buildings

Article

Mechanisms of Learning and Innovation in Project Performance: Evidence from Chinese Hydropower Industry

Senchang Hu [†], Heng Zhao [†] and Wenzhe Tang *

State Key Laboratory of Hydroscience and Engineering, Institute of Project Management and Construction Technology, Tsinghua University, Beijing 100084, China; hsc21@mails.tsinghua.edu.cn (S.H.); zhaohang22@mails.tsinghua.edu.cn (H.Z.)

* Correspondence: twz@mail.tsinghua.edu.cn

† These authors contributed equally to this work.

Abstract: Hydropower, a renewable energy resource, underpins China's economic and social advancement, gaining prominence amidst the country's energy structure metamorphosis. Enhancing the performance of hydropower development projects is imperative, with the mechanisms of learning and innovation wielding a substantial impact. The extant literature on how learning and innovation affect hydropower project performance remains nebulous, lacking a systematic model to elucidate these impact mechanisms. This investigation melds theoretical analysis with the idiosyncrasies of hydropower project development, forging a theoretical model to decipher the interplay of learning, innovation, and project performance. Employing a mixed-methods approach, we probe the influence of organizational learning orientation and individual learning on participant capabilities, engineering innovation magnitude, and overall project performance. Path analysis divulges that organizational learning orientation catalyzes individual learning, jointly enhancing engineering innovation and project performance directly, although the effect on each participant's capability necessitates mediation through the engineering innovation level. This pioneering study establishes the links and influence trajectories between learning, innovation, and project performance, systematically delineating them. It fills a scholarly void in exploring learning and innovation mechanisms within hydropower project development, propounding strategies to augment project efficiency and furnishing pragmatic, constructive insights for better engineering practice outputs.

Keywords: hydropower development; project level; learning system; engineering innovation; project performance

check for updates

Citation: Hu, S.; Zhao, H.; Tang, W. Mechanisms of Learning and Innovation in Project Performance: Evidence from Chinese Hydropower Industry. *Buildings* **2023**, *13*, 2665. https://doi.org/10.3390/buildings13102665

Academic Editors: John Kamara and Jurgita Antucheviciene

Received: 21 August 2023
Revised: 30 September 2023
Accepted: 16 October 2023
Published: 23 October 2023

1. Introduction

In recent years, the rapid development of China's economy has been accompanied by the continuous growth of electricity consumption across the whole society. Hydropower is an important part of the national renewable energy strategy. China's hydropower generation has been increasing steadily every year, and the installed power generation capacity and the number of hydropower development projects are also growing steadily [1,2].

Hydropower holds a pivotal role in the energy infrastructure of China, reliably meeting electricity demands across a broad spectrum of regions and industries. It contributes to 15–20% of the nation's electricity generation. Relative to alternative power generation modalities, hydropower presents a lower environmental footprint, a more sustainable supply chain, and a well-established development and management paradigm, thereby rendering multifaceted benefits to societal production and living standards [3–5]. Water conservancy and hydropower projects leverage the potential energy of water for electricity generation, thereby offering a clean energy source with minimal environmental pollution and zero carbon dioxide emissions. The hydropower development project studied in this paper includes four phases: a project feasibility study, project design, project implementation, and project closeout, each presenting its own set of technical challenges. Addressing these challenges necessitates the incorporation of advanced technological solutions and innovative approaches to resolve both technical and managerial hurdles [6,7].

In the context of China's carbon neutral and carbon peak strategies, hydropower, positioned as a substitute for fossil energies, holds prominence. Advancements in hydropower can pare down fossil energy utilization, cut carbon dioxide emissions, and mitigate air pollution. This underscores the imperative of enhancing the engineering performance of hydropower projects [8]. Conventional hydropower, especially leading reservoir power stations with strong regulating capacity and pumped storage power stations, is an important regulating resource for the power system, and can provide important support for the construction of a new type of power system [9].

In hydropower engineering projects, project performance is critical. Hydropower engineering projects aim to achieve efficient power generation, water storage, and other functions. In hydropower projects, controlled project duration, improved project safety, environmental protection, and other project performance factors can reduce the impact of the project on the environment, especially reducing the unnecessary loss of material and human resources in hydropower projects, achieving sustainable development of the project, and reducing carbon emissions [10,11].

The contribution of learning and innovation mechanisms to corporate performance has been widely recognized, but few studies have explored the contribution of learning and innovation to the performance of hydropower development projects. However, hydropower development projects extensively involve learning and experience acquisition as well as the innovation of enterprises and employees, so it is necessary to explore how learning and innovation mechanisms can promote the engineering performance of hydropower development projects [12,13].

This study endeavors to elucidate the role of learning and innovation in hydropower project development, forge a robust model delineating their influence on project outcomes, and distill pragmatic recommendations for engineering praxis. Rooted in empirical scrutiny, our insights derive from in-depth engagements with large-scale terrace power stations located in the Jinsha River's hydropower base.

The subsequent structure of this paper is as follows: Section 2 undertakes a comprehensive literature exploration, touching upon facets of corporate and individual learning situations, enterprise innovation, engineering-focused innovation, and project performance. Section 3 introduces a conceptual model elucidating learning and innovation in hydropower and posits empirical research inquiries. Section 4 elaborates on the quantitative research approach, shedding light on the rationale behind selecting specific qualitative case projects for an exhaustive examination. Section 5 unfurls the findings and their subsequent analysis. Section 6 employs path analysis, deconstructing the repercussions of organizational learning orientations and individual learning situation trajectories for participant competencies, the level of engineering innovations, and overall project outcomes. Section 7 distills the salient contributions of this study, suggesting actionable strategies for stakeholders in hydropower projects to elevate project performance. Section 8 encapsulates the findings, accentuating research constraints and prospective research avenues.

2. Theoretical Background

2.1. *Enterprise and Individual Learning Situation*

Enterprises, during their growth, lean on more than just tangible assets such as financial resources, equipment, land, and infrastructure. Increasingly, they focus their strategies on intangible assets, primarily rooted in human capital. These assets encompass organizational culture, knowledge repositories, technical proficiencies, regulatory frameworks, brand equity, and so on.

In the long-term development of enterprises, the experience of past business activities plays an important supporting role that can guide future production decisions and maximize enterprise benefits. At the same time, the method of knowledge management and the learning system in the process of enterprise development affect the ability of the enterprise to integrate various other resources to provide products or services, and the shaping of enterprise learning ability and learning systems is an important support system within an enterprise [14,15]. Constructing a learning atmosphere and promoting knowledge transfer can promote the coordination of resources and the innovation and development of enterprises; enterprises need to adopt this management style to not only ensure that employees master their own work, but also to establish the mechanism of information linkage between the employees themselves and the enterprise. This ability is crucial to the long-term development of an enterprise because it is the basis for the consolidation of the development of other capabilities. In the conditions of the knowledge economy, organizational learning, innovation, and organizational management are the most important intangible assets for companies to acquire in order to improve performance [16].

The ultimate purpose of learning activities in an enterprise is to serve each individual, and the realization of the specific goals of enterprise development must also depend on each individual [16,17]. Therefore, our research on enterprise learning ability also needs to focus on the study of individual learning ability at the same time. Defining an employee's learning ability is the level of his ability to absorb new knowledge based on his skills and experience, while the learning process of an employee consists of two parts: a rich knowledge base within the system and the individual's intensive expenditure of energy; the two are closely linked in laying a good foundation for an individual's capacity building [18,19]. The support of the knowledge system strengthens the effect of the intensive efforts of employees in the learning process, the transfer and exchange of information enables the understanding of new theories and technologies, and the discoveries made in the learning process lead to new inspirations and many new tasks based on such inspirations [20].

2.1.1. Components of Enterprise Innovation Capabilities

Schumpeter pioneered the theory of innovation, conceptualizing it as a recombination of production factors in "The Theory of Economic Development" (1912). Since then, the research on the connotation and mechanism of innovation on various levels has become richer and richer [21].

Enterprise innovation comprises any new or significantly improved product (goods or services), operational process (paths of production and service delivery), marketing method (packaging, distribution network for sales and distribution), workplace, or external relations in the implementation of new organizational structures and new management practices. When knowledge is commoditized, firms generate innovation, which appears in the form of new products, services, processes, or business models [22,23].

The presence of a comprehensive knowledge ecosystem within an enterprise augments the scope and depth of its innovative endeavors. This expansive innovation landscape invariably bolsters the performance metrics of the firm [24,25].

2.1.2. Factors Influencing Innovation Capacity

Optimizing the size and structure of linkage channels within a knowledge transfer network significantly boosts innovation output. A robust organizational system yields enhanced operational returns. Facilitating open innovation demands multifaceted support, notably from knowledge reservoirs and diverse external variables [26].

The germination of innovation within team-building hinges upon an organization's intrinsic innovation milieu. This is further anchored in organizational vision, security perception, task orientation, and the inherent support matrix [27].

The team climate stands as an integral pillar buttressing innovation. With innovation being quintessential for an organization's legacy and success, organizational evolution invariably necessitates systemic and structural shifts [28].

