

A Study on the Pathways for Enhancing Digital Literacy among Environmental Design Students

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Received: 2 October 2025; **Accepted:** 21 October 2025; **Published:** 17 November 2025

Abstract:

This study focuses on enhancing the multidimensional comprehensive abilities of environmental design students, including digital thinking, digital application skills, and digital social responsibility. By constructing a Unit-Modular, project-based learning (PBL) framework, optimizing a dynamically updated digital teaching resource library and diversified practice platforms, and reforming teaching methods, the research systematically integrates digital literacy cultivation throughout the entire professional curriculum. In practice, technological tools such as drone surveying, AI-assisted design, virtual simulation, and VR presentation are employed to digitize various design stages, including site analysis, conceptual ideation, and technical drawing. Furthermore, by aligning design outcomes with societal needs like rural revitalization and urban renewal, the study guides students in establishing a sense of responsibility for using digital technology to serve society. These initiatives effectively improve teaching quality and talent training outcomes, providing a transferable model and valuable experience for digital literacy education in environmental design programs within higher education.

Keywords:

Student Digital Literacy, Environmental Design, Project-Based Learning(PBL)

1. Research Background

The rapid advancement of digital technologies, such as big data and artificial intelligence, is profoundly transforming design practices. Within the field of Environmental Design, there is a growing reliance on smart technologies to enhance the efficiency and precision of the design process, enabling practitioners to address increasingly complex and dynamic challenges. Concurrently, a new trend is emerging in higher education for Environmental Design programs that emphasizes strengthening digital competencies. This shift makes it imperative for students to enhance their digital literacy.

Digital literacy for environmental design students refers to a multifaceted digital competency that integrates a digital mindset, digital application skills, and digital

social responsibility, all grounded in the core applied abilities of the discipline. Its constituent dimensions and content are aligned with national policies, educational guidelines, and the broader industry context.

From a policy perspective, the Chinese government places a high priority on enhancing digital literacy and skills across its population. In response, the Cyberspace Administration of China has released the “Action Plan for Boosting Digital Literacy and Skills Across the Nation” and the “Key Tasks for 2024” to implement this vision. These initiatives are designed to cultivate a high-caliber, interdisciplinary digital talent pool, aligning educational priorities with the demands of the digital era and fostering a healthy digital ecosystem.

From an educational perspective, digital literacy is also demonstrating a positive impact within the educational sector. For instance, Harbin Institute of Technology's initiative, “Building an Educational Big Data Application Ecosystem Empowered by Digital Intelligence,” provides students with personalized learning pathways by constructing an educational big-data platform, thereby enhancing their digital literacy. Additionally, the teaching case “Exploring the Educational Metaverse Application at Sias University” leverages the digital transformation of education to pioneer a novel instructional model that integrates digital instructors, human teachers, and large language models.

From an industry perspective, digital technologies are catalyzing the development of projects such as smart cities and smart campuses. These initiatives provide users with more intuitive and immersive experiences, thereby fostering multifaceted application scenarios for the advancement of digital technologies in environmental design.

With the advent of the big data era and the accelerating digital transformation, digital literacy has become an indispensable fundamental skill in modern society. The importance of digital skills is growing increasingly prominent on a global scale.

From a policy perspective, several countries and international organizations have released relevant policy documents to provide macro-level guidance for digital literacy education. This is exemplified by UNESCO's integration of digital literacy into the monitoring framework for Sustainable Development Goal 4 (SDG 4) for 2030. Furthermore, initiatives such as Norway's “National Digital Literacy Initiative” and the United States' “Digital Equity and Transformation Educators Preparation Program” provide crucial resources and recommendations to support digital learning and practice.

From an educational perspective, digital literacy education demonstrates characteristics of diversity and innovation in teaching practices across various disciplines. For instance, Canada's CanCode initiative is aimed at enhancing digital skills through K-12 learning and teacher professional development programs. Meanwhile, the ADOK project, developed in collaboration by Tampere University of Technology and other technical universities, which combines automation technology with the German language in an online course, exemplifies European efforts in pioneering teaching practices that integrate digital literacy with foreign language education.

In summary, to keep pace with evolving industry demands, environmental design education is continually innovating. It aims to cultivate digitally competent,

application-oriented talent with innovative thinking and practical abilities by infusing the curriculum with digital technological means.

