study, according to the conceptual scheme of service design for the system, design software (Adobe XD, etc.) was employed to create a service framework prototype

by utilizing the creativity and logical analysis abilities of the designers. The construction of the service framework prototype was able to facilitate feedback and communication for the stakeholders in project-based teaching, and these were also used in the validation and improvement of the research scheme.

3.5. Evaluation

The Net Promoter Score (NPS) was first proposed by Reichheld of Bain and Company in 2003 [41]. Its principal advantage lies in its simplicity of measurement and calculation, enabling the swift acquisition of survey results. The straightforward categorization of users facilitates the subsequent implementation of targeted marketing or improvement strategies for different customers.

The NPS primarily serves as a customer satisfaction metric that directly reflects customers' loyalty to a company. This indicator's numerical value stems from the ratio of existing customers to potential customers multiplied by the existing customers, and this ratio can directly exhibit the degree of service recognition and usage intent within a user's psyche.

In our research, a three-minute demo video was created for the digital service platform. Moreover, from 11 September to 28 September 2022, Net Promoter Score (NPS) questionnaires were distributed to obtain feedback on our service simulation scheme, evaluate its recognition, and determine the importance of each item.

The NPS was determined by asking users the following question: "To what extent are you willing to recommend [the company/product] to your friends/colleagues?" Scores from 0–10 were allocated, and the customers were divided into three categories based on their scores: Promoters (9–10 points)—these individuals will continue to enjoy the service and are highly likely to recommend it to others, showing high loyalty; Passives (7–8 points)—these customers are generally satisfied, yet not particularly loyal, and they may consider alternative products or services; Detractors (0–6 points)—these customers are dissatisfied with the product or service. Not only do they lack loyalty, but they might also disseminate negative information. The NPS is the percentage of promoters minus the percentage of detractors.

A sampling method was used to divide the users into two groups in this study: the enterprise end-users (employees of cooperative enterprises, etc.) and the university end-users (university administrators, teachers, students, etc.). We recruited 50 respondents for each survey. Firstly, the demo video was presented to the enterprise end- and university end-users, and they shared their experiences by using the digital service platform. Then, a 10-point NPS questionnaire (as shown in Table 5) was used to evaluate the service functions of different service ports in the video so as to better assess the content of the design scheme and serve as a reference for subsequent suggestions to the stakeholders for information services for production–education integration, as well as a basis for implementing priorities.

Table 5. NPS questionnaire on the functions of the digital service platform for project-based teaching.

No.	Question
1	To what extent are you willing to recommend the information and communication service function of the digital service platform for project-based teaching to your friends or colleagues?
2	To what extent are you willing to recommend the funding management service function of the digital service platform for project-based teaching to your friends or colleagues?
3	To what extent are you willing to recommend the teaching management service function of the digital service platform for project-based teaching to your friends or colleagues?
4	To what extent are you willing to recommend the review/evaluation service function of the digital service platform for project-based teaching to your friends or colleagues?
5	To what extent are you willing to recommend the publicity/promotion management service function of the digital service platform for project-based teaching to your friends or colleagues?

4. Results

4.1. Discovery Stage

Demands of Stakeholders

Against the background of production–education integration, the core of project-based teaching lies in the participation of multiple stakeholders, such as universities, enterprises, and businesses. High-quality project-based teaching should fully consider the interests and demands of all stakeholders and clarify their rights, responsibilities, and interests so as to generate a driving force for multi-party participation, win–win cooperation, and sustainable integration [42].

According to the literature review [3,21,43–45] and the interview results, we identified the demands of the stakeholders. In the context of the integration of production and education, the implementation process for project-based teaching is a joint action between participating entities with the goal of comprehensively improving the quality of human resource development and achieving a win–win situation for those involved in production, education, and other parties. Enterprises, universities, teachers, and students are all groups or individuals that can influence or be influenced by the achievement of this goal. This study conducted an analysis from the perspectives of the project provider, project manager, project leader, and project practitioner:

(I) Project provider—interests and demands of enterprises:

First of all, enterprises are the project providers among the stakeholders. Enterprises generally have three types of interests and demands—obtaining profits, obtaining resources that they do not have, and improving their competitiveness [3]:

(1) Obtaining profits: When enterprises participate in the integration of production and education, they wish to obtain better-skilled workers and improve productivity, and they prefer that the integration of production and education is a process in which the benefits outweigh the costs;
(2) Obtaining resources that they do not have: The cooperation between enterprises and universities is based on the fact that they possess heterogeneous resources. The human resources that enterprises rely on for survival and development are trained and provided by universities. For enterprises, the transformation and upgrading of technology, as well as the application of new technologies, also depend on the technical talents trained by universities to some extent;
(3) Improving the competitiveness of enterprises: From the more macro-perspective of dynamic capabilities, it was found that some enterprises should not only focus on specific technologies and talents, but should also consider the short-term benefits of the enterprise. The improvement of their long-term corporate culture, innovation ability, corporate image, and comprehensive competitiveness is more important;

(II) Project manager—interests and demands of the university:

For project managers, the interests and demands of universities are quite obvious. On the one hand, they wish to obtain financial support, resources, and equipment support from enterprises; on the other hand, in order to better train students, they wish to find internships and employment for them. The reasons for why a university would seek cooperation with an enterprise include the following: finding financial support to pay the salaries of researchers and provide funds for laboratory equipment; gaining in-depth insight into a research field; verifying the correctness of a theory through field investigation; making up for the insufficient funding required for research; assisting the university in achieving their highest mission; helping students establish connections with enterprises and find job opportunities; obtaining useful knowledge and applying it in teaching; looking for business opportunities;

(III) Project leader—interests and demands of the teachers:

Teachers lead teaching activities, and they are also in charge of projects. Teachers have two main interests and demands: (1) According to the "Homo economicus" characteristics

of people, such as employees in other industries and enterprises, teachers also need to meet their basic material needs, and they hope to achieve self-fulfillment, gain recognition from leadership, and obtain promotions while fulfilling their responsibilities; (2) Deepening the integration of production and education among teachers is beneficial for improving the training quality and employment for the students and enhancing the market competitiveness of application-oriented universities, thus meeting their own spiritual pursuits;

(IV) Project practitioner—interests and demands of the students:

The interests and demands of college students involve acquiring more knowledge and skills, and they are especially interested in learning transferable and general skills because these can lay a broad foundation for their future employment and provide more opportunities. In addition, students who receive apprenticeship training and corporate internships also hope to receive internship subsidies or apprenticeship allowances from the company. On the one hand, they want to receive compensation for their work; on the other hand, they also want to be reimbursed for the transportation expenses and other costs generated due to internships or training.

