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Article

Research-Led and Project-Based Learning: A Case Study on Self-Directed Pedagogical Approach for Modern Higher Architecture Education

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Abstract: Contemporary higher education prioritizes cultivating students' key competencies and comprehensive problem-solving abilities, specifically fostering innovation, goal orientation, and initiative. This study investigates a pedagogical framework that synergizes Research-Led Learning (RLL) and Project-Based Learning (PBL) to establish an open, exploratory learning environment. Employing a case study methodology, the research tracked architecture students engaging in a structured PBL process involving rigorous research activities—ranging from theoretical analysis to field investigations—to develop evidence-based design solutions. Evaluations from both student and faculty perspectives assessed the pedagogical effectiveness regarding learning outcomes and competency development. The findings indicate that this methodology effectively bridges the gap between research and practice, significantly bolstering students' capacity to address authentic challenges and propelling self-directed learning in architectural education.

Keywords: research-led learning (RLL); project-based learning (PBL); self-directed learning; pedagogical approach; modern higher architectural education; marine building

1. Introduction

Since the dawn of the 21st century, technologies characterized by intelligence, sustainability, and integration have rapidly emerged, fundamentally transforming human production methods and modes of thinking. Consequently, societal development increasingly demands high-level talents equipped with comprehensive problem-solving abilities (Bashier, 2014). The cultivation of "new quality talents" has thus become a strategic imperative for national development, with intelligent technology serving as a key pathway to foster such high-quality personnel (Xu & Wang, 2025). In response to these shifts, education reform globally has focused on developing innovative approaches to talent cultivation. Talent education has entered a new phase, now oriented towards fostering "key competencies". These competencies encompass critical thinking as a foundation, initiative learning capabilities as a key driver, knowledge innovation transfer and social constructive skills as a focus, and global competency as a reflection of values (Zhang & Zhang, 2017).

Against this backdrop, higher education must adapt by developing innovative teaching strategies and talent cultivation methods. This is particularly crucial in modern higher architectural education, a field characterized by strong social attributes and complex interactions between theory and practice. Architecture students must engage with the entire design lifecycle, enhance their awareness of social responsibility (Dang et al., 2023), cooperate effectively in teams, communicate with diverse stakeholders, and apply digital tools to sustainable design (Van Erp, 2022). Consequently, new learning and teaching approaches in architecture that integrate research and practice are paramount to guiding students toward addressing contemporary social challenges.

However, achieving these goals proves challenging within the traditional architecture education system, which faces significant limitations (Chen et al., 2017; Fang et al., 2023; Daly et al., 2014). Common challenges include flattened teaching models, limited innovation and practicality in coursework, a disconnect between societal demands and the architectural curriculum, and inadequate integration of design outcomes with social research methodologies. These obstacles hinder student engagement in research and practical applications, potentially leading to a superficial understanding of the discipline and a disconnect between academic learning and professional employment (Holmes, 2012).

To address these issues, architectural education must provide students with opportunities to engage in real-world problem-solving and knowledge construction. Research-Led Learning (RLL) and Project-Based Learning (PBL) have emerged as comprehensive pedagogical approaches that align with the rigorous requirements of architectural studies. These approaches can effectively enhance students' key competencies, facilitating the training of future architectural designers. Despite their potential, research on these pedagogical approaches within higher architectural education in China remains limited, focusing primarily on theoretical discussions. Practical implementations are sporadic and have not yet become mainstream. Furthermore, few case studies exist that offer universal value or serve as direct references for further study (Mo, 2018). Therefore, this study seeks to bridge this academic gap by presenting a constructive teaching case for research-led and project-based learning. The goal is to provide a robust reference point for future practices in architectural education and contribute to the ongoing development of innovative teaching methodologies.

2. Literature Review

2.1. Research-Led Learning (RLL)

Research-led learning (RLL) is an effective pedagogical approach commonly employed in higher education settings (Brew, 2012; Christ et al., 2003; O'Donnell & Tobbell, 2007; Robertson & Blackler, 2006). It emphasizes student-centered instruction and pedagogical philosophies (Smyth et al., 2016), allowing students to actively engage in the research process through lectures, faculty-led seminars, laboratory work, and coursework (Zamorski, 2002). Distinct from research-based, research-tutored, and research-oriented teaching, RLL focuses on learning current research within a discipline (Jenkins & Healey, 2009). It is argued that this approach represents an evolution from traditional methods towards a more constructivist, student-centered model of learning. In this paradigm, students become active participants in education, discovering knowledge rather than passively acquiring it through lectures and exams (Biggs, 1993; Biggs & Tang, 2007; Palincsar, 1998).

Building on this methodological framework, RLL fundamentally transforms the traditional model of knowledge dissemination. It fosters intellectual curiosity through inquiry, independent thinking, critical spirit, problem-solving, and creativity. Furthermore, it utilizes research to guide learning, integrate, apply, and create knowledge, while promoting intellectual development through real-world research engagement (Xi & Li, 2021; Zamorski, 2002). In architectural education, RLL plays a crucial role in promoting active learning and knowledge acquisition among undergraduates (Zychowicz, 2019). It empowers students to explore innovative concepts, thereby optimizing their critical thinking and comprehensive problem-solving abilities (Chen, 2014). Practice demonstrates that students' understanding of complex concepts is considerably enhanced through a cyclic process of "research-practice-rethink-teach." As they engage in research-based learning, the construction of knowledge becomes more natural (Dong & Deng, 2013). Ultimately, this educational philosophy enriches the diversity of higher education, creating a learning environment conducive to holistic personal development.

