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INTEGRATING GENERATIVE AI AND WEBAR INTO ENVIRONMENTAL DESIGN EDUCATION: A PROJECT-BASED CLASSROOM CASE STUDY

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ABSTRACT

Aim/Purpose	This study examines how generative artificial intelligence (GenAI) and web-based augmented reality (WebAR) can be integrated into a project-based introductory environmental design course and how students perceive the usefulness, feasibility, and demands of the resulting workflow.
Background	GenAI and AR are increasingly used in design education, but they are often taught as separate tools. A practical account is needed of how a broad AI-AR research agenda can be translated into bounded, novice-appropriate learning tasks.
Methodology	A descriptive classroom case study was conducted in one first-year course with 38 students working in 11 groups. The implementation comprised eight four-period stages, including a fieldwork stage conducted during the public holiday period. Evidence included teaching records, site-investigation reports, archived project outputs, course assessment

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records, and 36 responses to a non-login post-course questionnaire that collected no direct identifiers. Questionnaire responses were analyzed descriptively at the item level, and short open-ended responses were used to contextualize the findings.

Contribution This study documents a course-specific procedure, described here as research-to-teaching task translation, through which a broad GenAI-WebAR research agenda was narrowed into bounded and assessable undergraduate tasks. The term is used as a descriptive label for the procedure implemented in this course rather than as a new theoretical framework. The study also presents a project-based workflow connecting site observation, problem framing, ComfyUI-supported visual generation, iterative judgment, and Kivicube-based WebAR presentation.

Findings All 11 groups submitted the required types of project output during the course. During subsequent verification, complete archived deliverable sets could be opened and inspected for 10 groups. Component-level fulfillment varied across site-report completeness, correspondence with the original redesign, map or site positioning, and technical execution. Students generally perceived the workflow positively, particularly the continuing need for human design judgment, the connection between software learning and real design problems, and the contextual communication value of WebAR. However, perceived support from ComfyUI for rapid initial ideation was comparatively lower, while technical complexity and time pressure remained practical concerns.

Recommendations for Practitioners Instructors should sequence site observation before AI generation, constrain task scope for novice learners, teach criteria for contextual fit and design responsibility, and provide workflow templates and staged feedback. WebAR can be used to reconnect generated representations with location and audience.

Recommendations for Researchers Future studies should use comparison groups, independent performance-based assessments, pre- and post-course measures, and larger or multi-course samples to examine learning outcomes beyond student perceptions and group project completion.

Impact on Society Cloud-based GenAI and browser-based AR may reduce hardware and installation barriers for introductory design activities in institutions with comparable access to platforms, internet connectivity, and instructional support.

Future Research Future work should test the workflow across design disciplines, student populations, course durations, institutional settings, and levels of technical support.

Keywords AI-assisted design, environmental design education, generative artificial intelligence, project-based learning, research-informed teaching, WebAR

INTRODUCTION

Generative artificial intelligence and augmented reality are becoming increasingly relevant to design education, especially in architecture, environmental design, and adjacent visual and spatial disciplines. Text-to-image and diffusion-based tools are used to support early ideation, rapid visual exploration, and iterative concept refinement (Alamasi & Asfour, 2026; Jin et al., 2024; Montenegro, 2024). At the same time, AR and related immersive media have shown value in architectural and spatial education by strengthening visualization, spatial perception, site-based comparison, and communication of design intent (Diao & Shih, 2019; Hajirasouli & Banihashemi, 2022; Kerr & Lawson, 2020). These developments suggest that AI and AR can enrich how students generate, inspect, and communicate design ideas. However, their pedagogical value does not arise from tool adoption alone. The more important question is how these technologies can be embedded into teachable learning processes that connect site observation, design reasoning, visual generation, critical judgment, and spatial communication.

This question is especially important in introductory AI teaching for environmental design students. Existing work on AI education has shown the value of laboratory-based and project-based approaches for connecting abstract concepts with application contexts (Russell et al., 2005, 2012). Yet authentic environmental design tasks demand more than mere exposure to tools or isolated technical exercises. Even a modest redesign brief requires learners to notice site conditions, interpret public-space problems, make preliminary spatial judgments, compare alternatives, and communicate proposals in intelligible visual form. For first-year undergraduates, such demands can easily exceed what introductory courses can support. Recent studies on generative AI in design education point to a similar tension: AI-generated imagery can support early concept generation and visual exploration, but becomes less reliable when site specificity, workflow continuity, controlled development, originality, and design responsibility become central (Alamasi & Asfour, 2026; Jin et al., 2024). Without appropriate scaffolding, AI-generated images may remain visually attractive but weakly connected to contextual understanding and design learning.

This tension leads to the issue of research‑teaching integration. Research-informed teaching brings current disciplinary questions and modes of inquiry into the classroom (Elsen et al., 2009; Griffiths, 2004), while authentic and project-based learning provides real-site and group-project structures, and instructional scaffolding provides demonstrations, templates, feedback, and technical support (Herrington & Oliver, 2000). In this paper, the term research-to-teaching task translation is used to describe the course-design procedure through which a broad GenAI-WebAR research agenda was selectively narrowed and organized into bounded undergraduate learning tasks. Research-informed teaching identifies the research-derived content brought into the classroom; authentic and project-based learning provides real-site and group-project contexts; and instructional scaffolding provides demonstrations, templates, feedback, and technical support needed by novice learners. In this usage, task translation highlights the intermediate course-design work through which research content is selected, reduced, sequenced, and aligned with observable deliverables and assessment requirements; its use beyond this course remains to be examined.

A research gap emerges at the intersection of these discussions. Although prior work has examined GenAI-supported design ideation, AR-based spatial visualization, and research-informed project learning, fewer studies explain how these elements can be sequenced as a coherent, novice-appropriate workflow. In particular, limited attention has been paid to how first-year students can move from site evidence to bounded design tasks, AI-assisted exploration, critical selection, and contextual WebAR communication within a single introductory course. The assessment criteria, instructor support, and technical conditions required to implement such an integrated workflow have also received limited attention.

To address this gap, this paper reports a descriptive classroom case study of a project-based pedagogical innovation in undergraduate environmental design education. The course was organized around a redesign project for a scenic, public environmental space in Guilin, China. Students identified site-based issues, developed preliminary redesign concepts, used ComfyUI workflows for text-to-image, image-to-image, and inpainting-based generation and refinement, and presented their outcomes through Kivicube-based WebAR. The completed implementation examined how a research-oriented GenAI-WebAR agenda could be converted into a manageable learning pathway for novice design students. Evidence included teaching records, student project outputs, course assessment records, and questionnaire responses. The study addressed the following research questions:

RQ1: How can a broad GenAI-WebAR design agenda be translated into a bounded, scaffolded, and assessable project-based learning workflow for first-year environmental design students?

RQ2: To what extent did the 11 student groups complete the required site-investigation, AI-assisted redesign, and WebAR presentation outputs, and what differences or implementation difficulties were evident across the projects?

RQ3: How did students perceive the usefulness, feasibility, and practical demands of the integrated workflow?

The study makes three contributions. First, it documents a course-specific procedure for selecting, bounding, sequencing, and supporting research-derived undergraduate tasks. Second, it presents a project-based GenAI-WebAR workflow that links site investigation, problem framing, visual exploration, iterative judgment, and contextual presentation. Third, it provides empirical evidence on workflow feasibility and student perceptions from a completed classroom implementation, along with a criterion-level analysis of the original course assessment scores for all 11 groups.

Theoretical Background and Related Work

Generative AI in Design Education

Generative AI has rapidly entered design education, especially in architecture, interior design, environmental design, and related visual-spatial disciplines. Current applications are mainly concentrated in the early phases of the design process, where text-to-image and diffusion-based systems support concept generation, visual exploration, rapid iteration, and the externalization of vague ideas into discussable visual forms (Alamasi & Asfour, 2026; Montenegro, 2024). Generative AI is therefore often understood not as a replacement for design thinking, but as a medium for exploratory sketching, prompting, and representational experimentation (Cao et al., 2025; Tong et al., 2023). Recent reviews map GenAI applications across multiple architectural design stages but indicate that educational use and empirical evidence remain concentrated in early-stage ideation and conceptual development, while later-stage integration and long-term learning effects are less established (Alamasi & Asfour, 2026; Li et al., 2025).

Empirical studies further show that AI-assisted tools can broaden design alternatives, improve work efficiency, and help students transform verbal concepts into visual references (Jin et al., 2024; Montenegro, 2024). Freshman-level teaching experiments also suggest that AI image generation may function as a new mode of sketching when assignments are scaffolded through tutorials, prompt structures, and intermediate representational tasks (Tong et al., 2023). However, existing studies identify pedagogically important difficulties in aligning AI-generated outputs with site and programmatic conditions, controlling design expression, and sustaining systematic use across the design process (Jin et al., 2024; Montenegro, 2024). Student enthusiasm for AI-generated imagery is accompanied by concerns about originality, judgment, authorship, algorithmic bias, and responsible use, particularly beyond the early stages of design (Huh et al., 2025; Wang et al., 2025). Therefore, the educational value of generative AI depends less on image generation itself than on how it is embedded in a structured learning process that preserves human judgment, iterative comparison, and contextual evaluation.