4.2. Definition Stage

4.2.1. Analysis of User Journey Maps

A user journey analysis aims to understand what users need and what their hesitations and concerns are. Although most organizations are quite adept at collecting data about customers, the collected data cannot reflect the actual feelings and experiences of customers well. However, a simple scenario simulation can achieve this, and one of the best scenario simulation tools is user journey analysis [46].

First of all, we used the user journey mapping method to conduct a full-process analysis of the four types of stakeholders and simulated user behavior in three scenarios: before a project, during the project, and after the project was completed. For example, in the early stages of a project, there will be user behaviors such as docking, communication, providing the project, and providing the necessary resources for the project. During the mid-term reporting stage, there will be requests and opinions, and we should focus on user behaviors, such as exploring project feasibility, project progress, and resource requirements. In the later stage of the project, users will have behaviors such as providing substantive opinions and fully communicating with the project team. After the project is completed, there will be project settlement scenarios and behaviors such as obtaining project results, establishing long-term cooperative relationships, and showcasing collaborative projects. In this study, we identified the service pain points of different stakeholders in the cooperative process of project-based teaching and identified their service gaps (as shown in Figures 3–6).

4.2.2. Summary of the User Pain Points

The analysis of user pain points included two aspects: first, that of whether the user experienced "pain"; second, the degree of the user's "pain" [47]. For the first aspect, the user's pain points needed to be correctly identified. One the one hand, the pain points needed to be based on certain user demands, which should have the possibility of transforming into "demands"; on the other hand, the pain points referred to the problems to be solved, which would change according to factors such as the user demands and time.

Table 6 summarizes the user pain points. For example, the pain points for enterprise users included inconvenient communication, poor management of project cooperation processes, etc.; the main pain point of universities lay in the difficulty in integrating the curriculum and project management; the pain points for teachers included effective management of project-based courses while also balancing the requirements of both projects and courses; the pain points for students lay in the lack of project practice and the lack of convenient platforms for learning and communication in their work.

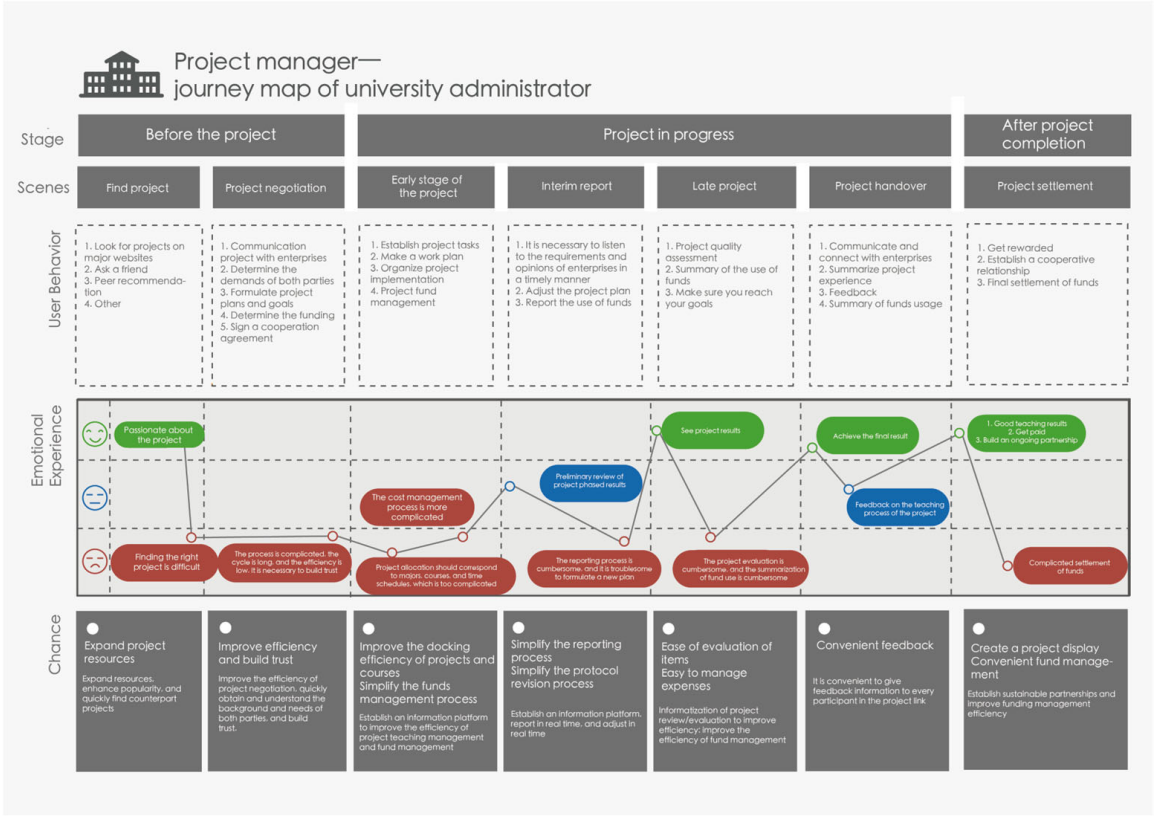

Figure 3. Project manager—journey map of a university administrator (illustrated by the authors).