2.2. Project-Based Learning (PBL)

In conjunction with Research-Led Learning (RLL), numerous pedagogical methods emphasizing autonomy, collaboration, and inquiry have emerged, among which Project-Based Learning (PBL) stands out as a comprehensive RLL-applied approach. PBL is recognized for its ability to build students' capability to develop essential life skills (Shpeizer, 2019). Defined as a teaching model where students work on goal-oriented projects and carry out research under teacher guidance, PBL reorganizes knowledge systems and reconstructs teaching forms. Rooted in constructivist theory, this innovative approach emphasizes experiential, student-centered learning where knowledge is actively constructed rather than passively consumed (Brundiers & Wiek, 2013; Manikutty et al., 2022). In PBL, students are tasked with addressing real-world social challenges to produce specific, feasible solutions, continuously refining them for the most effective resolution (Yu, 2024). This approach encourages independent inquiry, self-directed learning, and creative thinking at every stage of the architectural design process. By engaging with real-world problems, students develop the skills needed to navigate future uncertainties (Fernandes et al., 2021). Furthermore, PBL promotes interdisciplinary collaboration, encouraging students to cooperate with stakeholders from various fields, which aligns with the growing emphasis on talent cultivation in contemporary higher architectural education.

Within the context of higher education, extensive research has addressed PBL across various disciplines, such as Engineering (Fernandes et al., 2021), Biology (Abishova et al., 2020), and language teaching (Sirisrimangkorn, 2021). These studies highlight PBL as a pedagogical approach instrumental in developing university students' skills for the 21st-century workforce. Concurrently, the advantages of PBL in higher architectural education are becoming increasingly evident. However, few case studies in this field offer universal value or serve as direct references for further research.

In summary, both PBL and RLL are rooted in constructivist theory, rendering their integration a systemic and effective pedagogical approach. This study conceptualizes "Research-Led and Project-Based Learning" as a unified pedagogical model that begins with identifying a project and involves active exploration by students from diverse disciplines under teacher guidance. Through collaborative research embedded in real-world contexts, students acquire and apply knowledge to explain phenomena or solve problems, ultimately transitioning into interest-driven, self-regulated, and research-led learners. This approach enables students to synthesize multiple pathways across different disciplines for self-directed inquiry, thereby enhancing their innovative architectural design and flexible problem-solving skills.

3. Methods

3.1. Research Objectives

The primary objective of this study is to evaluate the impact of Research-Led Learning (RLL) and Project-Based Learning (PBL) methodologies on architecture students, with a specific focus on the enhancement of key competencies, problem-solving skills, and academic achievement. The study investigates the efficacy of this innovative pedagogical approach when applied to architectural design curricula. Furthermore, it examines the role of these methodologies in fostering self-directed learning and cultivating a sense of social responsibility within the context of the "new normal" in higher education.

3.2. Research Method

This research adopts a qualitative case study approach as the primary methodological framework. This design allows for an in-depth exploration of the pedagogical process and student development within a real-world educational setting. Data collection employed a mixed-method strategy to ensure rigor:

Semi-structured In-depth Interviews: Conducted to elicit detailed insights into participants' experiences and perceptions.

Direct Observation: Systematically employed throughout the teaching process to track students' engagement, performance, and behavioral growth in learning activities. This triangulation of data sources ensures the validity and reliability of the research findings.

3.3. Research Samples

The study was conducted at a coastal architectural institution in Shandong, China. The primary sample consisted of 40 junior architecture students enrolled in the design course utilizing the RLL and PBL approaches. In addition to the student sample, the research involved a panel of eight experts specializing in fields relevant to the project theme, including marine ranching, offshore wind power, marine administration, marine ecology, alternative energy, civil engineering, and building technology. These experts participated in the project through semi-structured interviews conducted by the students as part of their research phase. The qualitative data were coded in the order of E1, E2, and so on (Table 1).

As this paper is being written, the teaching method has been used in other grades and classes in our school. The study has already been practiced on a large scale in the school as a proven teaching case.

Table 1. Teacher Participant Details of the In-depth Interviews.

	Personal Information	Research Field
E1	Chief engineer, at an offshore wind power development company in Shanghai	Offshore wind power
E2	Investigator, Qingdao Customs District P.R. China	Marine administration
E3	Foreign Academician, The Engineering Academy of Japan	Alternative energy
E4	Researcher, Institute of Oceanology, Chinese Academy of Sciences	Marine ranching
E5	Professor, School of Civil Engineering	Civil Engineering
E6	Professor, College of Marine Life Sciences	Marine Ecology
E7	Professor, School of Architecture	Building Technology

3.4. Procedure and Data Analysis

This study employed a concurrent mixed-methods design, collecting both qualitative and quantitative data simultaneously to ensure robust findings.

Qualitative Data: Data were obtained through semi-structured interviews focusing on the feasibility and effectiveness of architectural design projects developed using the RLL and PBL methods. Interviews lasted approximately 30 min and were transcribed and coded to protect respondents' confidentiality.

Quantitative Data: A questionnaire utilizing a 5-point Likert scale was developed to assess students' learning outcomes. Concurrently, students' architectural design proposals were assessed using a multivariate evaluation method (assessing criteria such as functionality, aesthetics, and technical feasibility). The results from both analyses were integrated (triangulated) to provide a comprehensive understanding of how this pedagogical method influenced students' innovative design skills and self-directed learning. For the quantitative analysis of the questionnaire, equal weights were assigned to all assessment dimensions, and mean values were calculated to determine central tendencies.