AR and WebAR in Spatial Design Presentation

A second relevant body of work concerns augmented reality and related immersive technologies in architectural, spatial, and design education. Reviews show that AR can enhance spatial perception, visualization, comprehension of three-dimensional relationships, and communication of design intent by linking virtual content to real environments (Diao & Shih, 2019; Hajirasouli & Banihashemi, 2022;

Tan et al., 2022). Since design education depends heavily on the interpretation of space, scale, and viewpoint, AR has been valued as a means of making projected interventions more legible than conventional two-dimensional drawings alone (Birt & Cowling, 2018; Kerr & Lawson, 2020).

This literature is especially relevant where design outcomes must be presented in relation to specific places. Location-based and site-linked AR models can help students connect design proposals with local data, environmental context, and user perspective (Ünal & Demir, 2021). Mobile mixed reality and XR studio environments have also been shown to support design communication, comparative visualization, and interaction among students, reviewers, and audiences (Birt & Cowling, 2018; Crolla et al., 2024). Within this broader field, WebAR has practical significance for teaching because its lightweight, cross-platform delivery model avoids the advanced download and installation required by app-based mobile AR (Qiao et al., 2019). However, existing AR and WebAR studies in design education often focus on technical systems, visualization effects, or isolated course applications. Less attention has been given to how WebAR can be integrated into a scaffolded learning workflow in which spatial presentation is connected to site observation, proposal development, and design reflection rather than treated as a separate final display step.

Pedagogical Foundations for the GenAI-WebAR Course Design

The third strand of literature concerns the pedagogical foundations that can make GenAI-WebAR-supported design tasks meaningful for novice learners. Project-based learning, authentic learning, and research-informed teaching provide the first basis for this study. In built-environment disciplines, research-informed teaching connects student learning with disciplinary inquiry rather than limiting teaching to knowledge transmission (Brew, 2012; Griffiths, 2004). Undergraduate education can be strengthened when students engage with research questions, processes, and modes of investigation (Elsen et al., 2009). Authentic learning further suggests that educational tasks should resemble forms of reasoning and action found in real practice while remaining teachable and assessable within course settings (Herrington & Oliver, 2000). In this study, these principles justified the use of real scenic and public-space issues as learning contexts, while requiring that they be narrowed to bounded tasks suitable for first-year students.

Experiential learning and design thinking provide a second basis for organizing the course process. Experiential learning emphasizes a cycle of concrete experience, reflection, conceptualization, and further action (Kolb, 1984), while design thinking frames design learning as an iterative process of problem framing, ideation, prototyping, testing, and refinement (Razzouk & Shute, 2012). In the present course, these ideas were translated into a sequence of site observation, task definition, AI-assisted visual exploration, comparison and refinement, and WebAR-based communication. Generative AI was therefore not positioned as a shortcut to final design, but as a medium for producing provisional visual materials that could be questioned, selected, and improved. Research in another educational context has similarly applied the Learning by Design framework to AI-enhanced multimodal activities, highlighting the knowledge processes of experiencing, conceptualizing, analyzing, and applying, as well as the need for systematic and responsible pedagogical integration (Katsampoxaki-Hodgetts et al., 2025).

Cognitive apprenticeship, scaffolding, and technology-enhanced learning further explain how the workflow supported novice learners. First-year design students often lack stable criteria for judging site problems, image quality, spatial plausibility, and communicative clarity. Cognitive apprenticeship emphasizes learning through modeling, coaching, scaffolding, articulation, reflection, and gradual transfer of responsibility (Collins et al., 1989). In this course, staged demonstrations, task boundaries, workflow templates, interim feedback, and evaluative prompts helped students move from tool operation toward situated judgment. Technology-enhanced learning also cautions that technology use is not inherently beneficial; the key questions are what is enhanced, for whom, and through what process (Kirkwood & Price, 2014). From this perspective, generative AI supported ideation, visual variation, localized modification, and iterative comparison, while WebAR supported contextualized presentation. Together, these theoretical perspectives suggest that the pedagogical value of GenAI-WebAR teaching depends on task structuring, staged guidance, reflective judgment, and contextual communication.

METHODOLOGY

RESEARCH DESIGN

The study adopted a descriptive classroom case-study design. This design was selected because the purpose was to document how an integrated GenAI-WebAR workflow was translated into and implemented in a real introductory course, and to examine its feasibility of implementation, group-level project outputs, and students' perceptions of its usefulness and practical demands. Evidence was drawn from teaching records, site-investigation reports, archived group project outputs, course assessment records, and a post-course questionnaire. The specific data sources and analysis procedures are described in the following sections. The study did not employ random assignment, a control group, or pre- and post-intervention testing; consequently, it was not designed to estimate causal changes in learning performance.

COURSE CONTEXT AND PARTICIPANTS

The intervention was implemented in the course Introduction to Computational Thinking and Artificial Intelligence offered by an art and design school at a university in China. It took place during the second semester of the 2025–2026 academic year and was organized into eight four-period stages, totaling 32 scheduled 45-minute periods. Stage 3 consisted of fieldwork conducted during the public holiday period rather than an ordinary classroom session. The participants were 38 first-year undergraduate students majoring in Environmental Design, who worked in 11 project groups. The site investigation report and the final integrated project were completed and assessed at the group level.

Guilin provided a familiar and concrete teaching context with observable issues related to visitor experience, spatial guidance, environmental presentation, resting facilities, cultural storytelling, and public-space interface design. The project engaged students with selected components of these issues and did not require comprehensive professional planning solutions.

PEDAGOGICAL DESIGN AND COURSE-SPECIFIC TASK TRANSLATION

In this course, research-to-teaching task translation involved selecting and reorganizing research-derived content into a sequence of bounded learning tasks for first-year students. Real site problems provided authentic project contexts, and the workflow guided students from observation and ideation through refinement and communication. Demonstrations, templates, and feedback provided staged support throughout this process, while GenAI and WebAR were embedded within the design activities rather than taught as isolated software skills.

The translation followed three principles. First, tasks began with documented site conditions rather than abstract prompts. Second, broad observations were narrowed into visually representable interventions at a specific node, entrance, route segment, facility, interface, or visitor-experience scene. Third, generated alternatives were compared with the original condition and then re-situated through WebAR so that students could communicate where an intervention was located, what problem it addressed, and how it changed the site. These boundaries kept the project within the scope of an introductory course.

Each stage was also aligned with a defined student activity, an observable deliverable, and an assessment focus. In this arrangement, research-informed teaching provided the source of the project content; authentic and project-based learning provided the real-site and group-project structure; experiential learning and design thinking informed the sequence from observation to refinement; and scaffolding was implemented through demonstrations, workflow templates, group consultations, and technical support.

Learning Activities, Technology Access, and Instructor Support

The 32 class periods were organized into eight four-period stages, progressing from conceptual preparation and field investigation to task framing, AI-assisted proposal development, WebAR presentation, and final integration. Stage 3 was conducted as fieldwork during the public holiday period. Each group was required to submit original site photographs, corresponding AI-generated redesign images, and a WebAR project. Table 1 details the instructional focus, student tasks, instructor support, deliverables, assessment focus, and observed difficulties at each stage. Throughout the workflow, AI-generated images were treated as provisional representations to be compared with original site conditions and refined before selected proposals were reorganized through map-linked WebAR.

Table 1. Stage-by-stage implementation of the GenAI-WebAR project

Stage and duration	Instructional focus	Student task	Instructor support and technology	Expected deliverable and assessment focus	Observed difficulty
1. Conceptual preparation, 4 periods	AI foundations, general AI-assisted design, and ComfyUI workflow logic	Complete introductory exercises and review a public-space design case	Concept explanation, workflow demonstration, Chaoxing cloud access	Preparatory exercise; basic understanding of AI and workflow logic	Unfamiliarity with node relationships and technical terminology
2. Field-investigation preparation, 4 periods	Fieldwork methods and urban street-space observation	Define investigation topics, routes, photographic evidence, and group tasks	Investigation framework, examples, and task requirements	Investigation plan; clarity and relevance of observation focus	Topics were sometimes too broad or insufficiently connected to observable evidence
3. Field investigation, 4 periods	Site observation and evidence collection	Conduct fieldwork, photograph selected locations, and prepare the investigation report	Fieldwork instructions and consultation	Site report and original photographs; evidence quality and problem identification	Some observations remained general rather than site-specific
4. Task framing and introductory ComfyUI practice, 4 periods	Converting observations into bounded design tasks	Present fieldwork findings, select sites, and formulate limited intervention tasks	Group critique, task-boundary discussion, and introductory workflow guidance	Site selection and task statement; problem–task correspondence	Difficulty reducing real spatial problems to manageable design tasks
5. AI-assisted proposal development, 4 periods	ComfyUI workflow development and preliminary visual exploration	Use text-to-image and image-to-image methods to develop design alternatives	Workflow templates, examples, parameter guidance, and troubleshooting	Preliminary redesign images; site-feature retention and design direction	Node connections, model selection, prompt formulation, and output control