2. Research Objectives

This project plays a significant role in advancing pedagogical practices and enhancing educational quality. First, the cultivation of digital literacy has become central to the digital transformation of education. Enhancing students' digital literacy aligns with the policy directives outlined in the “2024 Key Tasks for Enhancing Digital Literacy and Skills Across the Nation.” It also supports the development goals of Wuhan Institute of Design and Sciences’ smart campus initiative, fulfills the university’s objective of cultivating high-quality application-oriented talents, and corresponds with the “2+2” non-traditional project-based practical teaching framework adopted by the School of Environmental Design. By strengthening digital literacy, this endeavor aims to refine the practical teaching model in application-oriented universities, address the limitations of traditional instructional approaches, and drive the digital transformation of higher education. Furthermore, it contributes to building an inclusive and integrated national system for developing digital literacy and skills across urban and rural populations.

Second, it aims to align with the learning characteristics and needs of environmental design students. By stimulating students' innovative thinking and digital mindset, the project helps them better adapt to digitalized work environments, enhances their digital application capabilities and comprehensive learning skills, improves their ability to solve complex problems, and provides new means of design expression for the environmental design discipline.

Third, it seeks to establish a new bridge for digital social responsibility. Through the enhancement of digital literacy, the project maintains close connections with the forefront of industry design practices. It enables digital design outcomes to serve society, support environmental protection, and contribute to rural revitalization.

In summary, this research aims to align with the digital transformation of the environmental design industry and, in conjunction with national policies on digital literacy education and the practical context of environmental design programs in higher education, explore effective pathways to enhance the digital literacy of environmental design students. By establishing a scientifically grounded teaching framework and optimizing instructional resources and methods, the study seeks to strengthen students' digital thinking, application skills, and sense of digital social responsibility. The ultimate goal is to cultivate high-quality, application-oriented digital talent that meets industry demands, while also driving teaching reform in environmental design programs, improving educational quality, and providing transferable models and experiences for digital literacy development in environmental design education.

3. Scope of the Study

This research focuses on enhancing the digital literacy of environmental design students, with a specific emphasis on the project-based course series within the Environmental Design program at Wuhan Institute of Design and Sciences. The study covers four types of project-based design units: Landscape Design, Interior Design, Rural Residential Space Design, and Comprehensive Design.

To provide diversified design platforms for different project types, the study addresses six core design modules: fundamental principles, site analysis, conceptual development, material selection, technical drawing, and design representation. It appropriately employs a range of teaching methods, including multimedia lectures, case analysis, field investigations, the PDCA (Plan-Do-Check-Act) cycle, virtual simulation, and task-driven instruction.

Grounded in the industry requirements for environmental design professionals, this research develops digital enhancement strategies centered on three dimensions: digital thinking, digital application skills, and digital social responsibility. It explores specific pathways and methods for improving students' digital literacy through both theoretical instruction and practical training, while also addressing the development of teaching resources, faculty training, and the establishment of evaluation systems.

4. Analysis of Digital Literacy Components

“Digital literacy refers to an individual’s professional-level cognition and understanding of the digital environment, enabling them to skillfully utilize digital technologies, critically retrieve and use digital resources, and maintain a strong sense of online responsibility as a competency and literacy.” [1] For students majoring in environmental design, digital literacy specifically denotes a multidimensional digital comprehensive competency grounded in the core applied skills of the discipline. It integrates digital thinking modes, digital application capabilities, and digital social responsibility, serving as an indispensable attribute for their digitalized learning, design practice, and future career development.

Digital Thinking constitutes the core of digital literacy, referring to students’ ability to employ digital concepts, logic, and methodologies to address discipline-specific challenges in environmental design. It encompasses several key dimensions.

Data-Driven Decision-Making and Visualization: The capacity to utilize visual tools such as charts, diagrams, and images to interpret and communicate complex design concepts.

Digital Innovation Awareness: A proactive mindset toward exploring and applying digital technologies in innovative design contexts.

Digital Security Consciousness: The recognition of potential risks in digital environments and the cultivation of safe and responsible practices in using digital tools.