3.5. Ethical Consideration

Ethical approval for this study was granted by the Innovation Institute for Sustainable Maritime Architecture Research and Technology (iSMART). All participants, including students and experts, were fully informed of the study's purpose, and written informed consent was obtained prior to any interviews. Notably, ethical training was integrated into the curriculum; students were trained to draft ethical documentation—including cover letters, consent forms, and bilingual questionnaires (English and Chinese)—to foster a foundational understanding of ethical considerations in social research.

3.6. Research Process

The research process involved the practical implementation of RLL and PBL methodologies within a specialized architectural design curriculum. A third-year cohort was selected for this innovative teaching intervention, which spanned nine months beginning in May 2022. Under the instructor's guidance, students synthesized various research methods and field investigations, including direct observation, questionnaire surveys, and in-depth interviews. The entire teaching and research process was structured into three chronological stages, comprising four key sections, as illustrated in Figure 1.

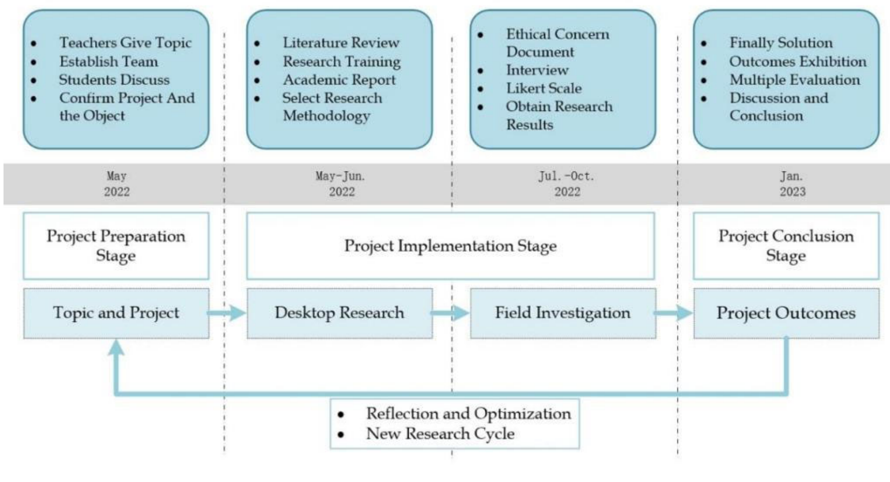


Figure 1. Research process flowchart.

3.6.1. Section 1: Topic and Project

This phase served as the preparatory stage for project implementation. The primary objective was to select an appropriate topic that matched students' capabilities while offering sufficient academic challenge. Well-designed learning projects stimulate intrinsic motivation for independent inquiry and innovation. Consequently, the students determined the specific project and research object based on preliminary rigorous study.

Initially, the instructor proposed the broad research theme, considering current "hotspots" in marine economy and ecological architecture. The 21st century is frequently termed "the century of the ocean", evidenced by the consistent annual growth of the Gross Ocean Product (GOP) in the global economy (Ma & Gao, 2018; Xie & Cui, 2020). According to the 2018 Chinese Marine Economic Statistical Bulletin issued by the Ministry of Natural Resources, China's GOP reached 8.34 trillion RMB in 2018, accounting for 9.3% of the GDP (Ministry of Natural Resources of the People's Republic of China, 2019). Thus, aligning the architectural design project with this sector connects students' academic research with critical real-world developments.

Specifically, the integration of marine ranching and offshore wind power represents a typical model of cross-disciplinary development between modern agriculture and new energy industries, holding significant economic and social value. However, current exploration in this field remains largely theoretical, lacking sufficient empirical studies (Luo & Fang, 2019). This project aimed to address this academic gap through practical design exploration.

Recognizing the high research value of this topic, students initiated a foundational literature review, identifying key problems derived from real-world conditions and national policies. Through a series of discussions and validations involving both faculty and students, the specific research project was finalized: "Optimizing the Functional Integration of Marine Ranching and Offshore Wind Power." This topic was selected for its strong relevance to current affairs and regional geographical advantages. A clear design objective was subsequently established: to provide a tangible solution for the functional integration of marine ranching and offshore wind power, thereby contributing to the sustainable development of China's marine economy.

3.6.2. Section 2: Desktop Research

The initial phase of project implementation focused on comprehensive desktop research. This stage was designed to assist students in clarifying project objectives, contextualizing the research background, establishing a robust research framework, and selecting appropriate methodologies. As a foundational component, the desktop research played a pivotal role in the project's feasibility analysis and laid the groundwork for the presentation of ultimate findings.

During this stage, students engaged with interdisciplinary and field-wide literature, systematically sifting through, extracting, and synthesizing valid information. This process served as the theoretical justification supporting their academic inquiry. The students began by analyzing national policies, current industry reports, and existing literature, subsequently contextualizing these findings within real-world problems. A critical objective was to examine the viability of integrating offshore wind power with marine ranching. To achieving this, students distilled key details from complex, interdisciplinary literature and determined the specific aims and methodology of their research.

Utilizing academic databases such as CNKI and Web of Science (WoS), students conducted systematic searches using keywords including "marine building", "offshore wind power", "marine engineering", and "marine sustainability". This allowed them to visualize the learning objectives and map the necessary content knowledge. Leveraging social research methodologies, students effectively conducted an interdisciplinary literature review tailored to their knowledge and capabilities. Team members consulted relevant technical manuals and materials to formulate an implementation plan, proposing the project site, equipment requirements, and schedule. Subsequently, they identified specific research methods and determined the presentation style for the outcomes.

Finally, students drafted an academic report in English to summarize findings from the references, strictly adhering to standard scholarly citation protocols. Under faculty guidance, they refined their research methodologies and academic writing skills through iterative revisions of their literature review and project reports.