Stage and duration	Instructional focus	Student task	Instructor support and technology	Expected deliverable and assessment focus	Observed difficulty
6. Proposal refinement, 4 periods	Comparison, inpainting, reference guidance, and project deepening	Compare alternatives and refine selected proposals	Group consultation, technical correction, and contextual-fit feedback	Revised before-and-after proposals; local control, site fit, and human judgment	Mismatch between visual effects and actual site conditions
7. WebAR presentation, 4 periods	AR as a communication medium and the AI-AR workflow	Organize maps, original images, redesign proposals, and explanations in Kivicube	Platform demonstration, scene construction guidance, and mobile testing	Initial WebAR project; content completeness, location correspondence, and accessibility	Account use, loading, hotspot placement, and access links
8. Discussion and final integration, 4 periods	Troubleshooting and project consolidation	Revise ComfyUI and Kivicube outputs and complete the group submission	Group-level discussion, error diagnosis, and final submission checking	Complete project; coherence, accessibility, technical execution, and presentation	Time pressure, troubleshooting, and final integration

ComfyUI was accessed through an Alibaba Cloud educational computing resource claimed and activated through the Chaoxing course platform. Each student and instructor received a computing allocation valued at RMB 300, which provided access throughout the course period and was sufficient for all required activities. No participant incurred an additional cost. Because image generation was performed in the cloud, students could use their personal computers without relying on local graphics card specifications; stable internet access and a valid platform account were the main technical requirements. The course materials included specific instructions on how to claim the Alibaba Cloud resource and activate it through Chaoxing.

Students were provided with instructor-prepared ComfyUI workflow templates rather than being required to build all workflows from scratch. The templates were adapted from publicly available community examples and customized for the course tasks and cloud environment. Students modified prompts, parameters, masks, reference images, and selected nodes according to their project needs. At the time of the course, Kivicube accounts could be registered free of charge, and the free account tier allowed the creation of two AR scenes, which was sufficient for the project requirements. Four class periods were allocated to the AI-AR workflow and the use of Kivicube, covering scene construction, map and image organization, interaction settings, link access, and mobile device testing. No dedicated AR headset was required.

Formative feedback was provided at three group-level checkpoints. Each group presented and discussed its site-investigation findings, preliminary ComfyUI-generated results, and initial Kivicube model separately. The feedback addressed problem definition, correspondence between site needs and proposed interventions, ComfyUI errors, contextual fit, WebAR content organization, and project accessibility.

Assessment Design and Formative Feedback

The complete course assessment consisted of five components. Students completed an online artificial-intelligence learning module (10%), a scenic-area planning case analysis (10%), a site-investigation report (15%), a final integrated ComfyUI–Kivicube project (40%), and a preliminary pavilion-redesign mini-project (25%). The preliminary mini-project provided an opportunity to practice basic design analysis and image-generation procedures before the main group project. Because it did not include WebAR or the complete site-investigation-to-WebAR workflow examined in this study, it was excluded from the cross-group project analysis. The remaining four components, accounting for 75% of the course grade, were aligned with the preparation and implementation of the workflow reported in this paper.

The case analysis and site-investigation report used a common 100-point rubric covering task completion (30 points), application of knowledge and methods (30), analytical and design thinking (25), clarity and submission conventions (10), and timely submission and revision following feedback (5).

The final project required each group to redesign three to five streetscape or public-space sites and submit before-and-after images, relevant ComfyUI materials, and a Kivicube WebAR project. The analytic rubric covered problem identification and site selection; proposal positioning and design logic; completeness and correspondence of outputs; ComfyUI workflow use; inpainting and visual control; proposal quality and human judgment; completeness of Kivicube content; AR interaction and technical implementation; integration and communication of results; and originality and submission conventions. The latter included disclosure of AI assistance and the sources of external materials. The complete rubric is provided in Appendix A.

The rubric also specified deductions for fewer than three redesign sites, missing WebAR content, inaccessible AR links, incomplete correspondence among locations and images, and unacknowledged use of AI-assisted or external materials. The assessment was accompanied by the three formative group consultations described above, so feedback addressed both design reasoning and technical execution before the final submission.

The original final-project scores analyzed in this study were assigned during regular course assessment by the first author, who was the course instructor, using the pre-established rubric in Appendix A. No second or independent assessor participated; therefore, inter-rater agreement was not examined.

Data Sources and Questionnaire Development

The study used five data sources: teaching records documenting implementation; 11 group site investigation reports; student project outputs, including original site photographs, AI-generated redesign images, and planar AR presentation models; the written assessment rubrics and group-level score records; and a post-course questionnaire. Thirty-six questionnaires were received from the cohort of 38 students, yielding a response rate of 94.7%. The questionnaire contained background and starting-point items, five-point Likert statements, and five open-ended questions. The complete instrument is reproduced in Appendix B.

The questionnaire was developed by the first author by mapping the items onto the course objectives, instructional sequence, project tasks, and written assessment criteria. Before administration, the Chinese draft was reviewed by three co-authors for content relevance, clarity, redundancy, ambiguity, terminological consistency, and alignment with the course design. The questionnaire was not formally piloted before administration. The item groupings were therefore used as organizational domains aligned with the course workflow rather than as validated measurement constructs.

Participants' prior experience with AI image-generation tools, ComfyUI, and AR/WebAR tools was documented in the first three items (Q1-Q3), while their perceived starting points were captured in the next four items (Q4-Q7). The remaining Likert items were organized into four course-aligned domains: site observation and problem framing (Q8-Q12), AI-assisted generation and judgment (Q13-Q21), WebAR-based spatial communication (Q22-Q25), and research-content integration and task structuring (Q26-Q34). Time pressure was treated separately in Q35. The final five items were open-ended questions (Q36-Q40).

The first three domains followed the functional sequence from site observation, through AI-assisted generation and judgment, to WebAR communication. The fourth captured students' cross-stage perceptions of how research content was bounded, supported, and organized as course tasks. The domains were used to organize the questionnaire and results rather than to establish a four-factor measurement structure.

Data Collection Procedure

The course ended on May 13, 2026. The non-login post-course questionnaire was open from May 20, 2026, to May 27, 2026, seven days after the course ended, and was distributed by the course instructor via a shared Wenjuanxing QR code. Final course grades had been determined before the questionnaire was distributed, although they had not yet been formally released to students.

Students were informed orally that participation was voluntary and unrelated to course grading, and that the responses would be used for course improvement, educational research, and academic publication. The questionnaire did not request names, student identification numbers, usernames, account identifiers, contact information, grades, or other direct identifiers, and completion of the questionnaire was not included in the course assessment. Thirty-six of the 38 students submitted valid responses. The two nonrespondents completed the course normally and experienced no academic consequence.

Wenjuanxing automatically displayed limited platform-generated metadata, including submission time, response duration, access channel, and a coarse city-level or region-level location label derived from the submission IP address. The numerical IP address itself was not displayed to the course instructor. Entries marked "WeChat" indicated only the access channel and did not disclose a respondent's WeChat identity. The platform did not display usernames, account identifiers, device identifiers, or other information that could reliably connect a response with an individual student. These metadata were not used to identify respondents.

The exported dataset used for analysis contained the platform-generated response sequence, submission time, and responses to Q1–Q40. It did not contain the coarse location labels, access-channel information, response duration, account information, or device identifiers. R01–R36 were researcher-assigned labels created after data export solely from the platform-generated response sequence: R01 corresponded to the first exported response, R02 to the second, and so forth. All students accessed the questionnaire via the same shared QR code; therefore, the response sequence was unrelated to student numbers, class list order, seating order, or other identity-based numbering. No linkage file or re-identification key was created; the available information did not provide a reliable means of identifying individual students, and no attempt was made to re-identify them.

Data Analysis

Teaching records and investigation reports were reviewed descriptively to trace the movement from site observation to bounded task definition. The categories of site issues reported in the results were derived from the problems documented in the 11 group reports and discussed during the course. All 11 groups were included in the project-output analysis. The original group-level scores assigned by the first author during course assessment were summarized using means, standard deviations, and ranges. These scores were treated as descriptive records of instructor-assessed group performance rather than as independent measures of learning or project quality.

Four project conditions were distinguished. Submission referred to whether a required deliverable type had been provided during the course. Component-level fulfillment referred to whether particular content requirements, such as report completeness, original redesign correspondence, and map or site positioning, were fully satisfied. Verification accessibility referred to whether the archived deliverable set could subsequently be opened and inspected. Assessed quality referred to the instructor-assigned rubric scores. A submitted and accessible project could contain component-level deficiencies and receive score deductions without being classified as unsubmitted or inaccessible.