Digital Application Ability represents the practical manifestation of digital literacy, referring to students' capacity to utilize digital technologies and tools for learning and practice in environmental design. It encompasses the following key competencies:

Digital Information Acquisition and Operational Skills: The ability to efficiently source, filter, evaluate, and organize design-related information using open educational resources and digital tools.

Digital Information Management and Communication Skills: Proficiency in using digital technologies for design document management, team collaboration, and communication, enabling effective design resource sharing and coordinated workflows.

Digital Design and Production Skills: Competence in skillfully operating various digital design software and equipment to undertake tasks such as design conceptualization, model building, technical drawing, and design presentation.

Digital Social Responsibility serves as the value-oriented dimension of digital literacy, referring to the obligations and duties that students should uphold towards society, the environment, and culture when utilizing digital technologies in design activities. It encompasses the following aspects:

Awareness of Design Norms and Standards: Adherence to the established design specifications and industry standards within environmental design practice.

Ecological and Environmental Consciousness: Application of digital technologies to create eco-friendly design solutions and promote the development of sustainable design practices.

Social Service Awareness: Leveraging digital design outcomes to serve societal needs, support environmental protection, and contribute to rural revitalization, thereby integrating design value with social demands to achieve broader social benefits.

In summary, digital thinking forms the foundation of professional learning, determining the depth and direction of digital application skills. Digital application ability serves as the vehicle for professional development, translating conceptual designs into practical outcomes. Digital social responsibility acts as the ethical baseline, consistently guiding and calibrating the orientation of both digital thinking and application. Together, digital thinking, digital application ability, and digital social responsibility constitute a closed-loop interactive relationship characterized by "foundational thinking – applied practice – ethical boundaries".

5. Analysis of Digital Literacy Enhancement Pathways for Environmental Design Students

5.1. Constructing a Unit-Based Modular Project-Based Learning (PBL) Framework

This study centers on four project-based design units within the environmental design curriculum: Landscape Design, Interior Design, Rural Residential Space Design, and Comprehensive Design. Each unit is structured around six core design modules: Fundamental Principles, Site Analysis, Conceptual Development, Material Selection, Technical Drawing, and Design Representation. By integrating these design phases, a "Unit-Based Modular" knowledge framework and curriculum system (Table 1) is established. This framework incorporates digital literacy development objectives into the content of each module, establishes a foundational framework for digital thinking, and aims to systematically enhance students' digital thinking capabilities.

Table 1. Unit-Based Modular Curriculum Framework

Unit-Based Modular Curriculum Framework						
Component	Thematic Units	Core Principles	Site Investigation	Concept Development	Material Selection	Technical Drafting
	Design Unit	Courses	Environmental Design Site Studies II	Graphic Thinking B	Project Drawing B	Design Representation

	Digital Literacy	Data-driven decision-making and visualization thinking	Digital innovation awareness	Digital information acquisition and application
Interior Design Unit	Courses	Principles of Public Building Interior Design	Graphic Thinking A	Project Drawing A
	Digital Literacy	Leveraging open educational resources and tools to facilitate knowledge sharing and innovation	Using charts, images, and other visual tools to understand and present complex concepts	Applying digital tools for collaborative design
Rural Residential Space Design Unit	Courses	Project Planning II		Rural Residential Building Renovation
	Digital Literacy	Efficiently searching, filtering, evaluating, and organizing information		Rural Environmental Design
Comprehensive Design Unit	Courses	Environmental Psychology and Design	Environmental Design and Ecology	Environmental Design Materials and Technology
	Digital Literacy	Understanding, analyzing, and utilizing data to inform decision-making	Using digital technology to explore new methods and ideas for creative thinking	Integrating digital technology with knowledge from other disciplines for interdisciplinary innovation and application

In the specific implementation process, digital mind mapping can be employed to summarize and systematize fragmented knowledge points, thereby constructing a foundational knowledge framework. This can then be integrated with corresponding project-based practical tasks to provide targeted reinforcement and analysis of theoretical content, facilitating the application of theoretical knowledge. The focus on knowledge points emphasizes the enhancement of digital thinking and digital application skills, guiding students to identify, analyze, and solve problems within a digital environment.