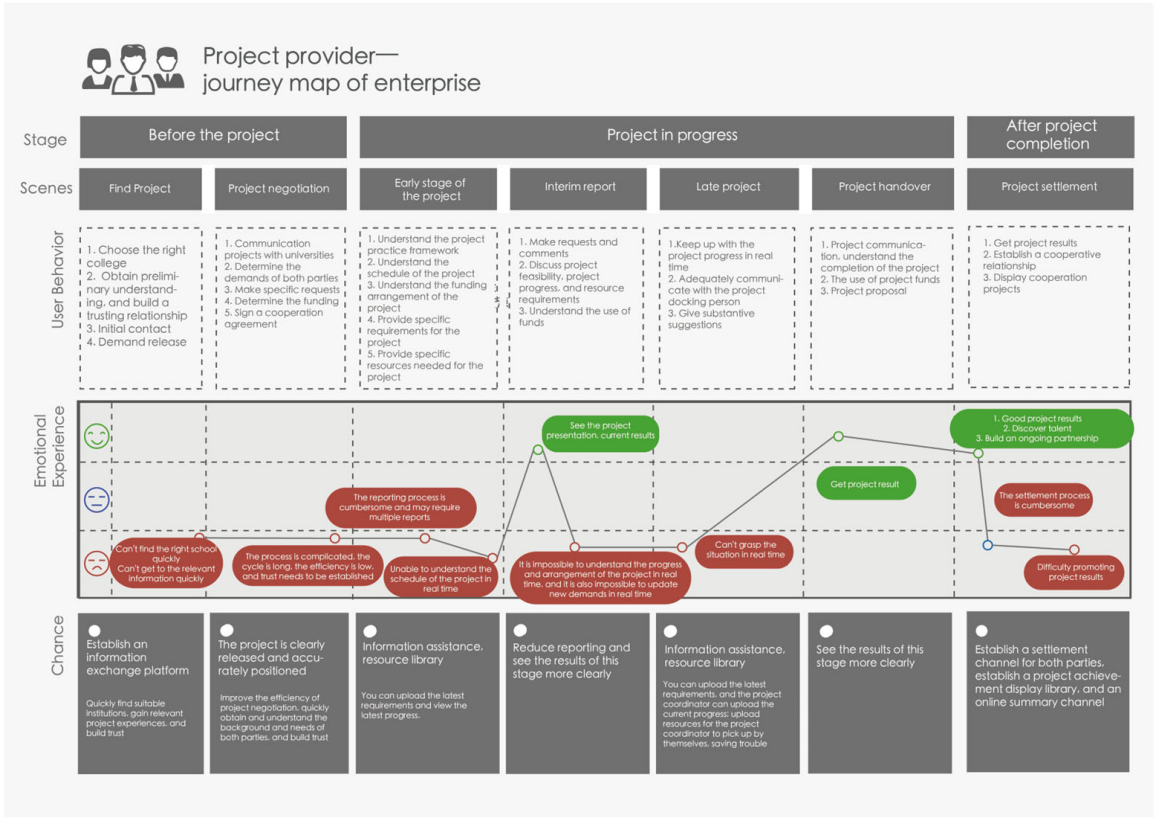

Figure 4. Project provider—journey map of an enterprise (illustrated by the authors).

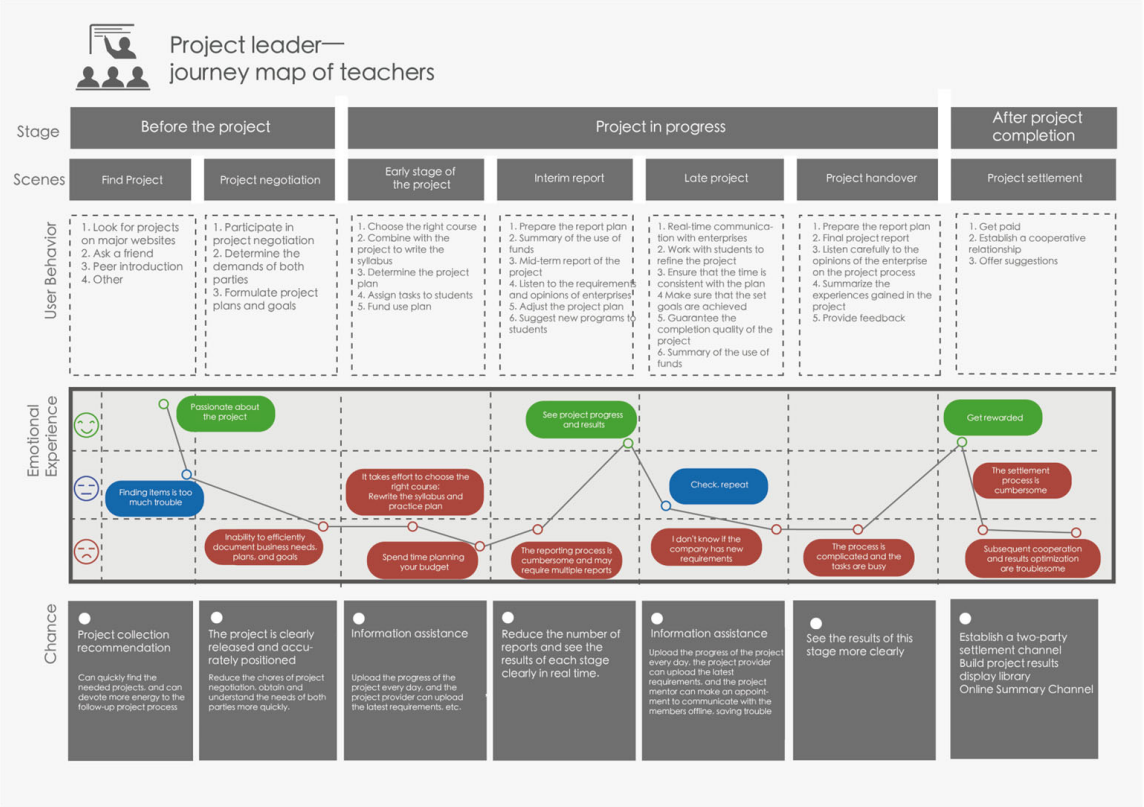

Figure 5. Project leader—journey map of a teacher (illustrated by the authors).