Responses to Q1-Q3 were summarized using frequencies and percentages. Responses to Q4-Q7 were summarized using item means, standard deviations, and the proportions selecting agree or strongly agree. Responses to Q8-Q35 were summarized using item means, standard deviations, complete five-category response distributions, and the proportions selecting agree or strongly agree. Item-level results formed the primary basis of questionnaire reporting. The course-aligned item domains were used only to organize the presentation of the results.

Open-ended responses were reviewed question by question using descriptive multi-label coding. The first author read all 36 original Chinese responses, developed the initial category framework, and assigned one or more categories where a response addressed multiple aspects. Two additional authors subsequently reviewed every original Chinese response, each category definition, and every coding assignment. This procedure constituted a consensus review of the full set of assignments rather than independent blind duplicate coding. Differences were discussed with the first author until agreement was reached. No inter-coder reliability coefficient was calculated, and the procedure is not presented as formal thematic analysis. Category frequencies represent the number of respondents mentioning each category; therefore, totals may exceed 36.

Illustrative quotations were selected to represent recurrent, critical, and divergent responses. The quotations were translated from Chinese into English by the first author. Minor punctuation adjustments were made for readability without altering the substantive meaning. Because many responses were brief, the categories and quotations were used to contextualize the item-level questionnaire findings rather than to support a comprehensive qualitative or thematic analysis.

RESULTS

PARTICIPANTS' PRIOR EXPERIENCE

Items Q1-Q7 described participants' prior experience and perceived starting points. All 36 respondents had previously used AI image-generation tools: 20 (55.6%) reported frequent use and 16 (44.4%) occasional use. However, prior experience with ComfyUI was limited. Twenty students (55.6%) had never used it, 13 (36.1%) had heard of it but had not used it, and only three (8.3%) reported previous use. Experience with AR or WebAR presentation tools was more varied: 11 students (30.6%) had never used them, 12 (33.3%) had heard of them but had not used them, and 13 (36.1%) reported previous use.

The Likert items produced a more differentiated picture. Agreement that students had little knowledge of generative AI applications in design before the course was moderate ($M = 3.28$, $SD = 0.78$; 36.1% agree or strongly agree). Reported lack of prior AI use for design ideation or image generation was lower ($M = 2.78$, $SD = 0.80$; 19.4%), consistent with the experience reported in Q1. By contrast, students more frequently reported limited prior knowledge of AR or WebAR presentation methods ($M = 3.72$, $SD = 0.78$; 69.4%) and difficulty translating site observations into concrete design tasks ($M = 3.58$, $SD = 0.73$; 61.1%).

Thus, the cohort was familiar with general AI image-generation tools but was largely inexperienced with the specialized ComfyUI workflow and relatively unfamiliar with WebAR and site-to-task translation. Because Q4-Q7 were completed after the course, they are treated as background descriptors rather than pretest measures or evidence of learning gains. Table 2 summarizes participants' prior tool experience and reported starting points.

Table 2. Participants' prior experience and reported starting points

Item	Result
Q1: AI image-generation tools	Occasional: 16 (44.4%); Frequent: 20 (55.6%)
Q2: ComfyUI	Never: 20 (55.6%); Heard but not used: 13 (36.1%); Used: 3 (8.3%)
Q3: AR/WebAR tools	Never: 11 (30.6%); Heard but not used: 12 (33.3%); Used: 13 (36.1%)
Q4: Limited GenAI design knowledge	M = 3.28, SD = 0.78; agreement = 36.1%
Q5: Limited prior AI design use	M = 2.78, SD = 0.80; agreement = 19.4%
Q6: Limited AR/WebAR knowledge	M = 3.72, SD = 0.78; agreement = 69.4%
Q7: Difficulty translating site observations	M = 3.58, SD = 0.73; agreement = 61.1%

COURSE IMPLEMENTATION STRUCTURE

The implementation followed the eight stages shown in Fig. 1, with conceptual preparation, site investigation, task framing, AI-assisted exploration, WebAR presentation, and final integration. The sequence positioned AI outputs as provisional materials for comparison and refinement and used WebAR to reconnect redesigned images with maps, original photographs, and spatial explanation.

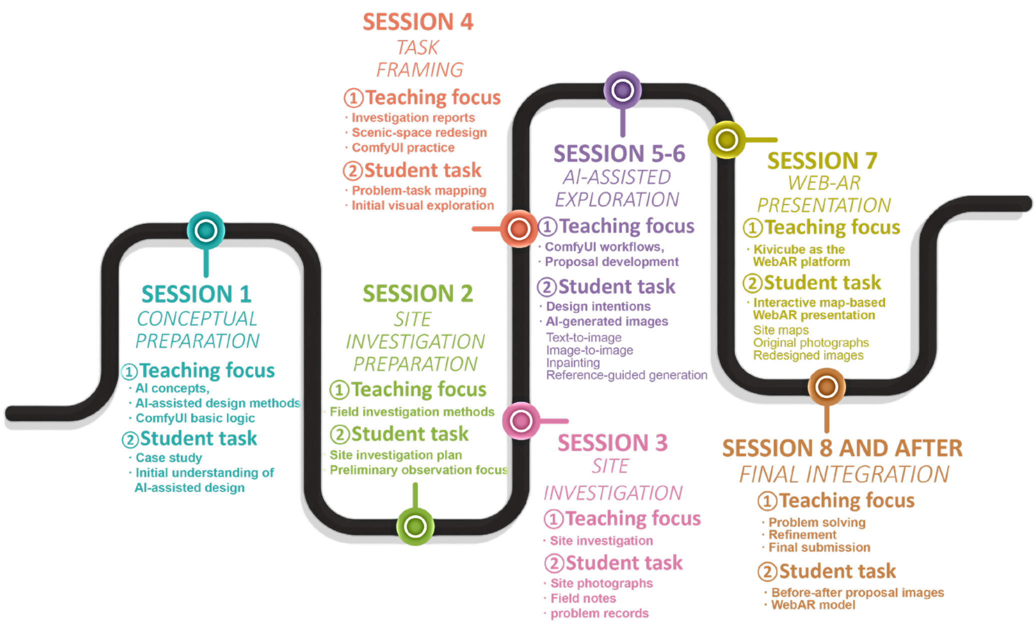

Figure 1. Course implementation structure of the research-informed GenAI-WebAR workflow

FROM SITE REPORTS TO DESIGN TASKS

The implementation emphasized the translation of student site reports into bounded design tasks. Based on all 11 group investigation reports and classroom discussions, the problems identified by students were synthesized into five categories: dilapidated facilities, insufficient lighting, lack of guidance, single-visitor experience, and inadequate supporting facilities. They were used as learning prompts for introductory design inquiry. Table 3 summarizes how the observed issues were translated into bounded design tasks. These tasks were subsequently represented through original site photographs, AI-assisted redesign images, and map-linked WebAR content.

Table 3. Site problem-task translation

Site observation focus	Identified site issue	Translated design task
1. Dilapidated facilities	Outdated restrooms, weathered stone structures, and blank walls lacking cultural expression	Upgrade facility appearance, support gentle conservation, and introduce culturally meaningful wall interfaces
2. Insufficient lighting	Dim exhibition or cave spaces and mismatched nightscape lighting around historical buildings	Improve spatial lighting, nightscape atmosphere, and light-shadow experience
3. Lack of guidance	Crowded entrance, unclear visiting routes, and weak spatial connection between the surrounding alleys and the scenic area	Design panoramic maps, wayfinding signs, spatial zoning, and transitional landscape interfaces
4. Single experience	Monotonous central-axis path and limited interactive cultural experience for young visitors	Introduce interactive check-in points, cultural experience scenes, and AR-supported interpretation devices
5. Inadequate facilities	Insufficient accessible facilities, rest platforms, shading, and rain-shelter spaces	Add handrails, anti-slip treatment, rest platforms, covered walkways, and green-integrated resting spaces

CROSS-GROUP PROJECT COMPLETION AND PERFORMANCE

All 11 groups submitted original site photographs, produced three to five AI-assisted redesign scenes, and created a WebAR project during the course. Component-level fulfillment nevertheless varied: nine groups submitted complete site-investigation reports, nine showed complete correspondence between original and redesigned images, and eight showed fully correct map or site positioning. During subsequent verification, the complete archived deliverable set could be opened and inspected for 10 groups; one archived WebAR project could no longer be reopened. Deficiencies in report content, image correspondence, or positioning were treated as component-level deficiencies that affected the rubric score, rather than as evidence that the entire project had not been submitted.

The instructor-assigned course-assessment records yielded a mean total project score of 84.09 (SD = 7.35), with scores ranging from 70 to 93. Table 4 summarizes submission, component-level fulfillment, verification accessibility, and instructor-assessed performance across the original course-assessment criteria.