2.1.3. Engineering Innovation

In engineering, innovation often diverges from pure technological novelty to knowledge transformation. Predominantly, emergent technology is rooted in engineering's market-centric applications, converting foundational scientific advancements into tangible economic value while streamlining and enhancing technological assortments [29–31].

At the same time, the organizational structure of engineering innovation is more complex, often relying on the project system, which is characterized by temporary and diverse participating subjects, which requires us to comprehensively consider, synergistically analyze, and continuously deepen research from the enterprise level to the project level [32–34].

Hydropower engineering projects have special characteristics, such as water conservancy hubs relying on natural construction and the uniqueness of the geographic environment of each project, which means the optimization, improvement, and innovation of technology and management levels profoundly determines the quality of the project, as well as its advantages and disadvantages [35,36].

2.1.4. Component Structure and Relevance of Engineering Innovation

Engineering innovation comprises not only improvements at the technical level, but also changes in management structures, social influence, marketing channels, and other aspects. Optimization and innovation in the engineering field is not necessarily a spontaneous creation or invention; the use of technology, materials, equipment, etc., from other professions that have never before been applied in the engineering field in a specific project and bring about an increase in benefits can also be called an effective and referable engineering innovation. Engineering innovation can be broadly categorized into innovation in the field of technology and innovation in management methods [37,38].

Engineering is a key bridge for transforming production technology into economic benefits, and engineering innovation should be the focus of attack for the cultivation of national innovation capacity, paying attention to the overall coordinated development of all aspects [38].

2.2. Project Performance

A project represents a conduit through which enterprises execute specific economic activities, with project performance delineating accomplishment metrics across various facets of the activity [39,40]. It is anchored on predefined objectives, commonly benchmarked using parameters such as duration, cost, and quality, while concurrently accounting for health, safety, and environmental stewardship. A robust assessment of project performance mandates an integrative appraisal across all process phases and project domains, with the synergy among all involved parties being pivotal for achieving desired engineering project outcomes. The inherent complexity of projects escalates the challenges in quantifying performance, underscoring the need for a thorough, accurate, and objective evaluation framework as a focal point for encapsulating project outcomes. Realizing optimal project performance not only amplifies the project's return but also aligns with the interests of all stakeholders. There are eight main aspects of performance in hydropower development projects, including safety, quality, health, environmental protection, schedule, problem solving, cost, and migration [41,42]. The process of innovation, alongside the emanating novelties, significantly influences project performance, serving as critical determinants of project quality and organizational efficacy [43,44].

3. Theoretical Modeling

3.1. Impact of Organizational Learning Orientation

A conducive organizational atmosphere assists members in enhancing their learning frameworks, alleviates apprehensions related to uncertainties, and fosters the dissemination and adoption of novel technologies and capabilities across individuals. This enriched environment encourages interdisciplinary exchanges and expedites the surfacing of tacit knowledge, thereby elevating the collective knowledge of members, augmenting individual problem-solving efficacy, and ultimately ameliorating organizational operational efficiency [45]. The resultant optimization in operational efficiency underscores the positive trajectory of organizational performance [46]. Through the corroboration of pertinent research findings and logical affiliations, this paper posits that a favorable organizational learning orientation augments individual learning, which in turn necessitates a guided approach to individual learning to elicit tangible impacts on project operation.

Hypothesis 1. *A good organizational learning orientation positively influences individual learning situations.*

3.2. Impact of Individual Learning Situations

An examination of innovative firms reveals that the instillation of an organizational learning culture—achieved through mergers, educative discussions for newly onboarded researchers, and collective new-course training—facilitates enhanced communication among personnel and fosters skill acquisition, leading to a substantial augmentation in the firm's innovation capacity [47].

Individuals, being the specific execution entities within the extensive framework of engineering projects, manifest a direct, positive correlation between their learning metrics and the facets of innovation capacity, participant aptitude, and project performance. Initially, innovation realization necessitates that participants assimilate and glean insights from prior project experiences while mastering the rudiments of emerging technologies and systems; thus, nurturing innovation capability is inextricably linked to individual learning.

Subsequently, it is imperative that knowledge dissemination within a project is efficacious. Enhanced dissemination and interchange of knowledge across the organization propels the capacity of each participant, attributable to a broader spectrum of individuals across varying hierarchies and sectors being privy to novel knowledge, thereby fostering complete empowerment.

Lastly, an individual's learning trajectory directly influences their performance caliber, which, in turn, is aggregated to reflect the project's overall performance. Thus, superior individual learning parallels an elevated collective performance in a project, underscoring the criticality of learning as a lever to boost project efficacy.

Hypothesis 2. *Enhanced individual learning situations positively influence the level of engineering innovation*.

Hypothesis 3. *Enhanced individual learning situations positively influence the competencies of each participant*.

Hypothesis 4. *Enhanced individual learning situations positively influence the level of engineering innovation.*

3.3. Impact of the Level of Engineering Innovation

The established literature robustly underscores the positive correlation between innovation and core competencies, with numerous studies elucidating the link between an enterprise's innovation capacity, business acumen, and overall performance through the lens of inter-functional coordination and teamwork [17,48]. In the realm of corporate research and development, the novelty and uniqueness of a product are deemed crucial assets for business success [49,50]. Particularly in hydropower development projects, the advent of novel processes and organizational structures markedly augments project efficiency and fosters enhanced collaboration among stakeholders.

Hypothesis 5. *An augmentation in the level of engineering innovation positively influences the competencies of each participant.*

3.4. Impact of Capabilities of Project Participants

Interdepartmental integration is pivotal for attaining overarching project objectives. This integration is fostered through avenues such as personnel mobility, informal social systems, organizational structure, incentives, and the formal synchronization of management processes, wherein a well-coordinated organizational framework significantly influences the fruition of the ultimate objective [51,52]. The substantial scale and complexity encapsulated in both the natural and social realms of hydropower projects necessitate a collaborative endeavor from owners, designers, contractors, and other involved entities to pool their competencies for successful project completion. In this discourse, we posit that the capabilities of each project participant wield a decisive and direct impact on project performance [53,54].

Hypothesis 6. *Enhancing the competencies of each participant positively influences the project performance.*

3.5. Theoretical Model of Learning and Innovation in Hydropower Development

Drawing from the foregoing literature analysis and hypothesis delineation, this research proffers a subsequent theoretical model elucidating the interplay of learning and innovation within hydropower development. The theoretical model is shown in Figure 1.

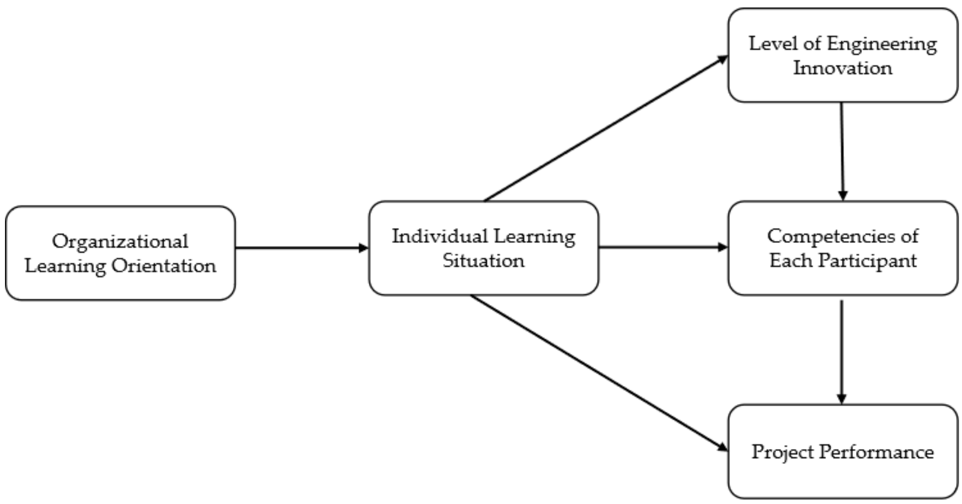

Figure 1. Theoretical model of learning and innovation in hydropower development.

The elements in the model are defined as follows.

Organizational learning orientation: the construction of a knowledge management system, learning support system, and communication platform among members in the organization.

Individual learning situation: the status of individual active learning consciousness, knowledge acquisition channels, and learning ability cultivation.

Level of engineering innovation: the status of hydropower project improvement and optimization and introduction of new technologies and modes in the stages of planning, design, construction, and migration.

Competencies of each participant: the business capacity of owners, designers, contractors, and other stakeholders involved in hydropower project development.

Project performance: comprehensive performance evaluation of hydropower projects in terms of progress, HSE, and other aspects.

4. Research Methods

4.1. Questionnaire Design and Data Collection

This study employs a questionnaire to amass quantitative data, analyze said data, evaluate hypotheses, and formulate a model delineating the interplay of learning and innovation in hydropower development. The questionnaire, a meticulously crafted structured survey tool, facilitates the gathering of research information from subjects in alignment with specified investigatory objectives. This method not only enhances the efficiency of data collection but also simplifies subsequent statistical processing and analysis. The data harvested through this medium tend to be more objective and distributed, thus accurately mirroring the realities of engineering projects.