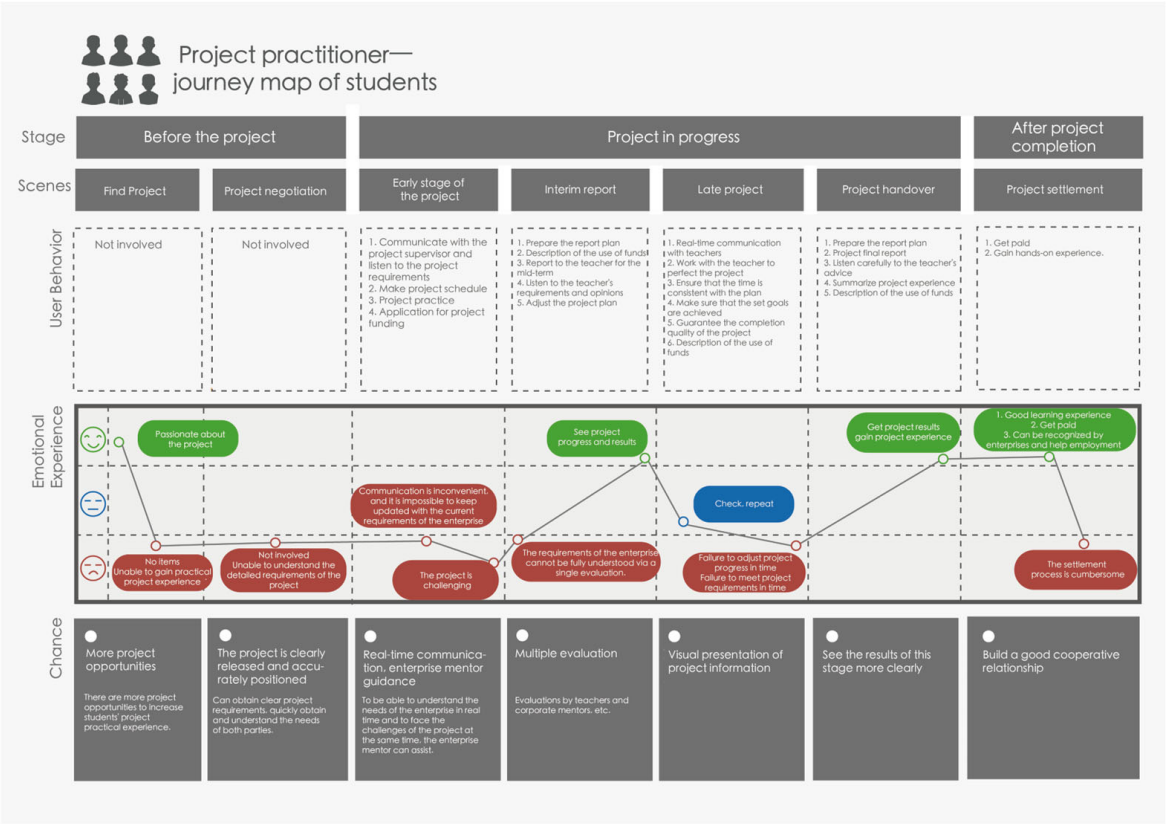

Figure 6. Project practitioner—journey map of a student (illustrated by the authors).

Table 6. Summary of the pain points from the user journey maps.

Role	Scenario	Summary of the Pain Points from the User Journey Map
Enterprise	Searching for cooperative organization	Unable to quickly find suitable colleges and universities; unable to quickly understand relevant information.
	Project negotiation	The process is complex, the cycle is long, and the efficiency is low. Trust needs to be established.
	Initial stage of the project	The reporting process is cumbersome, and multiple reports may be required.
	Initial stage of the project	Unable to keep up with the project's progress in real time.
	Interim report	Unable to keep up with the project's progress in real time and unable to update new demands in real time.
	Later stage of the project	Keeping up with the situation, communicating/providing suggestions in real time.
	Project closing report	The settlement process is cumbersome.
	Project settlement	Difficulty in promoting the project's results.
University	Looking for projects	Difficulty in finding suitable projects.
	Project negotiation	The process is complex, the cycle is long, and the efficiency is low. Trust needs to be established.
	Initial stage of the project	The docking issue between courses and the project allocation should correspond to relevant majors, courses, and schedules, which is too complex.
	Initial stage of the project	The funding management process is quite complex.
	Interim report	The reporting process is cumbersome, making it difficult to develop a new plan.
	Project closing report	Complicated project evaluation and summary of fund usage.
	Project settlement	Cumbersome fund settlement.
Teacher	Project negotiation	Unable to efficiently document the needs, plans, and goals of the enterprise.
	Initial stage of the project	Effort is required to select appropriate courses and rewrite course outlines and practical plans.
	Initial stage of the project	Time is spent in planning the budget.
	Interim report	The reporting process is cumbersome, and multiple reports may be required.
	Later stage of the project	Unable to find out whether the enterprise has any new demands.
	Project closing report	Complex process and heavy tasks.
	Project settlement	Cumbersome fund settlement. Subsequent cooperation and achievement optimization.
Student	Looking for projects	Without a project, practical experience cannot be obtained.
	Project negotiation	Unable to understand the specific requirements of the project without participation.
	Initial stage of the project	Inconvenient communication and inability to understand the current needs of the enterprise in time.
	Initial stage of the project	The project is challenging.
	Interim report	Unable to directly learn the requirements of the enterprise via a single evaluation.
	Later stage of the project	Unable to adjust the project's progress and meet the project's requirements in time.
	Project settlement	Cumbersome fund settlement.

4.2.3. Summary of Service Gaps

By analyzing the requirements and responsibilities of the stakeholders, as well as the user journey maps, the KJ method [40] was used to summarize the user pain points, and all pain points were divided into five types of service gaps: the lack of information and communication platforms, the lack of fund management platform, the lack of teaching management platforms, the lack of audit/evaluation management platforms, and the lack of publicity/promotion management platforms (as shown in Figure 7).