For example, within the site analysis module of the Landscape Design Unit, students can be guided to utilize UAV (unmanned aerial vehicle) scanning and photography equipment to collect site survey data, combined with mapping software techniques for data organization and analysis, thereby fostering data-driven visual thinking. In the conceptual development module, the introduction of AI-assisted tools can encourage students to leverage digital technologies to explore innovative design solutions, enhancing their awareness of digital innovation. By deeply integrating the cultivation of digital thinking, digital application skills, and digital social responsibility with specialized course modules, the application and digitization of theoretical knowledge can be achieved, allowing students to progressively enhance their digital literacy throughout their professional studies.

5.2. Optimization of Teaching Resources and Platforms

5.2.1. Establishing a dynamically updated digital teaching resource repository

Based on the current state of industry development and trends in digital technology updates, we will collect outstanding digital design cases in the field of environmental design, digital technology case tutorials, industry standards and specifications, open educational resources, and other relevant materials to establish a digital teaching resource repository. The repository will include content such as design software operation tutorials, modeling technology use cases, and design practice projects. It will also contain design project materials related to rural revitalization, smart campuses, cultural and tourism projects, and more, providing students with rich digital learning resources. Additionally, the teaching resource repository will be regularly maintained and updated to ensure the timeliness, practicality, and accessibility of the resources, enabling students to stay abreast of cutting-edge industry knowledge and technologies.

Furthermore, within the Interior Design Unit, the university-level virtual simulation experiment project, “Visual Virtual Simulation Experiment on Lighting Fundamentals in Environmental Design,” helps students overcome the limitations of physical laboratory spaces, equipment, and time constraints inherent in traditional teaching methods. In a virtual environment, students can freely construct models of interior spaces with different layouts, simulating parameter adjustments and effect presentations for various lighting scenarios, such as natural and artificial lighting. They can observe in real-time how changes in lighting intensity, angle, color temperature, and shadows impact the ambiance and functional zoning of interior spaces. The platform also supports repeated experiments and solution optimization, transforming abstract lighting design theories into intuitive, visual practical operations. This approach significantly enhances students’ understanding and application of interior lighting design principles.

In the Landscape Design Unit, leveraging the development and recording of the provincial-level first-class undergraduate online-offline hybrid course “Environmental Design Site Studies II,” a comprehensive teaching resource system has been established. This system integrates online theoretical learning with offline practical application, focusing on core modules such as schematic evolution, vertical analysis, functional layout, circulation organization, facility design, and planting design within site planning.

The online component includes high-definition instructional videos, supplemented with interactive exercises and virtual design tasks. For the offline portion, practical projects—such as campus site renovations and urban public space investigations—are incorporated to guide students in applying their online-acquired knowledge to real-world design scenarios. Furthermore, outstanding student projects and outcomes are archived into the digital teaching resource repository. This practice fosters a virtuous cycle of “course development - resource accumulation - educational feedback,” thereby continuously enriching both the content diversity and practical depth of the site design section within the resource database.

5.2.2. Building a Diversified Project-Based Practice Platform

Aligned with industry trends and student learning profiles, we will broaden the teaching scenarios by establishing a diversified project-based practice platform. This platform will provide students with authentic design practice environments, while tailoring task difficulty to accommodate students with varying learning abilities,

thereby enhancing their digital application skills. The practical project platform includes initiatives such as ecological architecture and site design for scenic areas, smart campus renovation projects, campus atrium landscape design projects, urban renewal initiatives, and rural revitalization projects. These projects span the four core units—Landscape Design, Interior Design, Rural Residential Space Design, and Comprehensive Design—ensuring close integration with the “unit-based, modularized” theoretical curriculum.

Within the practice platform, design tasks are structured into three tiers—advanced, intermediate, and foundational—allowing students to select appropriate design directions based on their individual learning capabilities (Table 2, Table 3). For example, advanced tasks require students to utilize software modeling technologies and AI-assisted tools to complete full-process design of complex projects, with design presentations conducted through VR technology. Intermediate tasks focus on digital model construction and design scheme optimization. Foundational tasks emphasize the application of basic digital tools and mastery of design specifications. Through this diversified practice platform and tiered task design, the needs of students with varying learning abilities are met, their enthusiasm and initiative in learning are stimulated, and their digital application skills are effectively enhanced.

Table 2. Core Design Components of the Practical Project Platform for Unit 1 and Unit 2.