In addition to collecting quantitative data, this study conducted qualitative research in the form of interviews and the collection of project documents. The interview methodology helped to generate useful and important information about what people perceived and how they interpreted their perceptions, thus providing an opportunity to reveal underlying knowledge. Project documentation enables the reliability of theoretical conclusions to be tested against practical examples. The adoption of a combination of quantitative and qualitative research methods enabled the researcher to scientifically and systematically study the mechanisms of learning and innovation on project performance [55,56].

Questionnaires were administered to managers and technicians engaged in prominent hydropower projects including Baihetan, Wudongde, and Nuozhadu. Utilizing a Likert seven-point scale to quantify indices [55], the survey encompassed: respondent demographics, appraisal of individual and organizational learning dynamics during the project, assessment of participant competence and collaboration, and evaluation of individual and project performance. Respondents, key managers, and technicians representing project stakeholders—owners and design, construction, and supervisory engineers—hail from varied organizations, bringing valuable professional expertise to ensure authentic project status representation through the collected data. Of the 563 questionnaires disseminated and retrieved, 459 were deemed valid based on the study's information criteria, reflecting a validity rate of 81.5%. Respondent demographics are delineated in Table 1.

Table 1. Basic information of respondents.

Basic Information	Classification	Percentage
Gender	male	91.2%
	female	8.8%
Educational level	doctoral degree	2.4%
	master's degree	17.0%
	bachelor's degree	59.3%
	college degree or below	21.2%
Position	company management	6.9%
	company department staff	14.3%
	project management	22.6%
	project subsector staff	54.4%
	other positions	1.8%
Working years in the hydropower industry	1–3 years	19.2%
	4–10 years	31.2%
	11–20 years	27.9%
	over 20 years	21.7%
Project experience	1–3	62.1%
	4–10	32.6%
	over 10	5.3%

Within case studies, qualitative analysis enhances the robustness of quantitative models. The focus of qualitative information collection encompasses engineers and pertinent case materials from frontline engineering endeavors of notable hydropower projects in recent times, including Udonde, Baihetan, Xiluodu, and Xiangjiaba, among others. Primarily nestled in the cradle of the Jinshajiang River hydropower development, these projects are large-scale terraced power stations within a shared basin, embodying a temporal and modal coherence in development. This unique configuration potently illustrates the transference of learning and innovation amidst these projects, thereby fostering a continuum of knowledge borrowing and novel methodologies.

4.2. Data Analysis Techniques

The data derived from the questionnaire were processed and interpreted using the Statistical Package for the Social Sciences (SPSS 22.0), specifically the Amos 28 version. A suite of statistical analysis techniques was employed in this study, encompassing the consistency test, sample mean analysis, ranking, and path analysis.

A pivotal metric in this context, Cronbach's α, gauges the reliability of the internal consistency. It is ascertained through the given formula:

$$\alpha = \frac{kr}{1 + (k-1)r}$$

k signifies the number of indicators present in the volume table and r denotes the average correlation observed between pairs of indicators. The thresholds for Cronbach's α are demarcated as follows: $0.7 \le \alpha \le 0.8$ (deemed acceptable), $0.8 \le \alpha \le 0.9$ (considered good), and $\alpha \ge 0.9$ (classified as excellent) [56]. Sample means serve as the cornerstone in deducing population metrics, and they are especially pivotal in discerning concentration tendencies within behavioral research. This study documented sample means for all indicators, arranged in a descending sequence. This arrangement aids in the intuitive comprehension of the relative importance of various issues. Path analysis was used for regression and the results were tested using significance level tests, which conformed to the typical 0.05 level, with 0.01 considered highly significant.

5. Research Results and Analysis

5.1. Scale Reliability Test

The reliability and validity of the five research concepts—organizational learning orientation, individual learning situation, level of engineering innovation, competencies of each participant, and project performance—were assessed. The findings are presented in Table 2.

Table 2. Convergent validity and reliability indicators.

	AVE (Average Variance Extracted) Values	CR (Composite Reliability)	Cronbach's Alpha
Organizational learning orientation	0.733	0.956	0.956
Individual learning situation	0.639	0.951	0.958
Level of engineering innovation	0.536	0.926	0.932
Competencies of each participant	0.621	0.947	0.976
Project performance	0.772	0.964	0.964

It can be seen from the calculation results that the AVE values for all concepts exceed 0.5, indicating strong convergent validity. This suggests that the evaluation indices within each construct are coherent, thereby allowing the index system to effectively capture the true nature of the constructs. Both the CR values and the Cronbach's alpha coefficients for each construct subscale exceed 0.9. This underscores the high reliability of the questionnaire data.

5.2. Analysis of Organizational Learning Orientation Evaluation

The evaluation of organizational learning orientation concerns the creation of knowledge resource management, the establishment of a learning support system, and the facilitation of communication platforms among organizational members. The questionnaire deployed indicators such as the level of enterprise knowledge database construction, cross-project experience transfer, and the refinement of training systems to quantitatively assess organizational learning orientation. In this scoring mechanism, seven points denotes special compatibility, four points indicates general compatibility, and one point signifies special incompatibility. The relevant statistics are illustrated in Table 3.

Table 3. Organizational learning orientation evaluation.

Evaluation Indicators	Mean	Rank
The enterprise learns from the experience of past projects to improve and optimize the engineering technology and management process of new projects.	6.17	1
The enterprise has established a project knowledge resource accumulation system to collect and summarize the lessons learned during the whole process of the project.	6.11	2
The enterprise has formed special departments or special positions to manage the knowledge base.	6.08	3
The enterprise carries out various training exercises to strengthen the knowledge transfer between projects.	6.06	4
The enterprise has established a platform for information exchange between projects.	6.06	5
The enterprise has established a complete project information system to collect basic information, meeting materials, and working documents of all ongoing and completed projects.	6.04	6
The enterprise has established a perfect and fast project knowledge base, recording all the materials of completed projects.	5.94	7
The enterprise prepares information on similar projects to help participants learn systematically before promoting new projects.	5.93	8
The average value	6.05	

With an average value of 6.05 for the combined scores, it is evident that enterprises involved in large-scale hydropower projects in China place significant emphasis on assimilating experiences and lessons from past endeavors. This showcases a robust learning culture and a comprehensive support system.

The score of 6.17 for "The enterprise learns from the experience of past projects to improve and optimize the engineering technology and management process of new projects" denotes the importance of learning from historical lessons for the continual progression of China's hydropower technology.

However, the score of 5.94 for "The enterprise has established a perfect and fast project knowledge base, recording all the materials of completed projects" indicates that the general workforce may face challenges in seamlessly navigating the amassed enterprise knowledge system, emphasizing an area for future enhancement in organizational learning systems.

The lowest score of 5.93 pertains to "The enterprise prepares information on similar projects to help participants learn systematically before promoting new projects". This implies potential inefficiencies during the initial phases of projects due to inadequate preparatory knowledge dissemination.

As the construction data of Xiluodu Power Station shows, the project department has implemented the benchmarking management mode, identified many projects of the same type at home and abroad, and regularly exchanged relevant technical issues to strengthen communication and learning with the outside world, which is conducive to avoiding detours in the project and also strengthens the transfer of information between industries. At the same time, it grasps the technical development of the hydropower industry and other related industries, pays attention to the research and application of new technologies, and effectively learns from experience.

5.3. Assessment of Individual Learning Environments

The assessment of individual learning environments entails an exploration of personal active learning awareness, avenues of knowledge acquisition, and the status of nurturing one's learning capabilities. For this study, we utilized metrics such as the propensity for anticipatory learning and avenues for and efficiency of knowledge procurement. In our grading framework, scores of seven, four, and one are indicative of special compatibility, general compatibility, and special incompatibility, respectively. The aggregated results are shown in Table 4.

Table 4. Assessment of individual learning environments.

Evaluation Indicators	Mean	Rank
Taking the initiative to learn from the lessons of similar projects in the past before undertaking new projects.	6.06	1
Learning and drawing lessons from past projects are necessary to improve the level of work.	6.05	2
When obstacles arise during a project, actively seek knowledge and experience from similar projects to help solve the current difficulties.	6.00	3
Adopt a method of communication with colleagues to learn from the knowledge and experience of previous projects.	5.96	4
After completing a project, actively seek the knowledge and experience of similar projects to deepen the learning effect.	5.94	5
Adopt a method of communicating with the personnel of partner companies to learn from the knowledge and experience of previous projects.	5.92	6
When carrying out projects, the channels for contacting and learning from the knowledge and experience related to previous projects are smooth.	5.86	7
Adopt a method of consulting with team leaders to learn from the knowledge and experience of previous projects.	5.83	8
Communication with personal friends outside the company to learn from past projects.	5.74	9
Learning from corporate experts by consulting with them.	5.71	10
Access to corporate knowledge base to learn from past projects.	5.68	11
Adopt a variety of training to strengthen the transfer of knowledge between projects.	5.66	12
Have a large amount of knowledge and experience from similar projects to support the completion of the work.	5.66	13
Participate in project workshops to learn from previous projects.	5.64	14
The average value	5.84	

The comprehensive average score of each index stands at 5.84, signifying an overarching trend of employees' elevated learning standards. Despite this, individual scores have seen a decrement when juxtaposed with organizational learning orientation scores. This suggests that the enterprises' learning systems haven't adequately bolstered the individual learning pursuits of their employees. The inadequate resource optimization and variances across links signal a primary focus for future enhancement of the enterprises' learning frameworks.