3.6.3. Section 3: Field Investigation

The field investigation represented the most critical and resource-intensive phase of the project implementation, occupying the majority of the program's duration. In this stage, students conducted empirical studies utilizing scientific research methodologies to obtain primary data. Ultimately, students were required to synthesize diverse resources to complete their research and deliver the architectural design outcomes.

Semi-structured Interviews Building upon the preliminary desktop research, the students employed semi-structured individual in-depth interviews to collect qualitative data. The interviewees consisted of experts from representative research fields related to the design objectives, specifically marine architecture and sustainable energy. Each interview lasted approximately 30 min and focused on two core questions:

- Question 1: Based on your academic and professional experience, what is the practical significance of a marine building that integrates the functions of marine ranching and offshore wind power?
- Question 2: Based on your expertise, what specific recommendations do you have regarding the architectural design of such a functionally integrated structure?

Subsequently, data analysis techniques drawn from Grounded Theory were applied to transcribe the interview records, code the content, and extract core thematic keywords.

Questionnaire Survey Concurrently, a questionnaire survey was administered to gauge expert attitudes towards the architectural design concept of integrating marine ranching and offshore wind power. This phase spanned one week (18 August to 24 August 2022). The questionnaire comprised two key assessment items, and descriptive statistics were calculated using a five-point Likert scale (1 = Lowest/Very Poor, 5 = Highest/Excellent):

1.1: Please rate your satisfaction with the proposed design concept of functionally integrated marine buildings (Table 2).

1.2: Please rate the scientific validity of the integration model between marine ranching and offshore wind power (Table 3).

Table 2. Question 1.1—levels of satisfaction.

	Not at All Satisfied	Slightly Satisfied	Moderately Satisfied	Very Satisfied	Extremely Satisfied
Your satisfaction with the marine building that supports the functional integration of marine ranching and offshore wind power	☐	☐	☐	☐	☐

(Not at all satisfied1; Slightly satisfied—2; Moderately satisfied—3; Very satisfied—4; Extremely satisfied—5).

Table 3. Question 1.2—levels of scientificity.

	Not at all Scientific	Slightly Scientific	Moderately Scientific	Very Scientific	Extremely Scientific
Please rate the scientificity of the integration of marine ranching and offshore wind power.	☐	☐	☐	☐	☐

(Not at all scientific—1; Slightly scientific—2; Moderately scientific—3; Very scientific—4; Extremely scientific—5).

3.6.4. Section 4: Project Outcomes

Synthesizing findings from both desktop and field research, students developed a design for a functionally integrated marine building, presented as a comprehensive architectural solution. Students produced detailed design concepts, technical drawings, and functional layouts for each floor level. These outcomes were communicated through diverse media, including design proposals, academic posters, 3D digital models, and video animations.

From an architectural perspective, the design illustrated an innovative solution for synergizing marine ranching with offshore wind power. The proposed structure is envisioned as a multi-functional offshore platform that extends spatial and energy resources to support auxiliary industries and critical marine activities. These functions include hydrological and meteorological monitoring, maritime search-and-rescue operations, earthquake observation, and maritime security. To achieve this functional integration, the design incorporated three key components (as illustrated in Figure 2):

- The top: wind turbine. Generating electricity and supplying energy to the equipment of the building and into the public grid.
- The middle: living platform. Establishing space for installing all equipment modules of wind turbines and fish farms (e.g., electricity power storage, water quality monitoring, and sea creature behavior tracking) and serving people (e.g., engineers, researchers and deep-sea fishing tourists) with accommodation.
- The bottom: reef foundation. As the supporting part of the entire marine building, provides a livable environment with appropriate shapes and skins to target marine organisms. It can also be fixed with breeding cages to expand the farm area.

This middle marine building consists of three layers—first floor, second floor, and basement, covering a deck area of 458 m^2 (263 m^2 for basement deck; 195 m^2 for first-floor deck) and a structural area of 436 m^2 (65 m^2 for basement; 206 m^2 for first floor; 165 m^2 for second floor) (Figure 3). All floors are interconnected while simultaneously separated by vertical circulation systems.