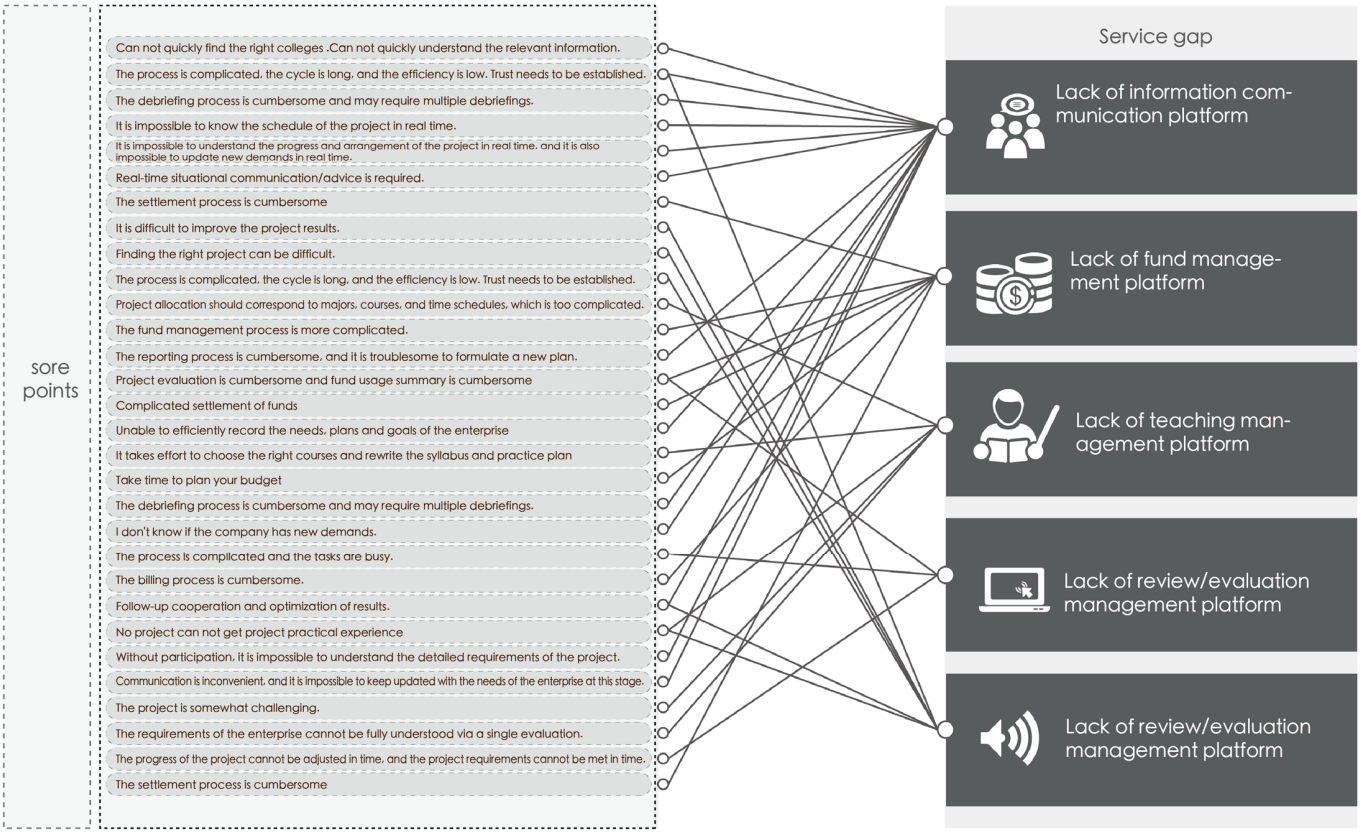

Figure 7. Summary of the service gaps (illustrated by the authors).

4.3. Deepening

4.3.1. Service Models

We systematically addressed the service gaps that were identified (as shown in Figure 8). This study aimed to propose a comprehensive service system and construct a conceptual digital service platform for project-based teaching (as shown in Figure 9) so as to provide information services to stakeholders in the project-based teaching platform and connect various links of the service ecosystem. Finally, a complete conceptual service ecosystem with a cloud platform for project-based teaching was developed, thus creating a service loop for project-based teaching.

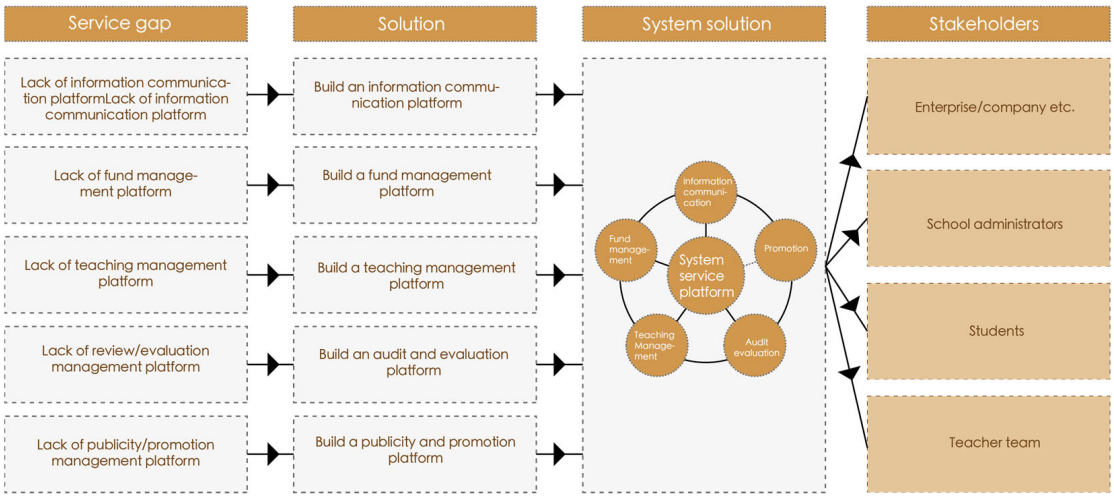

Figure 8. Systematic solution (illustrated by the authors).

Figure 9. Service system framework (illustrated by the authors).

4.3.2. Service System Framework Based on the Stakeholders

(1) Between students and enterprises: As a reserve of professional talent, students can provide human resources and a new workforce for enterprises, while enterprises can provide students with chances to obtain practical project experience and job opportunities. Therefore, students can post their completed assignments and other project results on the service platform, where enterprises can see relevant information, thereby exploring more suitable talent and creative work. Furthermore, enterprises can post relevant project resources and enterprise resources on the service platform, thus providing students with more information and opportunities for specialized projects;

(2) Between enterprises and universities: As project providers, enterprises provide projects and funding to universities, while universities provide human resources and support for the transformation and upgrading of new technologies in projects. Therefore, enterprises can propose project requirements and provide corresponding funds on the service platform, while universities can confirm the projects in the system and communicate with enterprises on the specific situations of projects;

(3) Between universities and teachers: As project managers, universities uniformly manage projects and allocate them to different teachers based on disciplines, majors, grades, and other factors. As actual project leaders, teachers are responsible for universities and integrate project requirements with actual teaching curricula. Therefore, university management can split large projects on the service platform, and teachers can plan actual courses according to the project requirements on the platform, thus achieving the digital management of projects and courses;

(4) Between teachers and students: As project practitioners, students need to gain practical work experience in actual projects; as project leaders, teachers integrate projects with their curricula, thus providing students with practical projects and curriculum tasks. As a result, students can understand the requirements of course tasks and

projects on the service platform, complete course tasks according to the requirements, and upload corresponding materials to the service platform. Teachers can check the students' homework on the service platform and systematically evaluate their homework with the university and enterprise.

4.3.3. Functional Modules of the Service Platform

According to the system service model and the construction of a closed service loop for the stakeholders, this study proposes an information and communication service platform, a fund management service platform, a teaching management platform, a review/evaluation management platform, and a publicity/promotion management platform to address issues such as the lack of communication of information, fund management services, teaching management services, review/evaluation management services, and publicity/promotion management services (as shown in Table 7). The details are as follows:

(1) Information and communication service platform:

The information and communication service platform can be used to release and match cooperative projects. Universities and enterprises can post information about collaborative projects, including the project requirements and cooperation conditions, on the platform. At the same time, the platform should also be equipped with an intelligent matching function and should recommend potential partners for both universities and enterprises according to their requirements and resources. The platform can provide tools for the communication of information for enterprises and universities, thus facilitating team collaboration and communication among enterprises, universities, teachers, and students. Such tools can include real-time chat, online discussion boards, and file sharing, which can promote cooperation and communication among different teams;

Table 7. List of the function concepts.