Notably, the scores for "Taking the initiative to learn from the lessons of similar projects in the past before undertaking new projects" and "Learning and drawing lessons from past projects are necessary to improve the level of work" are 6.06 and 6.05, securing the first and second ranks, respectively. This underscores a predominant consensus among employees regarding the significance of deriving learnings from concluded projects. Their keenness and heightened proactive learning attitude stand as pivotal assets for bolstering personal competency and, by extension, the holistic quality benchmark of the organizations.

The score for "The enterprise has carried out a variety of training exercises to strengthen the transfer of knowledge between the projects" is not low, indicating that the enterprises have established inter-project training exchanges, but also that seminars did not mobilize staff enthusiasm, and the actual role of the effect is not obvious. In the future, these areas should be enriched, as well as the content of the activities, and training in the organization should be conducted in a formal manner.

In the Xiangjiaba project design unit, implementing the annual staff training program advances the role of older staff to help each new employee to learn from at least one "master". Young employees in the process of learning from the experience of older staff enhance their own knowledge reserve level, while the older staff learn from the relatively high level of education of the new employees. The older employees also learn a lot of new technologies and ideas from the new employees with relatively higher education levels. This reflects the adoption of communication with colleagues to learn from previous project knowledge and experience.

5.4. Analysis of Level of Engineering Innovations

The evaluation of level of engineering innovations delves into the enhancement and innovation integrated into every phase of a hydropower project—spanning planning, design, construction, and migration. This assessment leverages the innovation metrics across each stage and the synergy and enhancement tactics among stakeholders. In our grading scheme, seven points denote special conformity, four points reflect general conformity, and one point indicates special non-conformity. The analytical data is illustrated in Table 5.

The average value of the comprehensive score of the level of engineering innovation indicator is 6.08, which is high; this indicates that all aspects of the development of domestic large hydropower projects have shown strong independent innovation ability, which is more in line with the status quo of China's hydropower industry, which is constantly overcoming difficulties.

The indicator "The formulation of the project construction plan has been optimized and innovated on the basis of the knowledge and experience gained from previous projects and in combination with the actual project" scores prominently. This shows that, due to the natural conditions of hydropower projects, the social environment affecting the project makes a big difference, the parties involved in the construction need to focus on the progress of the project constantly as new problems appear, and new tests are needed for continuous improvement and innovation.

The score of "The setting of the project incentive mechanism is optimized and innovated based on the knowledge and experience of past projects and the actual project" is only 5.84, ranking last. This shows that current hydropower projects have not done well in improving their reward and punishment systems and incentive feedback. An effective incentive mechanism can fully mobilize the enthusiasm of all parties involved and enhance the initiative of project personnel in innovation; therefore, optimizing the incentive system of the project by addressing the actual conditions and personnel needs is of great importance.

Table 5. Evaluation of level of engineering innovations.

Evaluation Indicators	Mean	Rank
The formulation of the project construction plan has been optimized and innovated on the basis of the knowledge and experience gained from previous projects and in combination with the actual project.	6.26	1
Project planning and scheme design have been optimized and innovated on the basis of past project knowledge and experience and in light of actual engineering practice.	6.15	2
The formulation of the project risk management plan is optimized and innovated based on the knowledge and experience of past projects and the actual project.	6.14	3
The owner will exchange relevant knowledge and experience from past projects with all parties involved in the project to help optimize and improve the work of the designers, constructors, and supervisors.	6.14	4
The HSE management system of the project is optimized and innovated based on the knowledge and experience gained from previous projects and the actual project.	6.10	5
The project design scheme was optimized and innovated based on the knowledge and experience gained from previous projects and in light of the actual project.	6.09	6
The development of the migration plan was optimized and innovated based on the knowledge and experience gained from previous projects and in light of the actual situation of the project.	6.09	7
Supervisors will share their knowledge and experience of previous projects with all parties involved in the project to help optimize and improve the work of the owner, constructor, and designer.	6.08	8
The design side will exchange relevant knowledge and experience from past projects with all project participants to help optimize and improve the work of the owner, construction side, and supervision side.	6.02	9
The development of the project procurement process has been optimized and innovated on the basis of the knowledge and experience gained from previous projects and the practicality of the project.	6.00	10
The constructor will exchange relevant knowledge and experience from past projects with all parties involved in the project to help optimize and improve the work of the owner, supervisor, and designer.	6.00	11
The setting of the project incentive mechanism is optimized and innovated based on the knowledge and experience of past projects and the actual project.	5.84	12
The average value	6.08	

This study found from the feedback of many project personnel that their salary level does not match their working conditions and labor, which affects their motivation for hard work and innovation. This is reflected in the low score of incentive mechanism innovation, which deserves the attention of hydropower development enterprises. In the Xiangjiaba project, the design optimization incentive mechanism is not well constructed, meaning that the designers' active optimization and innovation consciousness is not strong, and is often only passive; for example, the #1 to #5 diversion bottom holes adopt a hydraulic tensioning device to open and close the program, unlike the previous program, which had the advantages of lightweight and simple structure, large capacity of opening and closing, flexible configuration, good economy, etc. However, the new program was advocated for by the owner to carry out the optimization work passively.

5.5. Competencies of Each Participant

The "competencies of each participant" refers to the analysis of the business capacities of owners, designers, contractors, and other stakeholders involved in the development of hydropower projects. Understanding the competencies of each participant involved in a hydropower project is crucial for ensuring project success. By evaluating the capacity of stakeholders to perform their roles effectively, we can identify potential strengths and weaknesses, ensuring smoother project development. In this study, the performance indicators of each participant in their respective fields of specialization are used to measure the competencies of each participant in the project, in which seven points refers to special compatibility, four points refers to general compatibility, and one point refers to special incompatibility. The statistics are presented in Tables 6–10 below.

Table 6. Owner capacity evaluation.

Evaluation Indicators	Mean	Standard Deviation	Rank
Adequate knowledge and experience in similar projects	6.32	1.03	1
Sound integrated project control system	6.31	0.96	2
Strong ability to manage and control technology	6.18	1.07	3
Strong ability to integrate and coordinate resources	6.17	1.05	4
Good adaptability and flexibility to adjust according to the project reality	6.15	1.05	5
Strong information management ability	6.15	1.08	6
The average value	6.21		

Table 7. Designer capacity evaluation.

Evaluation Indicators	Mean	Standard Deviation	Rank
Strong technical design capabilities	6.05	1.04	4
Adequate knowledge and experience in similar projects	6.11	1.07	2
Strong communication and collaboration skills	6.01	1.13	5
Good service consciousness and attitude	6.10	1.07	3
Excellent reputation	6.14	1.04	1
The average value	6.08		

Owners are deemed most competent when it comes to having "Adequate knowledge and experience in similar projects". Their ability to maintain a sound "Integrated project control system" and manage technology effectively also scores high. Their aptitude to adjust to real-time project changes and implement strong information management systems are areas that seem closely matched in importance, as reflected by their nearly identical scores.

Designers score highest when it comes to their "Excellent reputation", followed closely by their knowledge and experience in similar projects. Their technical design capabilities could see improvements, as this category ranks fourth, and their communication and collaboration skills are the least prominent, suggesting that interpersonal skills might be an area where training or focus could be beneficial.

Table 8. Contractor capacity evaluation.

Evaluation Indicators	Mean	Standard Deviation	Rank
Excellent construction technology	6.04	0.99	3
Strong HSE management skills	5.99	1.04	5
Adequate experience in similar projects	6.18	0.99	1
High level of risk management	5.95	1.06	7
Excellent reputation	6.05	1.06	2
Good service consciousness and attitude	6.00	1.06	4
Strong communication and collaboration skills	5.97	1.03	6
Strong information management ability	5.84	1.10	8
The average value	6.00		

Table 9. Supervisor capacity evaluation.

Evaluation Indicators	Mean	Standard Deviation	Rank
Sufficient experience in similar projects	6.09	1.07	1
High technical level	5.93	1.10	2
Strong regulatory and review capabilities	5.89	1.10	3
The average value	5.97		

Table 10. Vendor capacity evaluation.

Evaluation Indicators	Mean	Standard Deviation	Rank
High level of suppliers of strategic materials and perfect guarantee	6.08	1.01	1
High level of suppliers of important materials, perfect protection	6.07	1.07	2
The average value	6.08		

Contractors seem most experienced when it comes to handling similar projects, as reflected by the top rank for "Adequate experience in similar projects". Interestingly, "Excellent reputation" and "Excellent construction technology" also rate highly. However, their weakest areas appear to be risk management and leveraging modern digital technologies, which may require more attention.

The highest-rated competency for supervisors is their experience with similar projects. While their technical level and regulatory capabilities are valuable, there's room for enhancement, given their lower rank.

Vendors have a strong capability in supplying strategic materials with a perfect guarantee, as reflected by the top ranking. Their supply chain strength for important materials rates closely behind. The average values being almost equal indicates that vendors are generally consistent in providing strategic and important materials.