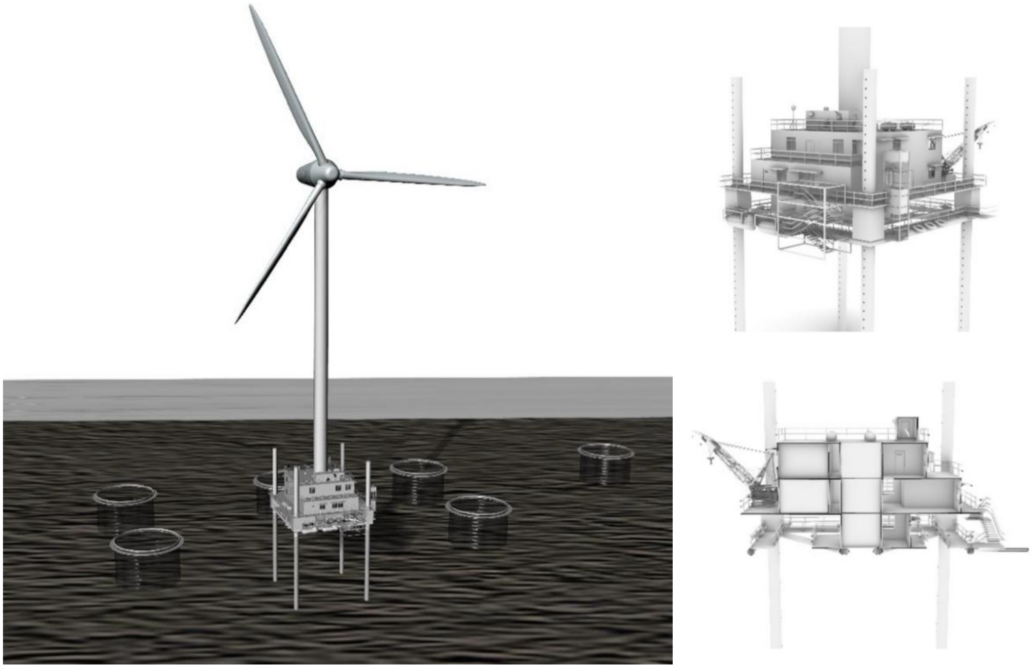
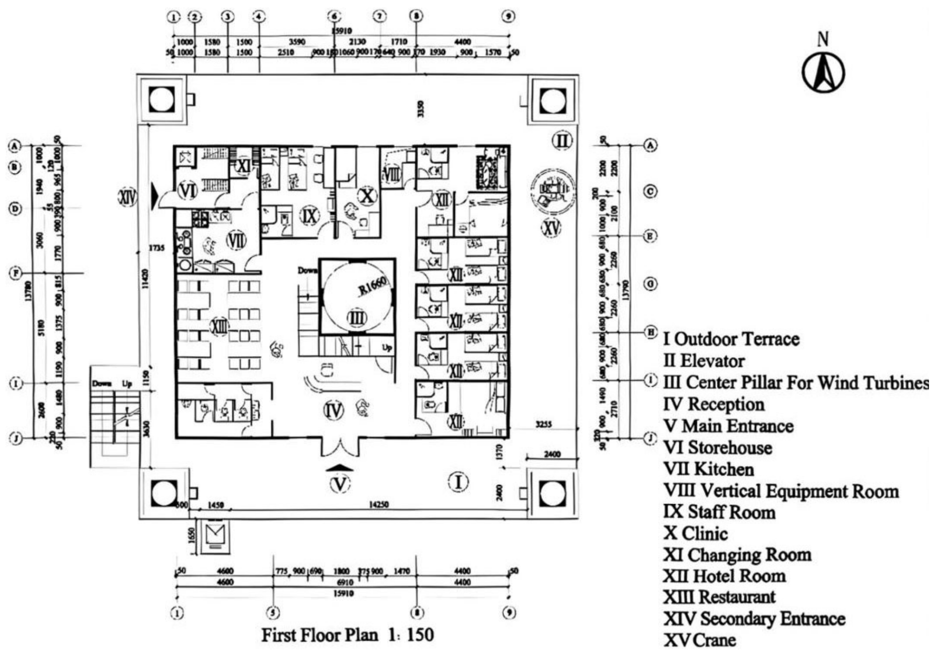


Figure 2. Design schemes of the marine building—perspectives (**left**) and sections (**right**).

The first floor functions as a hotel, mainly providing tourism services and accommodation. The second floor is an office area that provides space for equipment, engineers, and researchers based on the spatial requirements of volumes and number of attendants. The basement is designed for leisure activities, where tourists can engage in deep-sea fishing on the deck and make rough processing, storage, and cooking. The basement also features bar areas for socializing and entertainment.

The second floor is structured to support advancements in information technology and intelligent systems, while the other levels enhance the building's service-oriented functions. This multi-functionality helps reduce both construction and operational costs. Emergency escape devices are strategically located in the basement.