Functional Platform (Primary Functional Module)	The Main Functions of the Enterprise Port (Secondary Functional Module)	The Main Functions of the University Port (Secondary Functional Module)
Publicity/promotion management service platform	Achievement and resource library Publicity planning Brand promotion	Achievement and resource library Publicity planning Brand promotion
Information and communication service platform	University–enterprise communication Project release Project cooperation Personnel recruitment	University–enterprise communication Project reception Project cooperation Student applications
Teaching management service platform	Assistance in the revision of course outlines Assistance in the construction of course resources Assistance in project–course management	Project–course management Revision of course outlines Construction of course resources Uploading homework Course acceptance Demos by students
Review/evaluation management service platform	Project requirements Project progress Project evaluation Project feedback	Project evaluation Project assignment Project progress Project acceptance Project feedback
Fund management service platform	Project fund management Project budget Expense details	Project fund management Project fund distribution Project fund reimbursement

(2) Fund management service platform:

The fund management service platform is a digital platform that is used to manage the flow of funds between universities and enterprises. It can provide a convenient, transparent, and efficient channel for managing the fund use and settlement processes in cooperative

projects between universities and enterprises. For example, a university and enterprise can submit funding applications that include the project budget, cost details, and other information on the platform. Relevant departments can review and approve applications on the platform so as to ensure that the use of funds complies with related regulations and budgets. The platform also provides a secure payment system that enables universities and enterprises to conveniently transfer funds and make payments. This digital method can facilitate the distribution of a team's profits and improve the efficiency of fund utilization;

(3) Teaching management service platform:

Some large projects may involve knowledge and skills from multiple disciplines. According to the complexity of the project and the differences in curriculum integration, the platform can help universities better manage the project and curriculum. For example, a university administrator can divide complex projects into several subprojects according to the project characteristics and curriculum integration and then connect them with courses on different subjects (as shown in the Figure 10). During this allocation process, the university administrator needs to schedule time slots for the courses on the service platform. After the subprojects are integrated into the curriculum, a teacher can transform the project into a curriculum project according to the course requirements and instruct their students to complete the curriculum project. Finally, the teacher summarizes the collected course plans and completes the project;

(4) Review/evaluation management service platform:

The review/evaluation management service platform can provide review and evaluation functions that assist both enterprises and universities in reviewing cooperative projects so as to ensure compliance with requirements and evaluate the quality and effectiveness of projects. At the same time, the platform can provide students with teaching evaluation tools and functions and can introduce evaluation standards for enterprises. On the platform, teachers, universities, and enterprises can evaluate students' work and achievements from multiple perspectives. This can help improve the quality of both projects and teaching by establishing new evaluation standards. Meanwhile, the platform can also facilitate learning evaluations by students and evaluations and feedback for teachers, such as through homework submission and grading functions, in order to help monitor the progress of learning and projects and to provide personalized guidance;

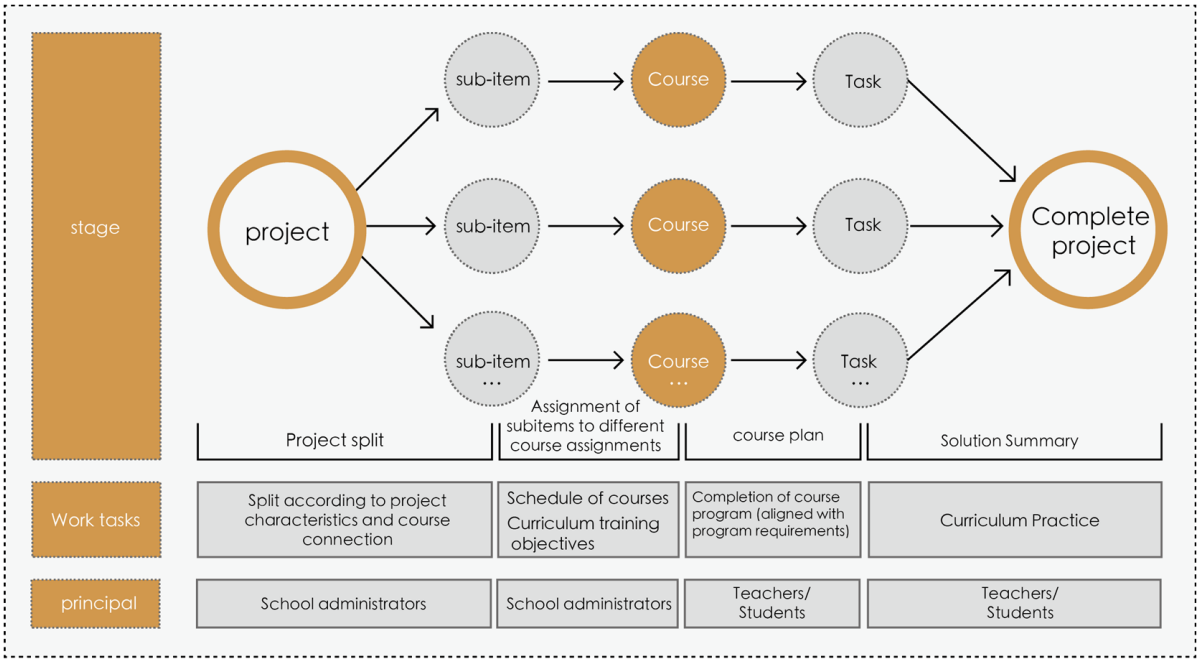

Figure 10. Content of project-based teaching management.

(5) Publicity/promotion management service platform:

The publicity/promotion service platform is specifically designed to provide publicity and promotion services for universities and enterprises. This platform generally provides the following services: (1) an achievement resource library—teachers, students, and enterprises can upload excellent coursework and jointly establish a resource library of excellent achievements; (2) Publicity planning—the abundant achievements and resources involved in production–education cooperation, including practical cases and learning materials that can be used and shared by stakeholders, can be published on this platform; (3) Brand promotion—the platform can help universities and enterprises enhance their brand awareness and image by designing logos, telling brand stories, and carrying out online and offline promotional activities.

4.3.4. Design of the Platform Prototype

In this study, the design prototype method was employed to design a digital prototype of the service model and concept. The authors of this study constructed a primary and a secondary functional framework for two service ports—the campus web and enterprise web—as shown in Figure 11.