Across all roles, including owners, designers, contractors, supervisors, and vendors, knowledge and experience in managing or contributing to similar projects seem paramount. This consistent emphasis across the board reiterates the importance of experiential learning in the hydropower industry. While most entities score near the six-point mark, suggesting a high level of proficiency, areas such as communication, risk management, and the integration of modern digital technologies emerge as potential areas for improvement.

In the course of the Udon De project, the owner's unit gave full play to the role of communication and coordination and promoted the exchange of all participants, forming a system of regular quality meetings at all levels and strengthening professional exchanges, such as monthly (weekly) regular meetings for testing and inspection and weekly meetings for temperature control. The regular quality meeting of the Ministry of Construction, held every quarter, is attended by the person in charge of each participant, which ensures the rapid feedback of information, the timely detection of hidden dangers and the timely treatment of problems, and enhances the pre-control and increases the rectification of quality problems. Various feedback and adjustment platforms led by the owner have favorably promoted the stable, safe, and efficient advancement of all engineering work.

5.6. Analysis of Project Performance

The project performance category encompasses a holistic assessment of a hydropower project's multifaceted performance, spanning areas such as project progression, HSE (health, safety, and environment), and migration-related tasks. In this survey, performance markers such as construction safety, occupational health, and migration tasks were utilized for a thorough analysis of the projects' efficiency. In the adopted scoring system, a score of seven denotes exceptional conformity, four denotes general conformity, and one denotes pronounced non-conformity. The results of this assessment are delineated in Table 11.

Table 11. Project performance.

Evaluation Indicators	Mean	Rank
Good construction safety performance during the project	6.08	1
Good quality performance during the project	6.00	2
Good performance in occupational health during the project	5.99	3
Good performance in environmental protection during the project	5.98	4
Good progress performance in project implementation	5.91	5
High efficiency in solving problems during the project	5.85	6
Good cost performance in project implementation	5.84	7
Good performance in migration work in the project	5.80	8
The average value	5.93	

As can be seen from the statistics in Table 11, the project construction safety performance score of 6.08 is the only one of the performance indicators that exceeds 6 points. Safety is one of the most important considerations in the current hydropower project implementation process, and the need to achieve zero safety accidents and zero hidden dangers has been repeatedly emphasized during the construction of hydropower plants such as Wudongde and Baihetan. The HSE management performance indicators of the hydropower projects are all better, indicating that current hydropower development is people-oriented, emphasizes environmental protection, and stresses comprehensive benefits. At Xiangjiaba Hydropower Station, from 2008 to the end of 2013, the release station carried out nine rare fish fry releases in the Jinsha River waters, releasing a total of 733,000 fish fry; it also initiated the release of the "four big fishes" in the reservoir area, which has played a positive role in solving the problem of eutrophication of the reservoir's local waters, transforming the mode of fishery development and publicizing ecological and environmental protection.

The indicators of problem-solving efficiency and migration work scored low. Problem-solving efficiency reflects the speed of cooperation between project parties to optimize technology and processes according to the actual difficulties of the project; while hydropower projects often involve large-scale resettlement of immigrants, the social problems faced are more complicated, which is a difficult point of management work. These two performance indicators are obviously related to the ability of hydropower development enterprises to optimize and innovate based on historical experience, and the results of this study initially indicate that the shortcomings of the current hydropower project performance lie in a lack of innovation. The specific relationship needs to be explored in the next study.

5.7. Correlation Analysis of Hydropower Development Learning and Innovation Model Elements

Our research analyzes the correlation relationship of elements of the hydropower development learning and innovation model; the results are shown in Table 12.

Table 12. Correlation matrix of elements in the hydropower development learning and innovation model.

	Organizational Learning Orientation	Individual Learning Situation	Competencies of Each Participant	Level of Engineering Innovation	Project Performance
Organizational learning orientation	1				
Individual learning situation	0.653 **	1			
Competencies of each participant	0.607 **	0.630 **	1		
Level of engineering innovation	0.649 **	0.671 **	0.884 **	1	
Project performance	0.641 **	0.715 **	0.672 **	0.711 **	1

Note: ** denotes significance at the 0.01 level (two-tailed).

From the Pearson correlation analysis, a pronounced positive correlation ($p < 0.05$) emerges between the organizational learning orientation, individual learning situation, level of engineering innovation, the competencies of each participant, and the project performance. Notably, the correlation coefficient between the level of engineering innovation and the competencies of each participant peaks at 0.884, signifying a robust correlation. These findings provide preliminary support for the interrelations between the study variables, setting the stage for a deeper examination of the research hypotheses.

6. Hydropower Development Learning and Innovation Model Test Analysis

6.1. Model Test Analysis

6.1.1. Model Testing Situation

The questionnaire data processed by SPSS was entered into AMOS, and the theoretical model of hydropower development learning and innovation was tested using the structural equation; the results are shown in Figure 2.

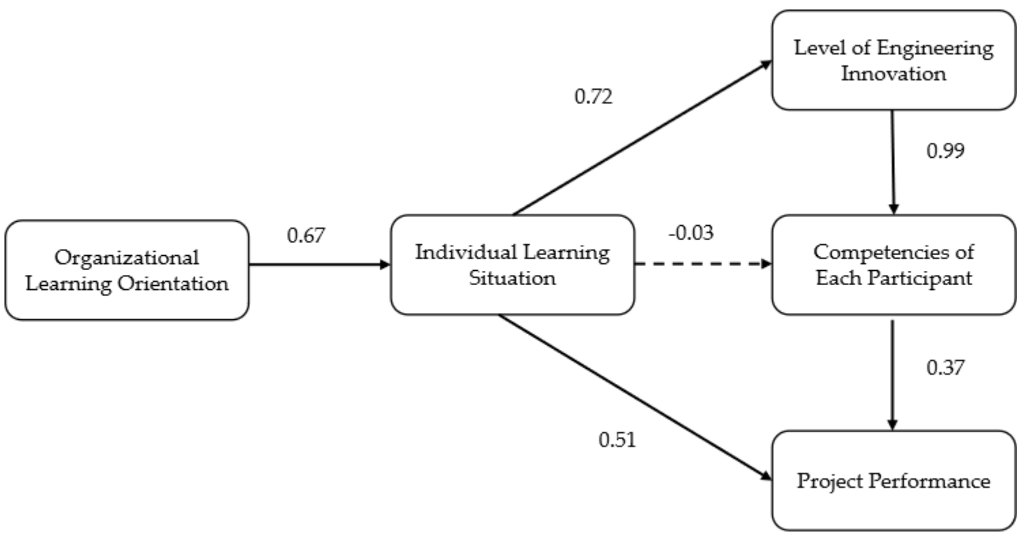

Figure 2. Learning and innovation model validation for hydropower development.

The connecting line in the figure indicates the action path, the negative number indicates that the path is not significant, and the positive number indicates the path coefficient.

6.1.2. Fit Indicator Test

Our research tested the model. From Table 13, it can be seen that X^2/df is 4.878, while RMSEA and RMR are less than 0.1, which indicates an ideal fit; CFI, TLI, and IFI are all greater than 0.8, and NFI is greater than 0.7, which is within the acceptable range, and therefore it can be judged that the fit is good.

Table 13. Indicators for fitting the model.

	X^2/df	RMR	RMSEA	CFI	TLI	IFI	NFI
	4.878	0.084	0.092	0.829	0.82	0.83	0.795
Excellent	<5.0	<0.1	<0.1	>0.80	>0.80	>0.80	>0.70
Standard value	3.0~5.0	0.08~0.10	0.08~0.10	0.70~0.90	0.70~0.90	0.70~0.90	0.70~0.90

6.1.3. Model Path Analysis

The model path analysis results follow in Table 14. Here, we further analyze the hypotheses.

Table 14. Path coefficient analysis of the learning and innovation model for hydropower development.

Path			Estimate	Lower	Upper	*p*	Percentage of Intermediary Effects
Individual learning situation	<---	Organizational learning orientation	0.674	0.591	0.747	0.000	
Project performance	<---	Individual learning situation	0.512	0.388	0.64	0.000	
Level of engineering innovation	<---	Individual learning situation	0.723	0.637	0.796	0.000	
Competencies of each participant	<---	Level of engineering innovation	0.985	0.921	1.061	0.000	
Project performance	<---	Competencies of each participant	0.374	0.228	0.508	0.000	
Competencies of each participant	<---	Individual learning situation	−0.033	−0.124	0.047	0.401	
Project performance <-Individual learning situation <-Organizational learning orientation			0.345	0.256	0.457	0.000	52.19%
Project performance <-Competencies of each participant <-Level of engineering innovation <-Individual learning situation <-Organizational learning orientation			0.18	0.113	0.265	0.000	27.23%
Project performance <-Competencies of each participant <-Individual learning situation<-Organizational learning orientation			−0.008	−0.032	0.011	0.369	

For H1, "A good organizational learning orientation positively influences individual learning situations", the coefficient is 0.674 and significance is reflected as $p = 0.401$. A positive and significant relation was observed between organizational learning orientation and individual learning situation. Enhanced organizational focus on learning augments active learning in members and heightens their adaptability to evolving technological and cultural milieus. Such adaptability fosters personal motivation and pushes individuals to recalibrate their learning techniques and augment their knowledge base.