Table 4. Cross-group project outcomes and rubric results

Panel A. Submission, component-level fulfillment, and verification accessibility

Required outcome	Groups meeting the criterion	Percentage
Complete site-investigation report	9/11	81.8%
Original site photographs submitted	11/11	100.0%
Three to five AI-assisted redesign scenes produced	11/11	100.0%
Complete original-redesign image correspondence	9/11	81.8%
WebAR project formed	11/11	100.0%

Required outcome	Groups meeting the criterion	Percentage
Map or site positioning fully correct	8/11	72.7%
Complete archived deliverable set accessible during subsequent verification	10/11	90.9%

Panel B. Instructor-assessed rubric results

Assessment criterion	Maximum	M	SD	Mean score rate	Range
Problem identification and site selection	10	8.27	1.10	82.7%	6-10
Proposal positioning and design logic	10	8.09	1.30	80.9%	6-10
Completeness and correspondence of outputs	10	9.00	0.63	90.0%	8-10
ComfyUI workflow use and technical execution	10	7.91	1.38	79.1%	6-10
Inpainting and visual control	15	12.64	1.36	84.2%	11-15
Proposal quality and human judgment	10	8.91	1.14	89.1%	7-10
Completeness of Kivicube content	10	8.91	0.70	89.1%	8-10
AR interaction and technical implementation	10	7.82	0.98	78.2%	6-9
Integration and communication of results	10	8.64	0.67	86.4%	8-10
Originality and submission conventions	5	3.91	0.83	78.2%	2-5
Total project score	100	84.09	7.35	84.1%	70-93

Note. Panel A reports submission, component-level fulfillment, and verification accessibility as distinct conditions. A project could be submitted and accessible while receiving deductions for incomplete correspondence, inaccurate positioning, or other component-level deficiencies. Panel B summarizes the original group-level scores assigned by the first author, who was the course instructor, during regular course assessment using the pre-established rubric. No second or independent assessment was conducted. M = mean; SD = standard deviation.

The highest mean score rates were found for completeness and correspondence of outputs (90.0%), proposal quality and human judgment (89.1%), and completeness of Kivicube content (89.1%). The lowest mean score rates occurred in AR interaction and technical implementation (78.2%), originality and submission conventions (78.2%), and ComfyUI workflow use and technical execution (79.1%). The groups therefore completed and organized the required outputs more consistently than they achieved stable software operation, AR interaction, and complete process documentation.

Illustrative outputs from selected groups are presented in Figure 2. These examples show the form of stronger completed work and are not used as evidence of uniform performance across all 11 groups. In each example, an original photograph documented a specific site condition and an AI-generated image visualized a corresponding intervention, such as facility renewal, lighting improvement, wayfinding enhancement, resting-space addition, or cultural-experience enrichment. The examples illustrate how the required deliverables connected site evidence with a bounded visual proposal.

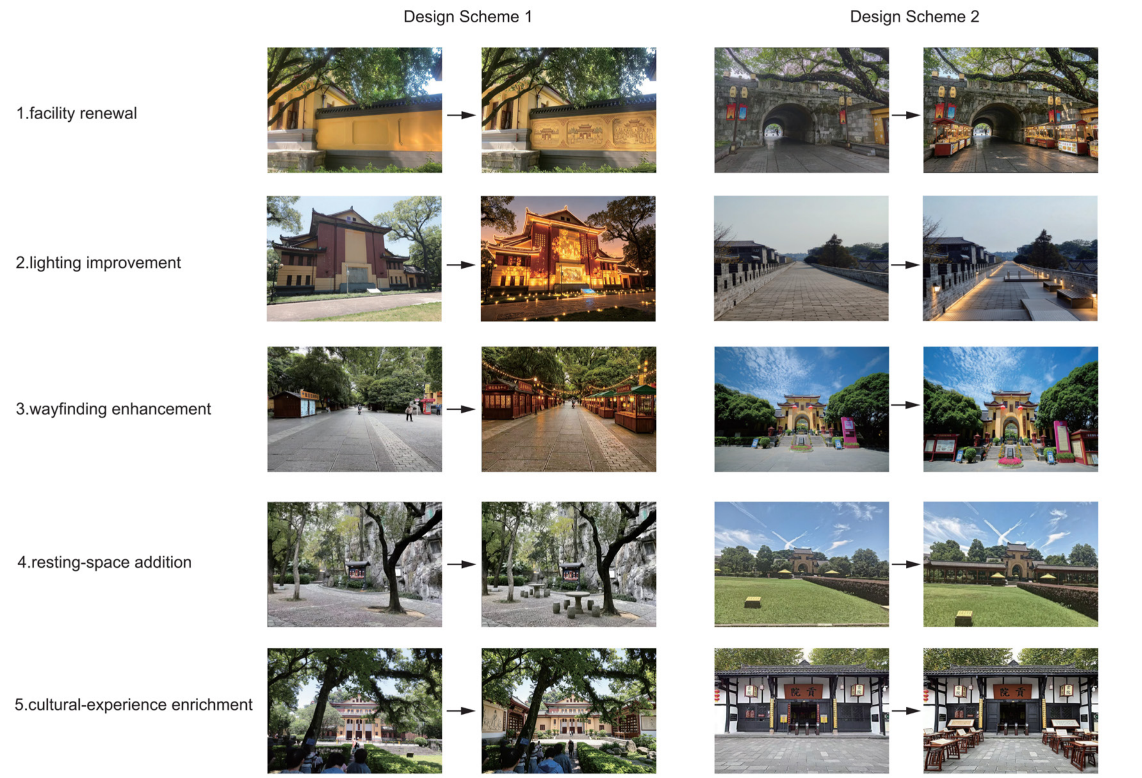

Figure 2. Illustrative student project outputs: original site photographs and AI-assisted redesign images

The planar AR models reorganized these materials through map-based access points. As shown in Figure 3, the selected interfaces correctly located the photographed sites on a map and linked them to the original and redesigned images. This arrangement enabled viewers to compare existing and proposed conditions in relation to their mapped locations.

Figure 3. WebAR presentation interface

Item-Level Questionnaire Findings

Perceptions were positive overall, but item-level results revealed meaningful variation. Table 5 presents selected item-level results that are most directly related to the research questions. The complete results for Q8–Q35 are reported in Appendix C. The course-aligned domains are used only to organize the presentation of the items.

Table 5. Selected item-level questionnaire results

Item	Abbreviated statement	M	SD	Agree or strongly agree
Q10	Observed problems became designable and expressible tasks	4.11	0.46	94.4%
Q12	Real spatial problems require appropriate simplification	4.06	0.63	83.3%
Q13	ComfyUI supported faster preliminary ideation	3.75	0.69	72.2%
Q16	AI images supported more intuitive group discussion	4.06	0.41	94.4%
Q19	Attractive AI results might not suit the actual site	4.33	0.59	94.4%
Q20	AI-assisted design still required human judgment	4.44	0.56	97.2%
Q21	AI improved efficiency without replacing design thinking	4.31	0.58	94.4%
Q22	WebAR connected proposals with specific site locations	4.08	0.50	91.7%
Q23	Map-based presentation clarified location relationships	4.19	0.52	94.4%
Q25	WebAR expressed the proposal–site relationship better than PPT	4.11	0.46	94.4%
Q27	Complex research topics became completable project tasks	4.00	0.59	83.3%
Q29	Cases, templates, and staged guidance supported completion	4.08	0.55	94.4%
Q31	Tool learning was connected with real design problems	4.25	0.50	97.2%
Q35	The project schedule was tight	3.81	0.79	63.9%

Note. Items were rated on a five-point scale from 1 = strongly disagree to 5 = strongly agree. Agreement comprises responses of agree or strongly agree. Full item-level results are provided in Appendix C.

The site-observation items were consistently positive, with the strongest agreement for converting observed problems into designable and expressible tasks (Q10, 94.4%) and the lowest for recognizing the need to simplify real spatial problems (Q12, 83.3%).

The clearest contrast appeared within the AI-related items. Agreement that ComfyUI accelerated preliminary ideation was comparatively lower (Q13, 72.2%), whereas students more consistently recognized that attractive outputs might not suit the site (Q19, 94.4%), that human judgment remained necessary (Q20, 97.2%), and that AI did not replace design thinking (Q21, 94.4%). WebAR responses were more uniform, with agreement ranging from 91.7% to 94.4% across the four items.

Within the items on research-content integration and task structuring, agreement was highest for connecting tool learning with real design problems (Q31, 97.2%) and lower for participating in a simplified research-style process (Q28, 80.6%) and converting complex research topics into completable project tasks (Q27, 83.3%). Time pressure remained the principal implementation concern: 63.9% agreed that the schedule was tight (Q35).

Open-Ended Responses

The open-ended responses provided a more qualified account of feasibility. Table 6 summarizes the most frequently mentioned categories for each question; the complete category summary is provided in Appendix D.