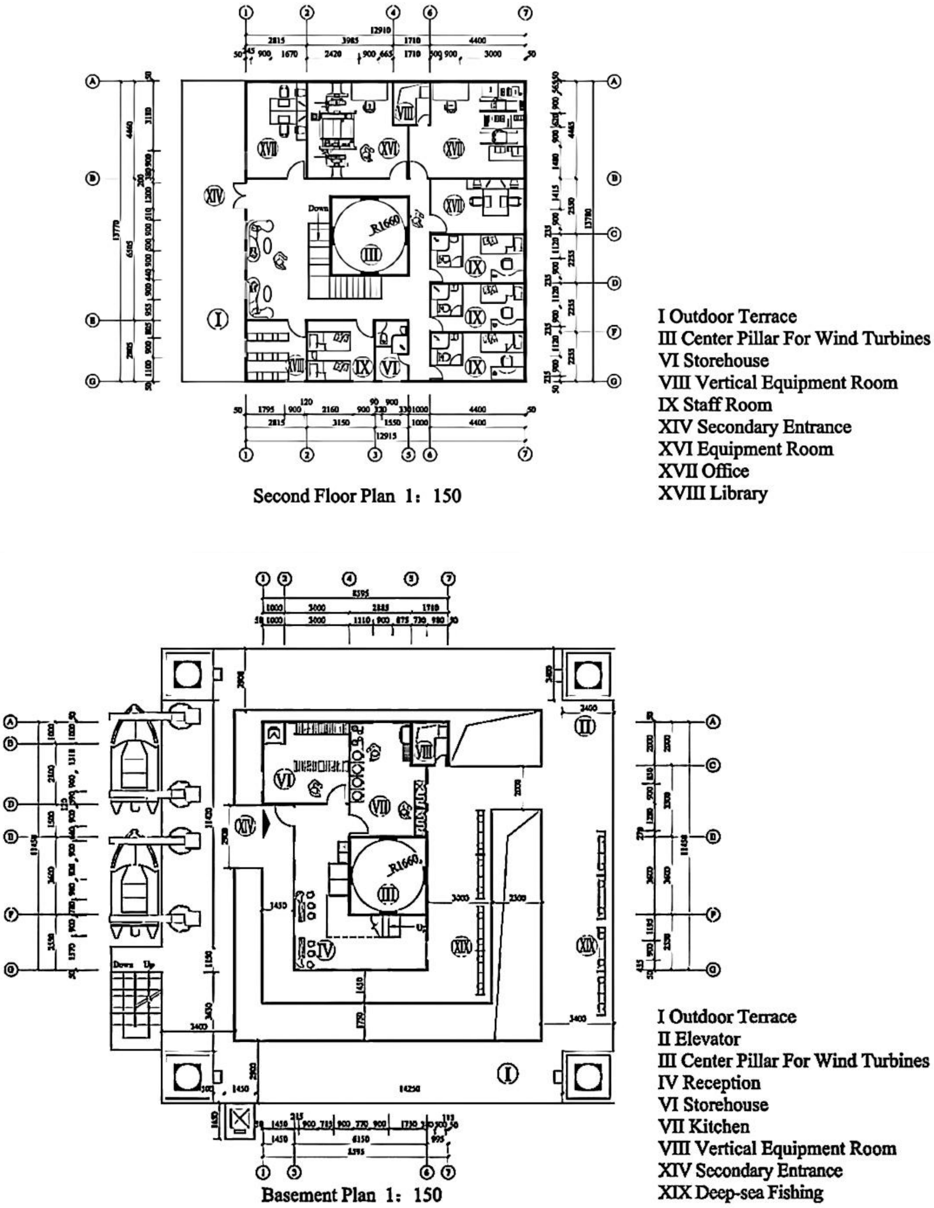


Figure 3. Design schemes of the marine building—floor plans.

To further its role as a multi-functional offshore platform offering expansion for other industries and activities, the second floor has reserved additional space for new devices. A vertical equipment room (No. VIII) runs through the building for the installation of pipelines. There are five pillars in total. The center pillar (No. III) is for the wind turbine, and it has the functions of disassembly and replacement as there is a clear difference between the running life of wind turbines and building structures. The other four side pillars are for the structure and artificial fish reefs. They support the entire building, and at the same time, they have a set of elevators (No. II) to adjust the distance between the building and sea level at any time.

Identifying an appropriate evaluation method in PBL is a complex task that requires careful consideration of several factors: who will perform the evaluation, what the basis and criteria will be, and how students' mastery of knowledge and skills will be measured (Helle et al., 2006; Marx et al., 1997). Consequently, this study employs a multi-dimensional evaluation framework, integrating both formative and summative assessments. Various stakeholders—including teachers, students, and external experts—were invited to participate in the process. This comprehensive approach incorporates student self-assessment, peer review, teacher appraisal, and external expert evaluation to assess the entire learning trajectory. The primary evaluation criterion was the extent to which the process fostered active learning and comprehensive competencies. By triangulating evaluations from multiple subjects based on project outcomes, the assessment results became more reliable and thorough. Finally, the research team summarized these findings to initiate a new research cycle.

- Summative Evaluation: As a critical component of this project, summative evaluation assessed the final project outcomes to measure overall success. Specifically, the project was evaluated based on the quality and feasibility of the integrated marine architecture design. Teachers, external experts, and peers contributed to assessing how effectively the research findings were translated into the final design scheme.
- Formative Evaluation: Formative evaluation permeated the entire learning process, utilizing qualitative criteria to assess students' learning status and depth of inquiry. It described the learning trajectory from multiple dimensions, ultimately portraying students' overall performance and reflecting the unity of "teaching-learning-evaluation".
- Student-Led Evaluation (Self and Peer Assessment): This dimension empowered students to take ownership of their learning. Self-assessment allowed students to reflect on various aspects, including topic selection, methodology, writing, and overall performance. Peer assessment was equally crucial, evaluating individual contributions and growth within the group context. These mechanisms facilitated mutual learning and personal development throughout the process.
- Teachers' Evaluation: Teachers employed an integrated approach, combining formative and summative evaluations. The ultimate goal was to foster students' growth as researchers and enhance their comprehensive abilities. Teachers systematically observed and assessed how learners organized and managed their work, formulated plans, conducted research, executed tasks, and presented their findings.

4. Results

4.1. Results of Desktop Research

The desktop research yielded significant findings regarding the current state and future trends of marine utilization. Firstly, the research defined marine ranching as artificial fishery habitats established based on marine ecological principles and modern marine engineering technologies to cultivate marine organisms with economic value in designated regions (Ning et al., 2015; Yang, 2016). Data analysis indicates that China currently hosts 90 national-level marine ranching demonstration zones, with an additional 178 projects scheduled for construction by 2025 (Li et al., 2019; Zhang et al., 2022).

Secondly, the literature review identified wind power as a dominant force in renewable energy generation, noting that offshore wind power is poised to become the "center of gravity" for the market's future expansion (Min et al., 2016). Offshore wind power technology is recognized as a critical alternative, representing a significant portion of the global renewable energy potential.However, the research also revealed that its development is currently hindered by challenges related to marine functional zoning, ecological protection, and regulatory constraints.

Crucially, the desktop research highlighted a growing academic and industrial consensus on integrating offshore wind power with marine ranching. As China enters a period of "cost parity" in offshore wind development, this combined model is projected to improve the ecological sustainability of offshore wind farms while fostering high-quality marine economic growth. The findings suggest that this "Marine Ranching + Offshore Wind Power" model represents an intensive solution for sea use, offering the potential to lower operational costs, increase economic benefits, and fulfill multi-energy synergy.