For H2, "Enhanced individual learning situations positively influence the level of engineering innovation", the coefficient is 0.723 and significance is reflected as $p = 0.401$. A conducive individual learning environment markedly boosts engineering innovation. Through individual learning situations, experience and innovative components in the hydropower sector are accrued, leading to improved proficiency with novel technological applications.

For H3, "Enhanced individual learning situations positively influence the competencies of each participant", the coefficient is −0.0334 and significance is reflected as $p = 0.401$. Individual learning situation was found to not directly enhance the competencies of each participant. Instead, the influence was channeled through the mediator of engineering innovation.

For H4, "Enhanced individual learning situations positively influence the level of engineering innovation", the coefficient is 0.512 and significance is reflected as $p = 0.401$. Active individual learning situations have a pronounced positive impact on project outcomes. The symbiotic exchange of knowledge and information amplifies the understanding and deployment of novel technologies, leading to enhanced project performance.

For H5, "An augmentation in the level of engineering innovation positively influences the competencies of each participant", the coefficient is 0.985 and significance is reflected as $p = 0.401$. Elevated engineering innovation significantly enhances the competence of project participants. The infusion of cutting-edge technologies and methods broadens the knowledge spectrum for participants, enhancing their overall efficiency.

For H6, "Enhancing the competencies of each participant positively influences the project performance", the coefficient is 0.374 and significance is reflected as $p = 0.401$. The competence of participants plays a pivotal role in determining the quality, safety, and timelines of the project. A direct relationship was observed: the higher the participant's capability, the better the overall project output.

The path of "Individual learning situation—Level of engineering innovation—Competencies of each participant" (Figure 3) has an impact on the competencies of each participant, i.e., individual learning situations necessitate the mediation of innovation to bolster the project competencies of each participant. This novel finding underscores the pivotal, yet often overlooked, role of innovation in translating the experience of individual learning situations into core competencies. From the hydropower industry perspective, the domestic hydropower sector, rooted in traditional engineering, displays inertia in the face of rapid changes. While legacy projects such as Sanmenxia predominantly banked on imported technologies with sub-optimal assimilation, modern projects such as the Three Gorges have heralded a paradigm of internalization followed by indigenous innovation, leading to significant engineering accomplishments.

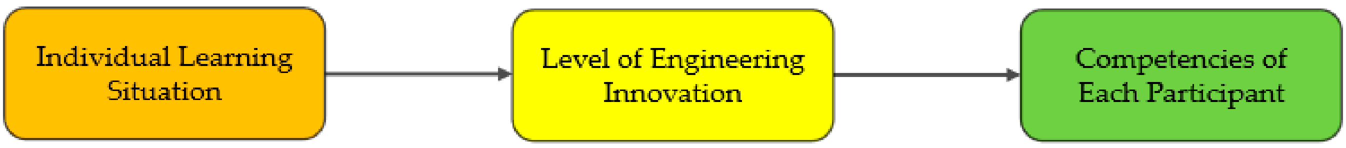

Figure 3. The path of "Individual learning situation—Level of engineering innovation—Competencies of each participant".

The path of "Organizational learning orientation—Individual learning situation—Project performance" (Figure 4) has a role in project performance, with a coefficient of 0.345 and a contribution rate of 64.6%, which indicates that good organizational learning can drive individual learning situations, improve individuals' learning abilities, and promote the flow of information and the application of technology. A good organizational learning atmosphere promotes the transfer of knowledge and incentivizes individuals within the organization to accumulate experience, consolidate technical skills, learn, innovate, and absorb new knowledge and new skills. Discovery and innovation in the process of organizational learning also allow individuals to stimulate their own potential and actively understand new technology and new modes to better complete their work, improve work efficiency, and to promote the project's various phases, which in turn contributes to the enhancement of project performance.

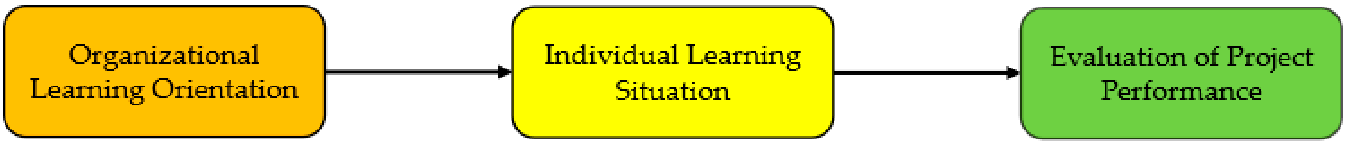

Figure 4. The path of "Organizational learning orientation—Individual learning situation—Project performance".

The path "Organizational learning orientation—Individual learning situation—Level of engineering innovation—Competencies of each participant—Project performance" (Figure 5) contributes to project performance with a coefficient of 0.18 and a contribution rate of 33.7%. This shows the comprehensive impact of learning and innovation on project performance. Organizational learning promotes individual learning situations, individuals' understanding of new technologies, and new, deeper modes of application while working on new inspiration, generating new innovations, applying knowledge in the work of innovation, enhancing personal efficiency, improving work, reducing losses, and, throughout the various stages of the project, enhancing the ability of each participant to efficiently and effectively complete of the objectives of the project with high-quality outcomes. While engineering innovation and participant ability can mediate the influence of individual learning situations on project performance, the relatively low coefficient highlights existing gaps. There remains a discernible need to fortify the innovation quotient and the aptitude for learning and innovation among participants.

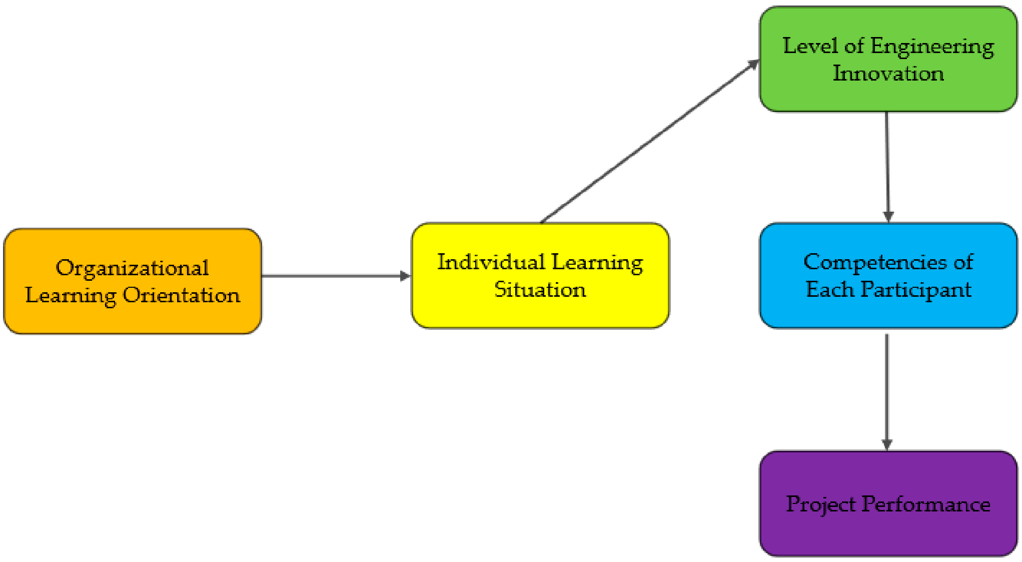

Figure 5. The path "Organizational learning orientation—Individual learning situation—Level of engineering innovation—Competencies of each participant—Project performance".

7. Discussion

In this study, a theoretical model was constructed to elucidate learning and innovation in hydropower development and was tailored to the current state of learning and innovation system construction in China's hydropower sector. The model is enriched by a comparative analysis across various stakeholders, integrating the research dimensions of organizational learning orientation, individual learning, level of engineering innovation, participant competencies, and project performance, thereby forming a comprehensive index evaluation system. This research framework lays a solid foundation for analyzing the challenges inherent in the learning and innovation systems of hydropower development enterprises within China.

The empirical validation of this theoretical model was achieved through the analysis of questionnaire data, augmented with relevant case data. The pivotal intermediary role of the engineering innovation level in mediating the impact of individual learning on participant ability is underscored, as detailed in Table 15.

Table 15. Mediation analysis.

Path	Estimate	Percentage of Intermediary Effects
Project performance<-Individual learning situation <-Organizational learning orientation	0.345	52.19%
Project performance<-Competencies of each participant <-Level of engineering innovation<-Individual learning situation <-Organizational learning orientation	0.18	27.23%
Project performance<-Competencies of each participant <-Individual learning situation<-Organizational learning orientation	−0.008	

This demonstrates the important roles of the two paths of "Project performance <-Individual learning situation <-Organizational learning orientation" and "Project performance <-Competencies of each participant <-Level of engineering innovation <-Individual learning situation <-Organizational learning orientation", provides in-depth guidance for each participant to improve the learning system and strengthen the innovation capability, helps the hydropower development enterprise to improve the level of systematic construction, and ultimately achieves the purpose of promoting the performance of the project.