Core Design Components of the Practical Project Platform								
Practical Project	Practical Projects							
	Unit 1				Unit 2			
	Landscape Design Module	High	Mid	Low	Interior Design Module	High	Mid	Low
Ecological Architecture Site Design Project	Ste Planning			√	Public Building Interior Design		√	
Smart Campus Renovation Project	Ste Planning			√	Public Building Interior Design		√	
Campus Atrium Landscape Design Project	Atrium landscape Design	√			Existing Interior Condition Analysis			√
Old Town Renovation Project	Public Space Landscape Renovation, Industrial Site Renovation		√		Adaptive Reuse of Public Building Interior			√
Rural Revitalization Project	Public Space Ecological Restoration, Courtyard Design			√	Renovation Design for Public Building Interior	√		

Table 3. Core Design Components of the Practical Project Platform for Unit 3 and Unit 4.

Core Design Components of the Practical Project Platform								
Practical Project	Practical Projects							
	Unit 3				Unit 4			
	Rural Residential Space Design Module	High	Mid	Low	Compressive Design Module	High	Mid	Low
Ecological Architecture Site Design Project	—	—	—	—	Site analysis, analysis of ecological measures, application of ecological materials, temporary building design.	√		
Smart Campus Renovation Project	—	—	—	—	Site analysis, intelligent systems analysis, eco-material analysis, building facade renovation	√		
Campus Atrium Landscape Design Project	—	—	—	—	Site Analysis, Vertical Circulation Analysis, Facility Analysis, Planting Design, Building Facade Analysis		√	
Old Town Renovation Project	Residential Building Interior Renovation Design		√		Site Analysis and Regeneration, Structural Reinforcement, Building Facade Renovation	√		
Rural Revitalization Project	Residential Building Interior Renovation Design		√		Site Analysis, Ecological Material Analysis, Building Facade Renovation			√

5.3. Reforming Teaching Methods and Approaches

5.3.1. Integrating Diverse Teaching Methods

Depending on the teaching content of different design units and modules, various teaching methods are appropriately adopted—such as multimedia theoretical instruction, case analysis, practical field studies, the "PDCA" (Plan-Do-Check-Act) cycle teaching method, virtual simulation teaching, and task-driven learning—to enhance teaching effectiveness:

(1) Multimedia Theoretical Instruction

As the most fundamental teaching method in the curriculum, it utilizes multimedia tools to present content such as situational analysis, logical reasoning, materials and construction techniques, and case studies. By displaying images, videos, and other visual aids, it enables students to directly and efficiently comprehend, master, and apply relevant knowledge. This approach lays a theoretical foundation for practical application and helps students build a systematic digital knowledge framework.

(2) Case Analysis Method

A frequently employed teaching approach in the course, it serves two main purposes:

Analyzing representative exemplary cases related to specific design projects, enhancing students' understanding and mastery through discussion, comparison, and critical thinking.

Conducting forward-looking and trend analyses aligned with course content. By integrating current events and news, it deepens students' appreciation of human-centered design principles, encourages the adoption of digital techniques and innovative thinking from case studies, and broadens their perspectives.

(3) Practical Field Study Method

This method serves as the prerequisite for design practice under task-driven conditions. After theoretical learning, activities such as classroom notes, sketching exercises, and on-site investigations help students understand the application of digital technologies in design projects. This strengthens their intuitive grasp of digital design, boosts learning interest, and deepens theoretical comprehension. By integrating "teaching, learning, and doing," it bridges theory and practice, enhances perceptual awareness, cultivates student capabilities, and emphasizes applied skill training.

(4) PDCA Cycle Teaching Method

In project-based teaching, activities are organized according to the Plan-Do-Check-Act cycle:

Plan: Define digital literacy goals and teaching tasks.

Do: Students engage in design practice using digital tools.

Check: Evaluate progress in digital literacy through presentations, peer reviews, and instructor feedback.

Act: Summarize teaching experiences, adjust strategies based on identified issues, and continuously refine the teaching process.

(5) Virtual Simulation Teaching Method

Leveraging virtual simulation software, this method constructs immersive design environments for students to practice in. Key modules are supported by provincial-level first-class courses (e.g., "Virtual Simulation Experiment First-Class Course") and university-level projects (e.g., "Visual Virtual Simulation Experiment on Lighting Fundamentals in Environmental Design").