Based on these findings, the project identified the integration of marine ranching and offshore wind power as a cutting-edge social development issue within the construction and marine engineering industries. The theoretical solutions synthesized in this stage provide practical frameworks for this integration, thereby contributing to the long-term sustainability of the modern ocean economy.

4.2. Results of Surveys and Interviews

Given the nascent stage of research on integrating marine ranching with offshore wind power, the effectiveness of multidisciplinary applications in this domain remains under-explored. Consequently, expert validation was crucial.

Quantitative Survey Results: The survey data demonstrated a highly positive expert consensus.

- In response to Question 1 (Satisfaction with design concepts), experts reported a mean score of 4.43/5.0, indicating strong satisfaction with the development prospects of the proposed marine architecture.
- For Question 2 (Scientific validity), a score of 4.71/5.0 signified expert acknowledgment of the students' proposals, recognizing the scientific rigor and innovation displayed in the integration model.

Qualitative Interview Insights: The interviews aimed to solicit expert feedback on design methodology and value to facilitate iterative improvements in student work. Qualitative data were collected and analyzed, from which students extracted key themes to refine their designs. Experts underscored the criticality of ensuring building safety, regional service integration, functional stability, environmental sustainability, and ecological restoration.

- Safety and Durability: Experts emphasized that the selection of construction materials and structural systems must prioritize the building's performance, stability, and safety in harsh marine environments.
- Emergency Strategies: Several experts recommended the development of explicit fire-fighting, evacuation, and maritime rescue strategies, aligned with the building's layout and the broader coastal planning framework.
- Ecological Function: Crucially, experts argued that marine buildings should transcend mere utility to include ecological restoration functions, thereby creating genuinely eco-friendly marine structures.

4.3. Results of the Multiple Evaluation

Overall Effectiveness: The summative evaluations demonstrated that the final marine architectural design schemes effectively synthesized the findings from both desktop research and field investigations. The integration of Research-Led Learning (RLL) and Project-Based Learning (PBL) empowered students to adopt divergent perspectives and innovative strategies, enabling them to explore the complexities of the discipline. Through a holistic process involving knowledge acquisition, practical application, and value formation, students synthesized multidisciplinary knowledge to enhance their comprehensive literacy and higher-order thinking skills. Furthermore, the study confirmed that this pedagogical approach is not only feasible and effective in architectural education but also holds significant research and practical value for functionally integrated marine architectural design.

Student Perspective: From the students' perspective, there was a general consensus that the learning process centered on PBL significantly raised their awareness of independent inquiry and motivated self-directed learning. As evidenced by peer evaluations, the establishment of a "learning community" facilitated robust knowledge exchange and collaboration, thereby enhancing teamwork. Students experienced tangible personal growth and benefited from insightful feedback provided by their peers.

Faculty and Expert Perspectives: From the faculty perspective, evaluations indicated that students demonstrated increasing independence in identifying problems and developing solutions as the project progressed. Under faculty guidance, students efficiently initiated research and achieved project goals through self-directed inquiry, successfully mastering research techniques to complete the integrated marine building design. Teachers acknowledged this learning process and provided constructive feedback to encourage deep self-reflection. Additionally, interviewed experts recognized the novelty and technical rigor of the design proposals. They affirmed that the undergraduates displayed the innovation and curiosity essential for future leading architects.

5. Discussion

5.1. The Pedagogical Approach for Developing Students' Key Competencies

The study demonstrated that the pedagogical approach effectively developed students' key literacy skills, including critical thinking, sustainability thinking, self-directed learning, collaborative inquiry, problem-solving, innovation, and interpersonal skills. This teaching organization method is flexible; it facilitates the deconstruction and reorganization of complex content according to different learning objectives, thereby optimizing knowledge structure, enhancing professional competence, and integrating various aspects of comprehensive innovative ability through projects. Students were encouraged to explore diverse solutions, which fostered creative thinking and independent inquiry. From literature review to field investigations, students learned to collect and integrate complex materials in alignment with research objectives, establishing a critical understanding of phenomena through self-reflection and motivated learning. In this sense, critical thinking endowed students with the ability to balance creativity and rationality, effectively elevating their mindset and professional skills.

Another significant outcome of this research-led and project-based learning approach resides in "cooperation". Students learned to articulate and exchange ideas logically and clearly, utilizing visual tools to present their concepts. This process enhanced their learning initiative, fostered a positive outlook on problem-solving, and improved their adherence to pertinent regulations. During the data collection stage, students were encouraged to consider various situations and respond dynamically to emerging realities. This adaptability was demonstrated in their exchanges with peers, consultations with faculty, and interactions with other stakeholders, through which they significantly developed their interpersonal and communication skills.

Furthermore, this approach established clear learning objectives while providing sufficient flexibility, allowing students to assume the role of "researchers." Students adopted various research approaches during problem-solving, flexibly adjusted their learning strategies according to research objectives, actively constructed new knowledge, and ultimately proposed project solutions. This process fostered accountability and selfassurance, motivating students toward continuous growth. By shifting from passive recipients of knowledge to active, engaged learners, students experienced a profound transformation in their approach to learning and academic exchange.

Finally, the pedagogical approach connected students' research with reality by engaging them in the discovery of social needs and real-life scenarios. In this process, students' sustainable development abilities and multiple intelligences were cultivated and enhanced, laying the groundwork for future research and providing a broader scope for practice. Consequently, students experienced the intrinsic satisfaction of self-directed learning, facilitating the transfer and integration of acquired knowledge into practice. At the same time, the sense of achievement and appreciation for the power of knowledge generated new research questions and projects, driving them towards higher levels of independent research.