Building on the empirical evaluation of the hydropower development learning and innovation model, this research proposes strategic recommendations to boost China's hydropower projects:

(1) The capability for engineering innovation critically mediates how learning situations positively impact participant capabilities. Hydropower development enterprises should bolster their innovation platforms, focusing on a progression from assimilation to independent innovation to enhance their competitive edge.

(2) The effectiveness of organizational learning orientation in boosting individual learning remains suboptimal. Enterprises must operationalize strategies such as pre-employment education and inter-project seminars, enriching content to facilitate the transformation of company knowledge into employee skillsets.

(3) While project participants' capabilities are markedly influenced by engineering innovation levels, the translation to project performance lags. Enhanced collaboration, communication, and complementary skill sharing are vital, with special attention to challenges in areas such as integration and cost management.

(4) Innovation in hydropower projects markedly diverges from that of individual enterprises. Given the dispersed nature of the project's resources—knowledge, skills, and materials—it is imperative for participants in enterprises to adopt intensive, collaborative strategies. Effective construction of innovation capacity demands mutual learning, fostering exchanges, and joint development initiatives.

8. Conclusions

8.1. Findings

This study delves deep into the realm of learning systems and innovation capacity within China's hydropower development projects. Key insights distilled from the research, backed by empirical data, shed light on the intricate mechanics of how organizational learning orientations catalyze individual learning situations, how engineering innovation mediates the transformation of learning into competencies, and, subsequently, how these competencies drive project performance. The specific findings of the study are as follows:

Organizational learning orientation plays a positive role in promoting individual learning situations. Individual learning situations cannot directly affect the ability of each participant and need to be indirectly promoted through the level of engineering innovation. Improving individual learning situations can directly promote the level of engineering innovation and project performance. Engineering innovation cannot be directly transformed into project performance and needs to be indirectly promoted through the ability of each participant.

The study of the hydropower development learning and innovation model mechanism found that the impact coefficient of the path "Organizational learning orientation—Individual learning situation" is 0.674, indicating that the organizational learning orientation has a significant positive impact on individual learning situations; however, there is room for further improvement of the promotion effect. The impact coefficient of the path "Individual learning situation—Each participant's ability" is −0.033, indicating that individual learning situations can not directly affect the ability of each participant in the project; however, the impact coefficient of the path "Individual learning situation—Level of engineering innovation" is 0.723, and the impact coefficient of the path "Individual learning situation—Level of engineering innovation" is 0.723.

The impact coefficient of the path "Level of engineering innovation—Each participant's ability" is 0.723, the impact coefficient of the path "Personal learning—Level of engineering innovation—Each participant's ability" is 0.985, and the impact coefficient of the path "Personal learning—Level of engineering innovation—Each participant's ability" is 0.712, indicating that personal learning situations significantly influence the level of engineering innovation. This shows that individual learning situations can significantly affect the level of engineering innovation, while the level of engineering innovation can significantly affect the capabilities of each participant in the project. The level of engineering innovation plays a necessary intermediary role in impact of individual learning situations on the capabilities of each participant. The impact coefficient of the path "Level of engineering innovation—Each participant's capability—Project performance" is 0.374, which indicates that improving the level of engineering innovation can enhance project performance by strengthening the capability of each participant in the project.

The above insights have important theoretical and practical significance, and suggest the following to improve the current situation of learning and innovation in hydropower development:

(1) China's hydropower sector has garnered extensive practical experience in engineering, forming a robust knowledge base crucial for the ongoing enhancement of hydropower technologies within the country. Nonetheless, there exists a lack of accessibility to this resource library, alongside deficiencies in the pre-service learning systems. The individual learning inclination among staff requires bolstering through tailored support, expert interactions, and enriched collective training avenues such as project seminars. The actual impact of these measures requires further augmentation.

(2) The existing incentive mechanisms within domestic large-scale hydropower projects fall short in fostering innovation, with a notable disparity in staff's subjective expectations. The inclination among enterprise staff for an optimized reward and punishment system is evident, signifying a need for enhanced mechanisms to incentivize innovation.

(3) Engineering innovation capability serves as a pivotal intermediary in translating learning outcomes into improved business competence for each participant. En-

terprises should leverage the academic credentials of their personnel, augment the construction of knowledge bases, and elevate the standards of information technology management. Fostering cross-sectoral and cross-regional information exchange, communication, and learning will enhance the ability of hydropower projects to assimilate new technologies and materials effectively.

(4) Amplifying both internal and external communication channels, alongside fostering multi-party collaboration, is essential for leveraging and optimizing new technology and machinery within hydropower development projects. Given their large scale, multifaceted nature, and the myriad stakeholders involved, achieving continuous progress in engineering innovation necessitates seamless cooperation, rigorous management, and coordinated development efforts across all participating enterprises.

8.2. Limitations and Future Research Directions

(1) The design of the index system of research elements needs to be improved. There are various theories on the division of indicators for measuring the learning level and innovation of enterprises in international studies, and no unified consensus has been formed so far. This paper has systematically explored the characteristics of hydropower project development, but theoretical and practical support need to be further tested. The next research plan is to establish a more perfect evaluation system through more research and visits.

(2) The theoretical system has not been established comprehensively enough. There is a certain gap between enterprise innovation and hydropower project innovation. Enterprises have systematic advantages in the transfer of experience and knowledge, while the temporary and combined nature of a project makes its influencing factors more complicated. The next step of the research plan is to combine the project level variable factors to perform a more comprehensive exploration of the formation and roles of innovation mechanisms.

(3) The research object of this paper is mainly Chinese large-scale terraced power station development projects; in the future, the research field can be broadened to include in-depth studies of international large-scale hydropower development projects and the role of learning and innovation system mechanisms, comparing the current situation of domestic and foreign construction and engineering development differences to provide more specific and effective strategic recommendations for China's hydropower development enterprises aiming to expand abroad.

Author Contributions: Conceptualization, S.H., H.Z. and W.T.; methodology, S.H. and H.Z.; validation, H.Z.; formal analysis, S.H.; investigation, S.H., H.Z. and W.T.; data curation, W.T.; writing—original draft preparation, S.H.; writing—review and editing, H.Z. and W.T.; project administration, W.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Natural Science Foundation of China, grant numbers 72171128 and 51579135, and the State Key Laboratory of Hydroscience and Engineering, grant numbers 2022-KY-04.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are all available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Zhang, D.; Wang, J.; Lin, Y.; Si, Y.; Huang, C.; Yang, J.; Huang, B.; Li, W. Present situation and future prospect of renewable energy in China. *Renew. Sustain. Energy Rev.* **2017**, *76*, 865–871. [CrossRef]
2. Muhammed, G.; Tekbiyik-Ersoy, N. Development of Renewable Energy in China, USA, and Brazil: A Comparative Study on Renewable Energy Policies. *Sustainability* **2020**, *12*, 9136. [CrossRef]