Table 6. Summary of the main open-ended response categories

Question	Most frequently mentioned categories
Q36: Most helpful component	AI/ComfyUI practice and workflow use (n = 26); project application and conversion of ideas into outputs (n = 8); instructor guidance and demonstrations (n = 5)
Q37: Main difficulty	Workflow, node, parameter, or error-diagnosis difficulties (n = 20); prompt formulation and control of generated results (n = 15); limited familiarity with software or basic digital operation (n = 14)
Q38: Contribution of WebAR	More direct or clearer presentation (n = 27); better expression or communication of design ideas (n = 14); stronger connection with the site or spatial relationships (n = 8)
Q39: Feasibility of research integration	AI/ComfyUI practice (n = 13); general affirmation without a specific example (n = 12); exposure to research or current methods (n = 7); task decomposition, scaffolding, or instructor guidance (n = 6)
Q40: Suggested improvements	More detailed, slower, or step-by-step instruction (n = 19); stronger AI or software foundations (n = 9); more practice time, class hours, or technical consultation (n = 8); troubleshooting guides, videos, or online support (n = 8)

Note. Multiple categories could be assigned to one response; therefore, category totals may exceed 36. The complete coding summary is reported in Appendix D.

Q36 responses most often identified hands-on ComfyUI and AI image generation practice as helpful, together with project application and instructor demonstrations. One respondent described how the instructor "guided us step by step through text-to-image and image-to-image tools, helping us learn new ways to support design" (R29).

Q37 responses concentrated on node connections, parameter relationships, error diagnosis, model conflicts, prompt formulation, and limited control. One respondent noted that "when the workflow logic failed, it was difficult to locate the source of the problem" (R08), while another described repeated debugging as time-consuming (R10). These comments contextualize the comparatively lower agreement with Q13.

Q38 responses generally described WebAR as making proposals clearer and more closely connected to specific sites. One respondent stated that WebAR "connected the actual site and the design more effectively" (R18), although three respondents were uncertain about its specific contribution. For Q39, no respondent explicitly rejected the feasibility of integrating research content into the course, but 12 responses offered only a general affirmation without identifying a specific supporting component. More detailed responses emphasized AI/ComfyUI practice, exposure to research methods, task decomposition, instructor support, field investigation, and AI-AR integration. One respondent noted that feasibility depended on selecting "mature research methods and tools with manageable entry barriers" and breaking them into "operable subtasks" (R08).

Q40 suggestions focused on slower demonstrations, step-by-step workflow materials, troubleshooting guides, video resources, additional practice time, and more opportunities for technical consultation. Nineteen respondents requested more detailed, slower, or step-by-step instructions. Eight requested additional practice time or consultation, and eight requested troubleshooting or video resources. One respondent suggested, "a troubleshooting guide for common ComfyUI errors, accompanied by step-by-step video demonstrations" (R08). Nine respondents offered no specific improvement or considered the existing course arrangement satisfactory.

DISCUSSION

RQ1 was addressed through a sequence of narrowing, staging, scaffolding, and alignment with observable outputs: site issues became bounded learning prompts, GenAI supported provisional visual exploration, and WebAR returned selected proposals to a mapped communication context. In this case, research-to-teaching task translation served as a course-specific descriptive label for how research-derived content was selected, bounded, sequenced, supported, and connected with assessment. It operationalized established principles of research-informed teaching, authentic learning, project-based learning, and instructional scaffolding; it was not examined as a distinct or generalizable pedagogical framework.

In relation to RQ2, the cross-group review provides the basis for assessing implementation feasibility. All 11 groups submitted the required output types, although component-level fulfillment, verification accessibility, and instructor-assessed performance varied. Submission, component-level fulfillment, verification accessibility, and instructor-assessed quality should therefore be treated as distinct conditions. GenAI and WebAR served complementary roles: GenAI expanded visual alternatives, while WebAR reconnected selected proposals with maps, original photographs, and site locations. The need to compare and revise generated outputs aligns with prior concerns about output control, site adjustment, originality, and responsible use (Huh et al., 2025; Jin et al., 2024; Montenegro, 2024; Wang et al., 2025).

RQ3 showed generally positive perceptions alongside specific implementation frictions. Students most consistently endorsed the continuing role of human judgment, the connection between tool learning and real design problems, and WebAR's support for site-linked communication. By contrast, the lower response time for rapid preliminary ideation and the open-ended reports of difficulties with nodes, parameters, prompts, and error diagnosis indicate that workflow complexity can offset expected efficiency benefits for novice users. A small number of students were also uncertain about WebAR's specific contribution. Perceived feasibility, therefore, depended on the instructional support surrounding the technologies, not on access alone.

For teaching practice, the case suggests four design principles. First, field observation should precede generation so that prompts are grounded in identifiable site conditions. Second, assignments should constrain the scale of intervention to match novice students' capabilities. Third, AI instruction should include explicit criteria for contextual fit, spatial plausibility, and design responsibility. Fourth, WebAR should be used to reconnect generated representations with location, purpose, and audience rather than being treated as a decorative final display.

Time pressure and technical complexity were the principal implementation constraints. Students needed additional support with workflow logic, error diagnosis, parameter relationships, and output control, suggesting the value of slower demonstrations, persistent step-by-step resources, structured troubleshooting, and more time for practice and critique. Transferability also depends on access to cloud processing, stable internet connectivity, preconfigured workflows, and continuing instructor support. The instructional sequence is adaptable, but platform-specific feasibility may differ across institutional settings.

Methodologically, the study is limited by its implementation within a single course and a small cohort, reliance on self-reported perceptions, and the absence of a control group, pre/post comparison, or long-term tracking. The purpose-built questionnaire relied predominantly on positively framed items and may have been affected by acquiescence or instructor-related social-desirability bias. Final course grades had been determined before questionnaire distribution but had not yet been formally released, and the questionnaire was administered by the course instructor. The small sample also precluded robust validation of the course-aligned item groupings. Accordingly, the findings indicate perceived value and implementation feasibility, not demonstrated improvements in learning effectiveness, design competence, creativity, or problem-solving ability.

The analysis of archived projects provides group-level evidence of submission, component-level fulfillment, accessibility, and variation, but it does not distinguish individual students' contributions or performance. In addition, the project scores were assigned by the course instructor without a second or independent assessor. They therefore represent instructor-assessed group performance under the course rubric and should not be interpreted as independently validated measures of learning, design competence, or project quality. Future studies should incorporate independent performance assessment, individual-level evaluation, comparison conditions, and longitudinal measures of design reasoning, technical independence, and critical judgment.

CONCLUSION

This descriptive classroom case study documents how a GenAI-WebAR research agenda was organized into bounded and assessable tasks within a staged first-year environmental design project. All 11 groups submitted original site photographs, three to five AI-assisted redesign scenes, and a WebAR project during the course. During subsequent verification, complete archived deliverable sets remained accessible for 10 groups. Component-level fulfillment and instructor-assessed performance varied in contextual correspondence, technical execution, map positioning, and WebAR implementation.

Students generally perceived value in connecting tool learning to real design problems, maintaining human judgment, and presenting proposals for specific sites. At the same time, workflow complexity, troubleshooting, output control, and time pressure remained material constraints. The case shows that the workflow could be implemented in a single course setting with substantial instructional and technical support and was generally perceived positively by students; however, its educational effectiveness requires independent, individual-level, comparative, and performance-based evaluation across other courses and institutional contexts.

ACKNOWLEDGMENTS

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ETHICS STATEMENT

This study used minimal-risk data collected through routine course evaluation. The non-login questionnaire was administered by the course instructor on May 20, 2026, after final course grades had been determined but before they were formally released. Students were informed orally that participation was voluntary and unrelated to course grading, and that the responses would be used for course improvement, educational research, and academic publication. The questionnaire did not request direct identifiers, and nonparticipation had no academic consequence. Consent to the use of questionnaire responses was indicated through voluntary completion after this disclosure. Thirty-six of the 38 students participated.

Wenjuanxing automatically displayed limited platform-generated metadata, including submission time, response duration, access channel, and a coarse city- or region-level location label derived from the submission IP address. The numerical IP address, WeChat identity, account identifiers, and device identifiers were not displayed to the course instructor. These metadata were not used for identification. No linkage file or re-identification key was created; the available information did not provide a reliable means of connecting responses with individual students, and no attempt was made to re-identify respondents. The analyzed dataset was therefore treated as de-identified rather than described as fully anonymous.

Separate written permission for publication was subsequently obtained from all student creators whose coursework is reproduced in the article. The permission covered the reproduction and academic publication of the selected project materials. Only materials covered by documented written permission were included, and the reproduced materials were de-identified.

At the time of the study, the authors' institution did not provide a formal ethics review or exemption procedure specifically applicable to minimal-risk research based on routine teaching evaluation using a non-login questionnaire with no direct identifiers. Accordingly, no ethics approval or exemption number was issued.

AI Use Declaration

Generative AI tools were used only to improve word choice, spelling, and grammar. The authors reviewed and approved the final manuscript and take full responsibility for its content.