5.2. The Pedagogical Approach for Teachers' Research and Teaching

Research-led and project-based learning place significant demands on teachers, leading to a transformation in their roles. Throughout the project implementation, the teacher assumes multiple roles, including project organizer, manager, creator, facilitator of learning, and educational researcher, while students act as the knowledge producers and primary drivers of the projects. Active learning, as facilitated by this pedagogical model, does not diminish teachers' involvement compared to traditional lecture-based teaching. On the contrary, the success of such projects is dependent on teachers' guidance and supervision at critical stages. Specifically, scholars and educators should embrace technologies to assist their teaching and research, and simultaneously provide guidance to help students use new technologies appropriately, taking into account both the positive and negative impacts on critical thinking development (Lin et al., 2025).

Teachers' "teaching" and "research" are inextricably linked in this pedagogical approach. For example, during field investigations, teachers addressed students' inquiries regarding research methods, organized learning activities, and provided essential pre-training. This training encompassed key methodological concepts, including the distinctions between unstructured, semi-structured, and structured interviews, as well as the principles of in-depth interviewing. Furthermore, it covered quantitative techniques such as questionnaire design, Likert scales, and statistical analysis (e.g., mean and median values), alongside qualitative analysis, ethical considerations, and application procedures. Moreover, teachers guided students in interview preparation, assisting them in establishing contact with potential experts, observing the interview process, and providing feedback on their performance. This necessitates that teachers possess a profound comprehension of these methodologies to deploy them effectively. Additionally, as students conducted their studies, their continuous production of new ideas and findings provided fresh inspiration for the teachers' own research.

This pedagogical approach prompts college teachers to rethink strategies for architectural education and reflect on their qualifications for implementing these strategies. Teachers are encouraged to engage beyond the academic campus and translate theoretical research into practice. By consciously integrating social development with research, teachers refine teaching projects, gain practical experience, and enhance their pedagogical competencies. Ultimately, this innovative model will enrich teaching methods and cultivate high-quality talents that meet societal demands.

5.3. Practical Application Analysis of this Pedagogical Approach

In the contemporary context, higher architectural education is compelled to establish a pathway that bridges scientific research with sociological research methods, while integrating architectural design with real-world challenges. Although research-led and project-based learning effectively address certain deficiencies in prevailing higher architecture pedagogies, scholarship and practical applications of this approach remain limited within this domain. This underscores the significance of the present case study in providing a practical exemplar for modern higher architectural education.

This study selected a representative case in higher architectural education to explore and verify how research-led and project-based learning promotes the key competencies of teachers and learners. The research found that this pedagogical approach, exemplified by the "Marine Building of Functional Integration" research project, provided students with an immersive learning environment where learning was seamlessly integrated with practice and research. As a practical implementation of Research-Led Learning (RLL), Project-Based Learning (PBL) positions students as active drivers of knowledge acquisition, emphasizing their individuality and innovation. The findings confirmed that this method effectively encourages college students to actively seek new information, formulate new research questions, and master new skills. Consequently, it significantly improves their comprehensive problem-solving abilities—including critical thinking, adaptive learning, and creativity—as well as their awareness of social responsibility. Upon completion of such projects, students are naturally propelled into subsequent research cycles, fostering their continuous professional development.

Furthermore, the study demonstrated that the research-led and project-based learning approach is highly dynamic and adaptable within architectural education, making it applicable to a wide range of pedagogical contexts. The findings of this study offer a robust framework, assisting administrators and educators in reconsidering teaching systems and the adaptability of architectural curricula. Moving forward, architecture teachers can draw on the theories and approaches outlined in this case, rationally integrating information technologies, and implementing self-directed PBL strategies to cultivate high-quality talents.

6. Conclusions

The research presented a case study elucidating the application and operationalization of research-led and project-based learning as pedagogical approaches in higher architectural education. It began by systematically delineating the definition, theoretical foundations, and operational mechanisms of this teaching philosophy, emphasizing a constructivist and self-directed learning approach. This philosophy provided a robust theoretical framework for the case study. Subsequently, the research offered a granular analysis of the students' self-directed learning trajectory, encompassing project definition, goal setting, literature review, methodology selection, sociological research development, architectural design, and the final presentation of learning outcomes.

The empirical findings of the study demonstrate that research-led and project-based learning represent an innovative and highly effective pedagogical paradigm for architectural design courses. This approach empowers students to synergize research with practice throughout the learning process, significantly enhancing the key competencies required to address complex real-world challenges and sustain self-directed learning in higher architectural education. The results validated the efficacy of these methods in fostering autonomous inquiry and problem-solving abilities, furnishing actionable insights for educators, researchers, and practitioners within the architectural domain.

Looking ahead, future work will expand the scope of this research by conducting comparative and cross-institutional studies across architectural design departments at diverse universities to further validate the findings and ensure generalizability. As a dynamic and sustainable pedagogical strategy, research-led and project-based learning is poised to play a pivotal role in bridging the schism between academic research and professional practice. Ultimately, this approach will serve as a catalyst for a paradigm shift, reshaping the teaching philosophies and methodologies of higher architectural education to meet the evolving demands of the future.

Author Contributions

Conceptualization, Q.B. and F.R.; methodology, Q.B., and F.R.; investigation, K.W., F.R. and H.D.; data curation, K.W. and F.R.; writing—original draft preparation, F.R. and K.W.; writing—review and editing, Q.B. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted following the Declaration of Helsinki, and received approval from a committee named Innovation Institute for Sustainable Maritime Architecture Research and Technology (iSMART) (The certificate number was 2022-5-22-01).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patients to publish this paper.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Conflicts of Interest

The authors declare no conflict of interest.

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