3. Li, X.-Z.; Chen, Z.-J.; Fan, X.-C.; Cheng, Z.-J. Hydropower development situation and prospects in China. *Renew. Sustain. Energy Rev.* **2018**, *82*, 232–239. [CrossRef]
4. Hennig, T.; Wang, W.; Feng, Y.; Ou, X.; He, D. Review of Yunnan's hydropower development. Comparing small and large hydropower projects regarding their environmental implications and socio-economic consequences. *Renew. Sustain. Energy Rev.* **2013**, *27*, 585–595. [CrossRef]
5. Bin, D. Discussion on the development direction of hydropower in China. *Clean Energy* **2021**, *5*, 10–18. [CrossRef]
6. Su, H.; Hu, J.; Yang, M.; Wen, Z. Assessment and prediction for service life of water resources and hydropower engineering. *Nat. Hazards* **2015**, *75*, 3005–3019. [CrossRef]
7. Piwowar, A.; Dzikuć, M. Water Energy in Poland in the Context of Sustainable Development. *Energies* **2022**, *15*, 7840. [CrossRef]
8. Wang, D.; Li, C.; Zhou, R. The changing role of the China Three Gorges Corporation in the Yangtze River: Exploration from hydropower development to comprehensive watershed management. *E3S Web Conf.* **2022**, *346*, 01027. [CrossRef]
9. Zhou, X.; Fan, S.; Sun, H.; Tang, L.; Ma, F. Practices of environmental protection, technological innovation, economic promotion and social equity in hydropower development: A case study of cascade hydropower exploitation in China's Dadu River basin. *Clean Technol. Environ. Policy* **2021**, *23*, 2827–2841. [CrossRef]
10. Nautiyal, H.; Goel, V. Sustainability assessment of hydropower projects. *J. Clean. Prod.* **2020**, *265*, 121661. [CrossRef]
11. Kaunda, C.S.; Kimambo, C.Z.; Nielsen, T.K. Hydropower in the Context of Sustainable Energy Supply: A Review of Technologies and Challenges. *Int. Sch. Res. Not.* **2012**, *2012*, 730631. [CrossRef]
12. Andreou, P.C.; Louca, C.; Petrou, A.P. Organizational learning and corporate diversification performance. *J. Bus. Res.* **2016**, *69*, 3270–3284. [CrossRef]
13. Obeso, M.; Hernández-Linares, R.; López-Fernández, M.C.; Serrano-Bedia, A.M. Knowledge management processes and organizational performance: The mediating role of organizational learning. *J. Knowl. Manag.* **2020**, *24*, 1859–1880. [CrossRef]
14. Haile, E.A.; Tuzuner, V.L. Organizational learning capability and its impact on organizational innovation. *Asia Pac. J. Innov. Entrep.* **2022**, *16*, 69–85. [CrossRef]
15. Peris-Ortiz, M.; Devece-Carañana, C.A.; Navarro-Garcia, A. Organizational learning capability and open innovation. *Manag. Decis.* **2018**, *56*, 1217–1231. [CrossRef]
16. Bhatt, G.D. Knowledge management in organizations: Examining the interaction between technologies, techniques, and people. *J. Knowl. Manag.* **2001**, *5*, 68–75. [CrossRef]
17. Darroch, J. Knowledge management, innovation and firm performance. *J. Knowl. Manag.* **2005**, *9*, 101–115. [CrossRef]
18. Migdadi, M.M. Organizational learning capability, innovation and organizational performance. *Eur. J. Innov. Manag.* **2021**, *24*, 151–172. [CrossRef]
19. Sanz-Valle, R.; Naranjo-Valencia, J.C.; Jiménez-Jiménez, D.; Perez-Caballero, L. Linking organizational learning with technical innovation and organizational culture. *J. Knowl. Manag.* **2011**, *15*, 997–1015. [CrossRef]
20. Ebner, A. *The Institutional Analysis of Entrepreneurship: Historist Aspects of Schumpeter's Development Theory*; Springer: Boston, MA, USA, 2003.
21. Hoy, F. Organizational learning at the marketing/entrepreneurship interface. *J. Small Bus. Manag.* **2008**, *46*, 152–158. [CrossRef]
22. Shao, S.; Hu, Z.; Cao, J.; Yang, L.; Guan, D. Environmental Regulation and Enterprise Innovation: A Review. *Bus. Strategy Environ.* **2020**, *29*, 1465–1478. [CrossRef]
23. Li, R.; Rao, J.; Wan, L. The digital economy, enterprise digital transformation, and enterprise innovation. *Manag. Decis. Econ.* **2022**, *43*, 2875–2886. [CrossRef]
24. Yeung, A.C.L.; Lai, K.-H.; Yee, R.W.Y. Organizational learning, innovativeness, and organizational performance: A qualitative investigation. *Int. J. Prod. Res.* **2007**, *45*, 2459–2477. [CrossRef]
25. Liu, Y.; Failler, P.; Ding, Y. Enterprise financialization and technological innovation: Mechanism and heterogeneity. *PLoS ONE* **2022**, *17*, e0275461. [CrossRef] [PubMed]
26. Xie, H.; Wang, Q.; Ge, Z. The Relationship of Organizational Culture, Learning Orientation, Organizational Innovation and organizational Performance. *Sci. Sci. Manag. S. T.* **2007**, *28*, 73–77.
27. Fagerberg, J.; Fosaas, M.; Sapprasert, K. Innovation: Exploring the knowledge base. *Res. Policy* **2012**, *41*, 1132–1153. [CrossRef]
28. Popper, M.; Lipshitz, R. Organizational learning—Mechanisms, culture, and feasibility. *Manag. Learn.* **2000**, *31*, 181–196. [CrossRef]
29. Osman, A.M.; Liu, Y.; Wang, Z. Influence of Organizational Culture on Construction Firms' Performance: The Mediating Roles of Innovation and Marketing Capabilities. *Buildings* **2023**, *13*, 308. [CrossRef]
30. Ozorhon, B. Analysis of Construction Innovation Process at Project Level. *J. Manag. Eng.* **2013**, *29*, 455–463. [CrossRef]
31. Chen, L.; Fong, P.S.W. Visualizing Evolution of Knowledge Management Capability in Construction Firms. *J. Constr. Eng. Manag.* **2013**, *139*, 839–851. [CrossRef]
32. Anonymous. "Engineering" innovation: Organizational factors affecting creativity and career satisfaction. *Hum. Resour. Manag. Int. Dig.* **2019**, *27*, 15–18.
33. Lippmann, T. Engineering innovation-related knowledge: How a core ontology makes innovations retrievable for innovation seekers. *Int. J. Coop. Inf. Syst.* **2013**, *22*, 1340004. [CrossRef]
34. Li, B. Engineering Innovation as the Main Battlefield for Innovation. *China Soft Sci.* **2008**, *10*, 44–51+64.

35. Zheng, T.; Qiang, M.; Wang, J.; Zhang, D. Evaluation of hydropower resource value of hydropower projects: Case study of Three Gorges Project. *J. Hydroelectr. Eng.* **2016**, *35*, 39–47.
36. Zhai, X.; Liu, A.M.M.; Fellows, R. Role of Human Resource Practices in Enhancing Organizational Learning in Chinese Construction Organizations. *J. Manag. Eng.* **2014**, *30*, 194–204. [CrossRef]
37. Zhang, J.; Ouyang, Y.; Ballesteros-Pérez, P.; Li, H.; Philbin, S.P.; Li, Z.; Skitmore, M. Understanding the impact of environmental regulations on green technology innovation efficiency in the construction industry. *Sustain. Cities Soc.* **2021**, *65*, 102647. [CrossRef]
38. Tang, C.; Xu, Y.; Hao, Y.; Wu, H.; Xue, Y. What is the role of telecommunications infrastructure construction in green technology innovation? A firm-level analysis for China. *Energy Econ.* **2021**, *103*, 105576. [CrossRef]
39. Haas, M.R. Knowledge gathering, team capabilities, and project performance in challenging work environments. *Manag. Sci.* **2006**, *52*, 1170–1184. [CrossRef]
40. Rady, M.; Kineber, A.F.; Hamed, M.M.; Daoud, A.O. Partial Least Squares Structural Equation Modeling of Constraint Factors Affecting Project Performance in the Egyptian Building Industry. *Mathematics* **2023**, *11*, 497. [CrossRef]
41. Hu, S.; Wang, Y.; Tang, W. Factors Influencing International Infrastructure Investment: An Empirical Study from Chinese Investors. *Sustainability* **2023**, *15*, 11072. [CrossRef]
42. Sun, H.; You, R.; Tang, W. Analysis of factors influencing HSE management and project performance in international construction projects. *J. Tsinghua Univ. Sci. Technol.* **2022**, *62*, 230–241.
43. Liuying, Z.; On, S.C. Incentivizing Relationship Investment for Project Performance Improvement. *Proj. Manag. J.* **2023**, *54*, 70–87.
44. Khahro, S.H.; Memon, A.H.; Memon, N.A.; Memon, Z.A.; Naresh, R. Influence of Social and Economic Factors on Construction Project Performance in Pakistan. *Sustainability* **2023**, *15*, 2469. [CrossRef]
45. Argyris, C.; Schon, D. *Organizational Learning: A Theory of Action Research*; Birkhäuser: Basel, Switzerland, 1978.
46. Connelly, C.E.; Kelloway, E.K. Predictors of Employees' Perceptions of Knowledge Sharing Cultures. *Leadersh. Organ. Dev. J.* **2003**, *24*, 294–301. [CrossRef]
47. Capon, N.; Hall, P. *The Marketing of Financial Services: A Book of Cases*; Prentice Hall: Upper Saddle River, NJ, USA, 1992.
48. Manu, F.A.; Sriram, V. Innovation, marketing strategy, environment, and performance. *J. Bus. Res.* **1996**, *35*, 79–91. [CrossRef]
49. Griffin, A.; Hauser, J. Integrating R&D and Marketing: A Review and Analysis of the Literature. *J. Prod. Innov. Manag.* **1996**, *13*, 191–215.
50. Veryzer, R.W. Discontinuous innovation and the new product development process. *J. Prod. Innov. Manag.* **1998**, *15*, 304–321. [CrossRef]
51. Croasmun, J.T.; Ostrom, L. Using Likert-Type Scales in the Social Sciences. *J. Adult Educ.* **2011**, *40*, 19–22.
52. Roscoe, J.T. *Fundamental Research Statistics for the Behavioral Sciences*; Holt, Rinehart and Winston: New York, NY, USA, 1969.
53. Wu, G.; Liu, C.; Zhao, X.; Zuo, J.; Zheng, J. Effects of fairness perceptions on conflicts and project performance in Chinese megaprojects. *Int. J. Constr. Manag.* **2022**, *22*, 832–848. [CrossRef]
54. Xing, W.; Hao, J.L.; Qian, L.; Tam, V.W.; Sikora, K.S. Implementing lean construction techniques and management methods in Chinese projects: A case study in Suzhou, China. *J. Clean. Prod.* **2020**, *286*, 124944. [CrossRef]
55. Tavakol, M.; Dennick, R. Making sense of Cronbach's alpha. *Int. J. Med. Educ.* **2011**, *2*, 53–55. [CrossRef] [PubMed]
56. Santos, J.R.A. Cronbach's Alpha: A Tool for Assessing the Reliability of Scales. *J. Ext.* **1999**, *37*, 2TOT3.