(6) Task-Driven Method

Instructors assign task sheets based on specific objectives, integrating digital technology applications into task requirements. By completing concrete design tasks, students proactively learn and utilize digital tools. This approach emphasizes student

initiative and integrates "teaching, learning, doing, guiding, and assessing" to foster professional competence and enhance vocational skills.

Example: In the Rural Residential Space Design Unit, tasks such as "Using SketchUp and VR to Renovate Rural Residential Designs" motivate students to actively acquire relevant digital skills and improve their digital application abilities.

5.3.2. Enhancing the Integration of Technology and Art

In both course instruction and practical sessions, we actively utilize hardware and software tools such as drone scanning and photography equipment, AI technology, virtual simulation applications, SketchUp digital modeling, and VR virtual technology to strengthen the fusion of technology and art (Table 4). This enables the digitization of all practical phases, providing technical support for enhancing students' digital literacy and design application capabilities.

Table 4. Digital Pedagogical Approaches.

Practical Design Phase	Digital Pedagogical Approaches				
	Digital Design Methodology				
	UAV Photogrammetry & Scanning	Artificial Intelligence(AI)	Virtual Simulation	Digital Modeling (SketchUp)	Virtual Reality (VR)
Site Investigation	√				
Conceptual Design		√	√	√	
Material Selection		√	√	√	√
Technical Drafting				√	√
Design Presentation		√	√	√	√

During Site Analysis:

Drone scanning and photography are employed to capture high-definition images and 3D data of the site. These are analyzed and processed using CAD and CASS software technologies, offering precise data support for design decisions.

During Conceptual Design:

AI-assisted design tools are used to generate preliminary design drafts. Students then refine and innovate based on these drafts, improving both design efficiency and creativity.

During Material Selection:

Building on SketchUp digital modeling, virtual simulation software, AI, and VR technologies simulate the appearance, performance, and application effects of different materials, assisting students in making more informed material choices.

During Technical Drawing:

SketchUp is utilized to construct digital models, achieving parametric and visual representation of design drawings.

During Design Presentation:

VR technology is leveraged to create immersive design presentations, allowing clients to experience design schemes more intuitively.

Through the deep integration of technology and art, we enrich the digital teaching environment and enhance students' digital application skills and design innovation capabilities.

5.4 Design Outcomes Fostering Self-Accomplishment

Using digital technology as a bridge, the educational outcomes of the environmental design program are deeply integrated with the national rural revitalization strategy. Through the digital empowerment of design achievements, not only is professional expertise injected into rural development, but students also gain recognition and enhancement of their self-worth through practical engagement. This process helps establish a sense of digital social responsibility and supports applied talents in transitioning from adapting to and integrating into society to actively serving it, gradually building a solid system of self-efficacy.

Throughout this process, students are guided to develop a sense of responsibility that “digital technology serves society,” closely linking their academic perspective with societal needs. This assists applied talents in transitioning from theoretical learning in the classroom to meeting social demands, from practical exploration on campus to integrating into social development, and ultimately to serving society with their professional capabilities, forming a closed-loop growth path of “learning-practice-service.”

In specific practice, students address practical needs such as the renovation of indoor and outdoor human habitats, urban renewal, and digital spatial upgrades. They use digital design tools to complete tasks such as scheme modeling, effect rendering, and the drawing of engineering technical documents. The resulting digital technical drawings provide accurate technical support for project advancement. This model, where design outcomes serve real needs, allows students to tangibly feel the close connection between their professional value and social development, breaking the cognitive misconception that campus learning is disconnected from social application.

6. Conclusions

By constructing a unit-based, modular project teaching framework, optimizing teaching resources and platforms, reforming teaching methods and approaches, and promoting the role of design outcomes in self-affirmation, the digital thinking, digital application skills, and digital social responsibility of environmental design students can be effectively enhanced. Students demonstrate higher motivation and innovation in digital design practice. Some student works have received awards in various competitions, teaching quality has significantly improved, and a transferable model and experience for digital literacy education in environmental design programs in higher education have been provided.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

Funding

This work was supported by the School-level Teaching Research Project: “Research on the Pathways to Enhance Digital Literacy for Environmental Design Students in the Context of Industry Development”.

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