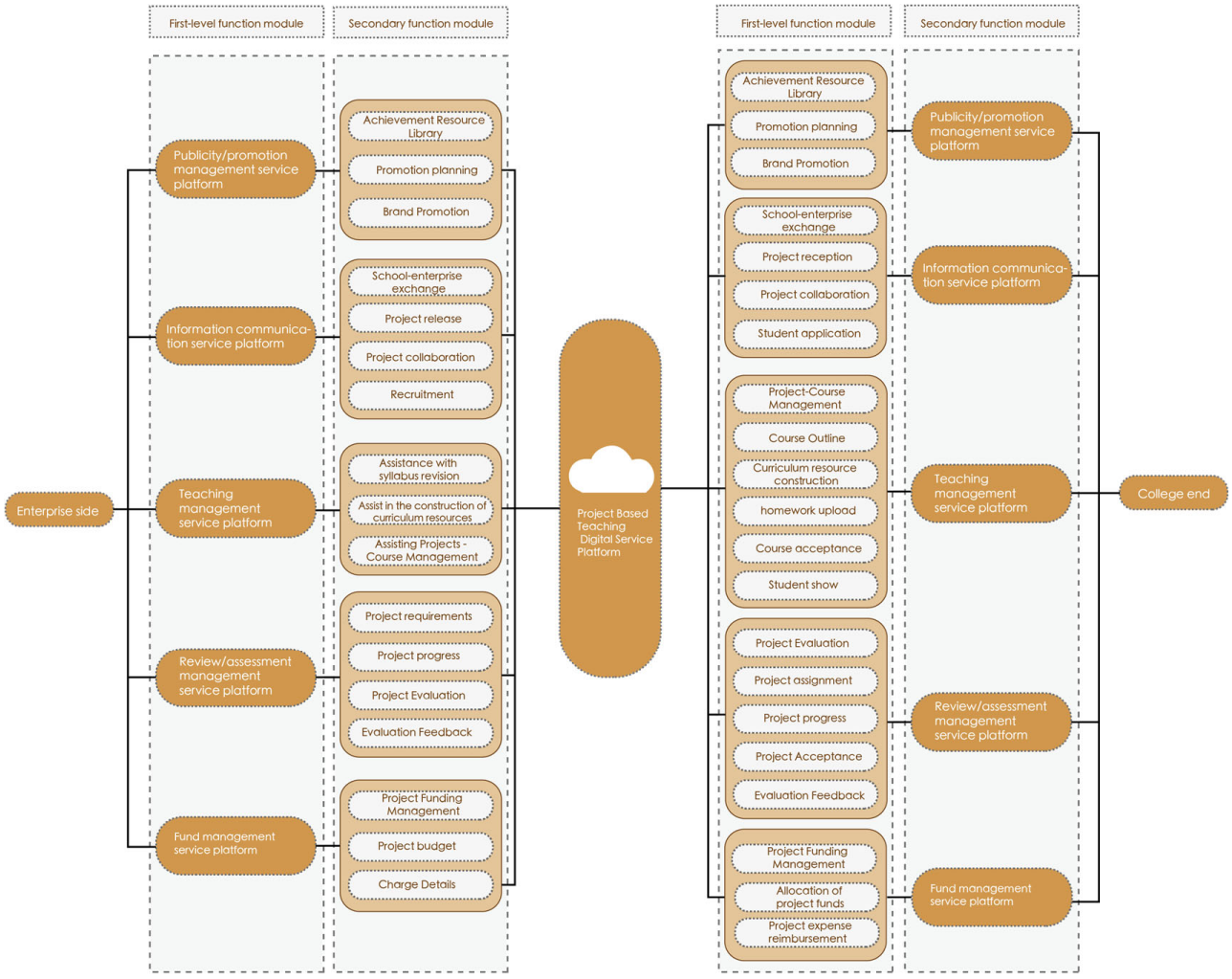

Figure 11. Primary and secondary functional modules for enterprises and universities.

4.4. Verification of Results

An NPS questionnaire was used to verify the recognition of the service simulation scheme and to evaluate and rank the importance of functional service points during

the process of project-based teaching. Generally, an NPS score of below 0 indicates that a service/product has many issues that urgently need to be addressed. A score between 0 and 30 implies satisfactory performance, with more satisfied than dissatisfied users, but there is room for improvement. A score exceeding 30 suggests an excellent performance with high user satisfaction. If the NPS score surpasses 70, this shows high customer satisfaction with the service/product, and this can imply that a good reputation can be attained through user recommendations. The higher the NPS score for the service/product, the higher the user recommendation rate, and the greater the possibility of acquiring new users.

4.4.1. Questionnaire Results for University Users

According to the results of the university NPS questionnaire survey (as shown in Table 8), all service functions were recognized. Among them, the information and communication service function ranked first, with an NPS of 84%, followed by the teaching management service function, with an NPS of 72%; the fund management service function was in third place, with an NPS of 70%; the publicity/promotion management service function ranked fourth, with an NPS of 68%; and the review/evaluation management service function was in the fifth place, with an NPS of 64%.

Table 8. Questionnaire results for university users.

Type	Critical Users						Passive Users		Recommended Users		Net Promoter Score
	1	2	3	4	5	6	7	8	9	10	
Question 1	0	0	0	0	0	3	1	1	3	42	84
Question 2	0	0	0	0	4	2	2	1	3	38	70
Question 3	0	0	0	1	2	1	3	2	3	38	72
Question4	0	0	0	3	3	1	2	2	4	35	64
Question 5	0	0	0	1	1	3	1	3	3	27	68

4.4.2. Questionnaire Results for Enterprise Users

According to the survey results of the enterprise NPS questionnaire (as shown in Table 9), it can be seen that all service functions were recognized. Among them, the publicity/promotion management service function was ranked at the top, with an NPS of 82%, followed by the information and communication service function, which had an NPS of 76%; the fund management service function was in third place, with an NPS of 72%; the review/evaluation management function was ranked fourth, with an NPS of 66%; and the teaching management service function was in fifth place, with an NPS of 58%.

Table 9. Questionnaire results for enterprise users.