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APPENDIX A: ASSESSMENT CRITERIA AND POINT ALLOCATION FOR THE FINAL INTEGRATED COMFYUI–KIVICUBE PROJECT

Assessment criterion	Maximum points	Evidence assessed	Assessment focus
Problem identification and site selection	10	Site-investigation report and original photographs	Specificity of the identified problem, relevance of the selected site, and adequacy of supporting site evidence
Proposal positioning and design logic	10	Task statement, proposal explanation, and redesigned images	Correspondence between the identified problem and proposed intervention, and clarity of the design rationale
Completeness and correspondence of outputs	10	Original photographs, redesigned images, and submission files	Required number of sites and completeness of one-to-one correspondence between original and redesigned images
ComfyUI workflow use and technical execution	10	Submitted workflow or process materials and generated outputs	Appropriate use of the provided workflow, correct operation, and technical stability
Inpainting and visual control	15	Initial and refined generated images	Local modification, preservation of recognizable site features, consistency, and control of visual results
Proposal quality and human judgment	10	Selected final proposals and explanatory materials	Contextual suitability, spatial plausibility, critical comparison, and responsible selection of AI-generated alternatives
Completeness of Kivicube content	10	Kivicube WebAR project	Inclusion and organization of maps, original photographs, redesigned images, and explanatory information
AR interaction and technical implementation	10	WebAR project tested through mobile access	Correct location or hotspot settings, loading, link accessibility, and functional interaction
Integration and communication of results	10	Complete final submission	Coherence among site evidence, redesigned proposals, maps, and WebAR presentation, and clarity of communication
Originality and submission conventions	5	Final files and accompanying documentation	Original contribution, disclosure of AI assistance, acknowledgment of external materials, file naming, and submission compliance
Total	**100**		

APPENDIX B: ENGLISH TRANSLATION OF THE POST-COURSE QUESTIONNAIRE

The questionnaire was originally administered in Chinese. The English version below is a faithful translation provided for transparency and reproducibility. Items 1–7 collected background and prior-experience information. Items 8–34 were organized into four course-aligned domains for descriptive presentation, Q35 addressed time pressure, and Items 36–40 were open-ended. The domains were not treated as validated measurement constructs.

Common Likert anchors: A = strongly disagree (coded 1); B = disagree (coded 2); C = neutral (coded 3); D = agree (coded 4); E = strongly agree (coded 5).

Table B1. Background and prior-experience items (Q1‑Q7)

#	Item	Response options
1	Have you used AI image-generation tools before?	A. Never used B. Occasionally used C. Frequently used
2	Have you used ComfyUI before?	A. Never used B. Heard of it but not used C. Have used it
3	Have you used AR or WebAR presentation tools before?	A. Never used B. Heard of it but not used C. Have used it
4	Before this course, I had little knowledge of generative AI applications in design.	Five-point Likert (A-E)
5	Before this course, I had rarely used AI tools for design ideation or image generation.	Five-point Likert (A-E)
6	Before this course, I had little knowledge of augmented reality or WebAR presentation methods.	Five-point Likert (A-E)
7	Before this course, I found it difficult to translate site observations into concrete design tasks.	Five-point Likert (A-E)

Table B2. Course-aligned Likert items and time pressure (Q8‑Q35)

Domain 1: Site observation and problem framing (Items 8-12)

#	Item — 5-point Likert (A = strongly disagree; E = strongly agree)
8	Field investigation helped me identify specific problems in real public or scenic spaces.
9	The course helped me turn general impressions of a site into clearer design problems.
10	The course helped me further turn observed problems into tasks that could be designed and expressed.
11	I could understand why a design proposal should first respond to site problems rather than directly pursue image effects.

#	Item — 5-point Likert (A = strongly disagree; E = strongly agree)
12	This project helped me realize that real spatial problems must be appropriately simplified before they can become student design tasks.

Domain 2: AI-assisted generation and judgment (Items 13-21)

#	Item — 5-point Likert (A = strongly disagree; E = strongly agree)
13	ComfyUI helped me form preliminary design ideas more quickly.
14	Image-to-image methods helped me explore designs while preserving site characteristics.
15	Inpainting methods were suitable for modifying local areas within site photographs.
16	AI-generated images helped our group discuss different design proposals more intuitively.
17	I recognized that AI-generated images cannot be directly equated with a final design proposal.
18	I learned to compare, select, and modify AI-generated results.
19	Some AI-generated results were visually attractive but not suitable for the real site.
20	This project made me realize that AI-assisted design still requires human design judgment.
21	AI tools improved generation efficiency but did not replace design thinking.

Domain 3: WebAR-based spatial communication (Items 22-25)

#	Item — 5-point Likert (A = strongly disagree; E = strongly agree)
22	WebAR presentation helped me connect design proposals with specific site locations.
23	The map-based presentation made the spatial relationships of proposals clearer.
24	Comparing original site photographs with updated images made design changes easier to understand.
25	WebAR presentation expressed the relationship between proposal and site better than an ordinary slide presentation.

Domain 4: Research content integration and task translation (Items 26-34)

#	Item — 5-point Likert (A = strongly disagree; E = strongly agree)
26	The course translated relatively complex research topics into learning tasks I could understand.
27	The course translated relatively complex research topics into project tasks I could complete.
28	Through the “site investigation-AI generation-proposal refinement-WebAR presentation” workflow, I was able to take part in a simplified research-style design process.

#	Item — 5-point Likert (A = strongly disagree; E = strongly agree)
29	The cases, workflows, templates, and staged guidance provided by the teacher enabled me to complete this research-style project.
30	This project made me feel that research content can enter the undergraduate classroom through concrete design tasks.
31	This project was not merely software training, but connected tool learning with real design problems.
32	The output forms of this project—such as site photographs, AI-updated images, and WebAR models—are suitable as a basis for course assessment.
33	This project helped me understand that an undergraduate course does not completely solve research problems, but participates in some of their foundational and practical components.
34	With appropriate simplification and guidance, similar research topics could continue to be integrated into other undergraduate design courses.

Implementation constraint: Time pressure (Item 35)

#	Item — 5-point Likert (A = strongly disagree; E = strongly agree)
35	The schedule of this project was tight for completing investigation, generation, refinement, and presentation.

Table B3. Open-ended questions (Q36–Q40)

#	Open-ended item
36	Which part of the course project did you find most helpful, and why?
37	What was the greatest difficulty you encountered when using ComfyUI or other AI tools to complete design tasks?
38	How did WebAR presentation help you understand or express design proposals?
39	Do you think integrating the teacher's research content into the undergraduate classroom is feasible? Which parts of this project best demonstrate this feasibility?
40	If similar AI-AR design courses are offered in the future, what do you think most needs to be improved or strengthened?

APPENDIX C: FULL ITEM-LEVEL QUESTIONNAIRE RESULTS FOR Q8-Q35

Item	1 n	2 n	3 n	4 n	5 n	M	SD	4+5 (%)
Q8	0	0	5	24	7	4.06	0.58	86.1
Q9	0	0	4	26	6	4.06	0.53	88.9
Q10	0	0	2	28	6	4.11	0.46	94.4
Q11	0	1	2	24	9	4.14	0.64	91.7
Q12	0	0	6	22	8	4.06	0.63	83.3
Q13	0	2	8	23	3	3.75	0.69	72.2
Q14	0	0	5	27	4	3.97	0.51	86.1
Q15	1	0	3	24	8	4.06	0.75	88.9
Q16	0	0	2	30	4	4.06	0.41	94.4
Q17	0	0	2	24	10	4.22	0.54	94.4
Q18	0	0	3	26	7	4.11	0.52	91.7
Q19	0	0	2	20	14	4.33	0.59	94.4
Q20	0	0	1	18	17	4.44	0.56	97.2
Q21	0	0	2	21	13	4.31	0.58	94.4
Q22	0	0	3	27	6	4.08	0.50	91.7
Q23	0	0	2	25	9	4.19	0.52	94.4
Q24	0	0	3	24	9	4.17	0.56	91.7
Q25	0	0	2	28	6	4.11	0.46	94.4
Q26	0	0	4	27	5	4.03	0.51	88.9
Q27	0	0	6	24	6	4.00	0.59	83.3
Q28	0	0	7	21	8	4.03	0.65	80.6
Q29	0	1	1	28	6	4.08	0.55	94.4
Q30	0	0	5	25	6	4.03	0.56	86.1
Q31	0	0	1	25	10	4.25	0.50	97.2
Q32	1	0	4	27	4	3.92	0.69	86.1
Q33	0	0	2	24	10	4.22	0.54	94.4
Q34	0	0	4	21	11	4.19	0.62	88.9
Q35	0	1	12	16	7	3.81	0.79	63.9

Note. Full item wording is provided in Appendix B. Response categories were coded as 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. The columns headed 1 n through 5 n report the frequency in each response category; each row sums to 36. M = mean; SD = standard deviation; 4+5 (%) = percentage selecting agree or strongly agree.