Type	Critical Users						Passive Users		Recommended Users		Net Promoter Score
	1	2	3	4	5	6	7	8	9	10	
Question 1	0	0	0	0	2	2	1	3	10	32	76
Question 2	0	0	0	0	3	2	2	2	11	30	72
Question 3	0	0	0	0	5	2	3	4	9	27	58
Question4	0	0	0	0	3	2	2	5	8	30	66
Question 5	0	0	0	0	2	1	0	3	8	36	82

5. Discussion

Project-based teaching is a relatively new teaching model that has more autonomy and a broader range of practical teaching than traditional teaching. However, project-based teaching also involves many challenges. On the one hand, the stakeholders of project-based courses have different interests and demands. On the other hand, the process of project-based teaching may involve problems, such as incomplete integration channels, loose connections between projects and courses, and the absence of quality assurance, monitoring, and evaluation systems. These problems have hindered the sustainable and healthy development of project-based teaching. Therefore, this study is significant.

Firstly, this study sorts out the interests and demands of various stakeholders and improves their coupling degree. From a practical perspective, there are generally problems in the process of implementation of project-based teaching in the context of the integration of industry and education, such as difficulties in cooperation, lack of depth, instability, and sustainability. The reason for this is that the low coupling degree of the interests of stakeholders leads to weak symbiosis [41]. Stakeholders' interests and conflicts thereof have become the influencing factors of project-based teaching in the context of the integration of industry and education. Based on an analysis of the literature and stakeholder interviews, this study determined the interests and demands of various stakeholders and explored the smooth implementation of projects and project-based teaching from the perspectives of project providers (companies), project managers (universities), project leaders (university teachers), and project practitioners (students) in order to establish a close degree of coupling of their interests. This provides a research foundation for the effective integration of resources, the sharing of diverse interests, and the establishment of systematic service models.

Secondly, this study used the Double-Diamond model for service design to carry out the system analysis and design. On the one hand, the reason for this is that service design is the design of a service system, and the process is relatively complex. Therefore, this model helps one find a bridge between problems and solutions [48,49]. On the other hand, this model can be used to comprehensively understand the needs of multiple users and obtain reasonable solutions [50].

This study used the Double-Diamond model for service design to explore the lack of services in the process of project-based teaching. The project-based teaching process involves multiple stakeholders, and only when the interests of all stakeholders are taken into account can services be sustainable and healthy. Therefore, we designed a conceptual system for project-based teaching based on the demands of stakeholders and the pain points in services during the cooperative process of project-based teaching. Moreover, pertinent solutions that addressed these issues, such as an information and communication service platform, fund management service platform, teaching management service platform, review/evaluation management service platform, and publicity/promotion management service platform, were proposed, and digital service platforms were constructed for different stakeholders.

Thirdly, the efficacy and recommendation level of the service concepts were validated. The NPS survey revealed that all service functions proposed in this research were recognized, yet campus-based and enterprise-based users differed in their degrees of endorsement of various features. For instance, campus users tended to value information and communication service functions and teaching management service functions, whereas enterprise users preferred publicity management service functions and information and communication service functions. This further confirmed that different stakeholders have diverse interests and demands. Campus users prioritized expanding project resources and project–teaching management, while enterprise users focused more on corporate publicity, project communication, and docking. Based on this user feedback, the user experience of the digital project-based teaching service platform can be further improved.

Fourthly, this research holds substantial theoretical and practical value. It strives to foster steady and continuous development through stakeholder collaboration, thus bolstering the enthusiasm and unity of the participants. Historically, project-based teaching has primarily been concentrated on empirical research related to associated attitudes and perceptions. The practice of this approach and research on its mechanisms, models, and influential factors were also of interest. This research brings a novel research perspective into the development of project-based teaching within the context of the integration of production and education, wherein we employed service design methods to co-construct proposals for service concepts. Our research can propel studies linked to the needs of stakeholders in project-based teaching, thus enriching research on sustainable development in this realm. The tangible value of this research lies in its provision of an unbiased

understanding of the real requirements of various stakeholders in project-based teaching and the identification of service gaps in the process. It serves as a reference for other similar studies of the needs of users of project-based teaching. Simultaneously, we provided a comprehensive conceptual service scheme that was highly appreciated by stakeholders. This bears significant reference value and practical meaning for the enhancement of the service quality of project-based teaching and the advancement of the development of the integration of production and education.

6. Conclusions

The project-based teaching model is an inevitable byproduct of economic development reaching a certain stage. It fulfills the self-improvement needs of the education and teaching modes applied in higher institutions and is an essential link in cultivating high-skilled professionals. This model organically integrates schools with enterprises and markets through project connections, resolves students' practical issues, and enhances their hands-on abilities. Concurrently, through project practice, it boosts students' competitiveness in employment, laying a solid foundation for their post-graduation careers. However, the current model of cultivating project-based teaching in Chinese undergraduate vocational institutions has numerous areas for improvement and has not yet reached the ideal state of production–education integration.

This research provides a new perspective, using the Double-Diamond model for service design to conduct studies on the needs of diverse stakeholders in project-based teaching. Focusing on projects and project-based teaching, it explores the core demands of stakeholders and the issues and challenges that they encounter during the process. Based on problem analysis and a summarization of the pain points (i.e., deficiencies in the communication of information, funding management, teaching management, audit/assessment management, and promotion/propaganda management), we constructed a comprehensive service design scheme. This research determined the interests of stakeholders, addressed the service pain points and gaps in the process of project-based teaching, and aimed to increase the coupling degree of stakeholders therein. This can resolve the unstable state of production–education integration caused by inconsistent interests and demands between enterprises and institutions.

This research constructed an informatized service platform for project-based teaching. The platform's information and communication service facilitates information exchange between businesses and institutions; its fund management service eases financial administration for both parties; and the audit/evaluation management services allow better management of progress, audits, and other arrangements in project-based teaching. The teaching management service enables schools to effectively manage corporate projects, thus effecting the transformation from project to course tasks, thereby enhancing students' practical project abilities and collaboration skills. The promotion/propaganda management service benefits the publicity efforts of both businesses and institutions, thereby increasing their renown. The proposed concept, framework, and practice of this project service platform based on production–education integration hold a certain referential value.

7. Limitations

The limitations of this research lie in the small sample of participants. Consequently, the service concepts and results may vary with the number of stakeholders and their knowledge level. In subsequent studies, we plan to continue our research by hosting numerous seminars and collecting diverse data for more precise qualitative and quantitative analyses.

Additionally, due to the constraints of real-world conditions, the service concepts developed and designed in this research cannot be immediately put into practical use. Therefore, we cannot further verify and refine their effectiveness in practical applications. Henceforth, building on preliminary research, we will further analyze and assess the service concepts and advance the actual development, application, and real-world assessment

of the project-based teaching service platform. This will genuinely promote the in-depth development of production–education integration.

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