APPENDIX D: FULL CATEGORY SUMMARY, OPERATIONAL DEFINITIONS, AND ANONYMIZED EXAMPLES FOR THE OPEN-ENDED RESPONSES

Question	Category	Operational definition and inclusion rule	n	Anonymized example
Q36	AI/ComfyUI practice and workflow use	Included responses that explicitly identified learning, practising, or using AI image-generation tools, ComfyUI, or node-based workflows as a helpful course component.	26	“Starting from scratch, we used ComfyUI to build workflows and generate design materials.” (R08)
Q36	Project application and conversion of ideas into outputs	Included responses that emphasized applying course content in a project or converting theories, ideas, or design intentions into tangible outputs.	8	“Group collaboration and project practice helped me turn theory into a completed work.” (R12)
Q36	Instructor guidance and demonstrations	Included responses that attributed helpfulness to instructor explanations, demonstrations, step-by-step guidance, consultation, or direct support.	5	“The instructor guided us step by step through the text-to-image and image-to-image tools.” (R29)
Q36	Understanding AI or workflow logic	Included responses that emphasized understanding AI-generation principles, workflow structure, node logic, or the relationships among workflow components, rather than merely operating the software.	4	“The visual node operations helped me understand the logic behind image generation.” (R08)
Q36	WebAR/AR presentation	Included responses that explicitly identified learning, creating, or using AR or WebAR presentation as a helpful course component.	3	“The complete practice with AI tools and WebAR also taught me how to present a proposal interactively.” (R10)
Q36	Field investigation and site application	Included responses that identified field investigation, direct site observation, or applying learning activities to an actual site as helpful.	2	“The field investigation allowed us to listen, observe, and experience the site directly.” (R09)
Q36	General positive response without a specific component	Included responses that evaluated the course or its components positively but did not identify a particular activity, tool, or form of support.	1	“Everything was quite helpful.” (R23)

Question	Category	Operational definition and inclusion rule	n	Anonymized example
Q37	Workflow, node, parameter, or error-diagnosis difficulties	Included responses reporting difficulty constructing or connecting nodes, understanding workflow or parameter relationships, running workflows, resolving model conflicts, or locating errors.	20	"When the workflow logic failed, it was difficult to locate the source of the problem." (R08)
Q37	Prompt formulation and control of generated results	Included responses reporting difficulty expressing instructions or prompts, controlling generated images, or obtaining results consistent with the intended design.	15	"The AI did not understand my instructions and often generated images that did not meet my expectations." (R30)
Q37	Limited familiarity with software or basic digital operation	Included responses indicating insufficient familiarity with the software, tools, computers, or basic operating procedures, without identifying a more specific workflow problem.	14	"I was not familiar with the software tools and did not know how to use them." (R24)
Q37	Difficulty translating design intentions into visual results	Included responses stating that students had design ideas or intentions but were unable to express, visualize, or realize them satisfactorily through the available tools.	10	"I had ideas but lacked the ability to express them visually." (R16)
Q37	Complexity, memory demands, or time-consuming debugging	Included responses emphasizing the overall complexity of the workflow, difficulty remembering procedures, repeated trial and error, or the time required for debugging.	7	"Some workflows were complex, and the large number of unfamiliar models made them difficult to remember." (R19)
Q37	No difficulty reported	Included responses explicitly stating that no difficulty was experienced.	1	"I did not encounter any difficulty." (R04)
Q38	More direct or clearer presentation	Included responses stating that WebAR made the proposal more intuitive, direct, clear, visible, or easier to understand.	27	"It made the proposal more intuitive and clearer." (R24)
Q38	Better expression or communication of design ideas	Included responses stating that WebAR helped students express, present, explain, or communicate their design concepts or intended effects more effectively.	14	"It helped me present my design concept more effectively." (R33)
Q38	Stronger connection with the site or spatial relationships	Included responses referring to clearer relationships between the proposal and the actual site, spatial context, scale, proportions, positioning, or environmental conditions.	8	"It clearly showed whether the design proposal was harmonious or in conflict with the site." (R17)

Question	Category	Operational definition and inclusion rule	n	Anonymized example
Q38	Interactive, three-dimensional, or immersive presentation	Included responses referring to interaction, three-dimensional presentation, augmented-reality experience, immersion, or movement beyond static two-dimensional images.	7	"WebAR transformed the static proposal into an immersive and interactive three-dimensional experience." (R23)
Q38	Support for understanding, evaluating, or judging proposals	Included responses stating that WebAR helped viewers or designers understand, examine, compare, verify, or evaluate a proposal and its details.	7	"Placing the design in the actual spatial scale and lighting helped us judge whether its proportions, occlusion, and interaction were appropriate." (R08)
Q38	Uncertain or no clearly perceived contribution	Included responses expressing uncertainty, lack of knowledge, no contribution, or an inability to identify a specific contribution of WebAR.	3	"I do not know." (R06)
Q39	AI/ComfyUI practice	Included responses that identified AI or ComfyUI learning and practice as evidence that research-derived content could feasibly be incorporated into the course.	13	"It was feasible through learning and using ComfyUI." (R13)
Q39	General affirmation without a specific example	Included responses that affirmed feasibility but did not identify a course component, procedure, example, or supporting reason.	12	"It was feasible." (R05)
Q39	Exposure to research or current methods	Included responses referring to research findings, research approaches, current methods, or frontier technologies being introduced into classroom activities.	7	"The instructor translated research outcomes into classroom practice, allowing students to engage with frontier technologies." (R23)
Q39	Task decomposition, scaffolding, or instructor guidance	Included responses that attributed feasibility to selecting manageable research content, dividing it into operable subtasks, or providing structured instructor support.	6	"It is feasible provided that mature methods and accessible tools are selected and divided into operable subtasks." (R08)
Q39	Field investigation and site-based tasks	Included responses that identified field investigation, site observation, or the connection between investigation and course assignments as evidence of feasibility.	5	"It was feasible because the field investigation was connected with the course assignment." (R20)
Q39	WebAR or integrated AI-AR activities	Included responses that identified WebAR activities or the integration of AI and AR within the project as evidence of feasibility.	4	"The integration of AI and AR within the project showed that it was feasible." (R04)

Question	Category	Operational definition and inclusion rule	n	Anonymized example
Q39	Case analysis or design-project activities	Included responses that referred to case analysis, proposal development, design assignments, or project-based application as evidence of feasibility.	4	"It was feasible through the case-analysis activity." (R03)
Q39	Participation, motivation, or contribution of diverse ideas	Included responses that connected feasibility with increased participation, motivation, engagement, collaboration, or opportunities for students to contribute different ideas.	2	"It was feasible because students could contribute different ideas." (R26)
Q40	More detailed, slower, or step-by-step instruction	Included suggestions requesting slower explanations, clearer procedures, more detailed demonstrations, or step-by-step instructional materials.	19	"Explain the operating procedures a little more slowly." (R20)
Q40	Stronger AI or software foundations	Included suggestions requesting more introductory knowledge, basic software operation, AI-generation principles, prompt guidance, or preparatory training.	9	"Provide more foundational information and software practice." (R07)
Q40	No specific improvement or satisfaction with the current course	Included responses stating that no improvement was needed, offering no specific suggestion, or expressing satisfaction with the existing course arrangement.	9	"I think the course is already very good as it is." (R26)
Q40	More practice time, class hours, or technical consultation	Included suggestions requesting additional classroom time, practical exercises, experimentation opportunities, consultation, or technical assistance.	8	"Increase the class hours so that students can better master how to use the tools." (R24)
Q40	Troubleshooting guides, videos, or online support	Included suggestions requesting troubleshooting materials, error guides, instructional videos, online demonstrations, or other resources that could be consulted outside class.	8	"Prepare a guide to common ComfyUI errors, accompanied by step-by-step video demonstrations." (R08)
Q40	Simpler workflows or a lower entry threshold	Included suggestions requesting simplified workflows, fewer or easier operating steps, reduced technical complexity, or a more accessible starting level.	6	"Make the workflow simpler." (R16)
Q40	More cases, AR content, or disciplinary applications	Included suggestions requesting additional cases, AR or WebAR content, examples from the students' discipline, or broader applications of the technologies.	6	"Add more discipline-related cases and expand the AR interaction-design content." (R10)

Question	Category	Operational definition and inclusion rule	n	Anonymized example
Q40	Improved classroom displays, audio equipment, or access conditions	Included suggestions concerning classroom screens, projection, audio, visibility, audibility, network access, or other physical and technical access conditions.	2	"Provide additional screens or better audio equipment so that students at the back can see and hear clearly." (R36)
Q40	Greater course interest or enjoyment	Included suggestions that the course or its resources should be made more interesting, engaging, or enjoyable.	2	"Use more instructional videos to make the course more interesting." (R05)

Note. Responses were coded using a descriptive multi-label procedure. A response could be assigned to more than one category; therefore, category totals within a question may exceed 36. Examples were translated from the original Chinese responses by the first author and checked against the original responses by the two reviewing authors. Minor punctuation and grammatical adjustments were made for readability without altering their substantive meaning.

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