Digitalization Empowers Innovation in Landscape Design Education for the Inheritance of Intangible Cultural Heritage Patterns and Regional Culture

Lusha Li
Institute of Art Design and Animation, Sichuan University of Media and Communications, Chengdu 611745, Sichuan, China
Corresponding author: Lusha Li (e-mail: luciali0914@163.com)

ABSTRACT With the rapid development of digital technology, the protection, translation, and educational application of intangible cultural heritage patterns have gained new technical support. This paper focuses on the digital translation and application of intangible cultural heritage patterns and regional cultural symbols in landscape design education. Using 3D scanning, parametric design, and virtual reality technology, abstract cultural patterns are transformed into concrete landscape design language. The study constructs a complete methodological system covering digital acquisition, pattern-gene decoding, parametric translation, immersive design review, and teaching-effect evaluation. A comparative teaching experiment is conducted to verify the validity of the model. The results show that the digitally empowered teaching model significantly improves students' understanding of regional culture, design innovation ability, and spatial perception. The study provides theoretical support and a practical model for integrating regional cultural inheritance with landscape design education, and offers an operable path for transforming cultural symbols into spatial design elements through digital design technologies.

INDEX TERMS digital technology, intangible cultural heritage patterns, regional culture, landscape design education, parametric design

I. INTRODUCTION

AGAINST the backdrop of globalization and urbanization, the uniqueness of regional cultures is facing increasingly severe challenges. As a crucial carrier of regional culture, the intangible heritage of traditional textile craftsmanship—encompassing local weaving and dyeing techniques—faces an urgent need for systematic inheritance and protection to prevent the loss of artisanal wisdom. Preserving these textile traditions ensures that unique cultural identities remain integrated within the modern industrial landscape through digital archiving and innovative design applications. Landscape design, as an important discipline that coordinates the relationship between humans and nature and shapes the spirit of a place, not only bears the functional responsibility of creating ecologically livable spaces but also shoulders the cultural mission of continuing historical context and highlighting regional characteristics. However, examining the current state of landscape design education reveals that while training in ecological technology and spatial forms is relatively mature, there is still a lack of in-depth teaching systems and technical pathways for systematically transforming profound regional cultural genes, especially visual symbols represented by intangible cultural heritage patterns, into modern landscape design language. Traditional landscape design teaching often focuses on functional layout, plant configuration, or engineering technology, with the exploration of cultural elements often limited to superficial symbol collages or simple pattern transplantation, lacking in-depth analysis of the cultural connotations behind the patterns and innovative means of organically combining them with modern digital technology. This situation often leaves students feeling at a loss when faced with site designs with profound cultural connotations, or their designs become merely formalistic and lack cultural vitality.

Through the innovation of information technology, the digital means have invaded into every facet of the education of design, hence an approach, giving an impetus, or a new perspective to address the above issues. Digital technology not only shows a lot of advantages to enhance design efficiency and optimize the performance of engineering, but also provides infinite possibilities for the digital preservation, reconstruction and dissemination of culture. In particular, technologies such as parametric design, virtual reality (VR), and augmented reality (AR) will be able to produce three-dimensional spatial forms, which are constituted through algorithms from the development of complex two-dimensional patterns, and thus, a leap in thinking from plane to space and from abstract to concrete. This paper aims to explore how to put intangible cultural heritage patterns as important cultural symbol into the language of landscape design through digital technology, and build corresponding teaching models. This research aims to fill the current gap in cultural inheritance and educational integration by promoting landscape design education towards a heightened cultural consciousness and technological literacy that incorporates the spatial aesthetics of traditional textile craftsmanship. By integrating ancient weaving structures and dyeing textures into environmental design, the study provides new practical fields for the living inheritance of textile heritage through an interdisciplinary approach to digital preservation and creative space-making.

II. RELATED WORK

Contemporary landscape design research is showing a profound shift toward multidimensional integration. The method proposed by Lavorel et al. [1] helps designers systematically integrate multiple ecological functions and social needs, and promotes the planning and implementation of multifunctional landscapes. Cortesão and Lenzholzer [2] systematically sorted out the core characteristics, methodological basis and specific practice path of RtD in urban and landscape design. In landscape design professional exchanges and interdisciplinary cooperation, Liu and Nijhuis [3] combined the analysis of classic design cases to extract a series of key terms and their definitions for describing the characteristics of landscape space. Chi D [4] studied the relationship between various design elements of campus landscape and their ecological benefits by using quantitative analysis and regression analysis. Kim et al. [5] examined the application of digital technology in landscape art , and analyzed how technology expands the perception dimension, time dimension and public participation of landscape.

Taking Stanley Park in Canada as an example, He et al. [6] systematically evaluated the effects of existing plant landscapes on different senses. Hussein [7] found that the integration of AR technology significantly enhanced students' understanding of scale, proportion and spatial relationships, and promoted more in-depth site analysis and scheme iteration. Ioannidis et al. [8] conducted a retrospective cost-benefit analysis of the landscape design practices of several existing dam projects. Li and Gan [9] combined the characteristics of rural tourism landscapes and explored specific strategies for achieving low carbonization in terms of material selection (localization, renewable), energy utilization (solar energy, biomass energy), water cycle management, vegetation carbon sequestration and recreational activity organization. Im et al. [10] proposed that the application of MR technology greatly improved the accuracy, immersion and communication efficiency of special tree landscape design review. Most studies focus on the digital support of functional, ecological or general spatial cognition, while insufficient attention is paid to the digital translation and inheritance of regional cultural genes in the landscape. This paper explores how to transform intangible cultural heritage patterns, an important cultural symbol, into a landscape design language through digital technology, and constructs a corresponding teaching model to fill the current research gap in the path of in-depth cultural inheritance and educational integration, and promote the development of landscape design education towards a more culturally conscious and technologically literate direction.

III. METHODS

A. DIGITAL ACQUISITION AND GENE DECODING PROCESS OF INTANGIBLE CULTURAL HERITAGE PATTERN INFORMATION

The first step of the digital empowerment in the heritage of intangible cultural heritage patterns and regional culture is the creation of a high-precision digital acquisition system and deep genetic decoding mechanism. This study constructs an acquisition process that is based on multimodal data fusion. This process entails first field surveys of typical patterns in intangible cultural heritage as these aspects are generally in the form of embroidery, wood carving, stone carving or architectural painting. During the data acquisition phase, considering the practical feasibility and cost-effectiveness of the teaching scenario, this study adopted a lightweight acquisition scheme, mainly using consumer-grade devices. For recording planar patterns, a high-resolution SLR camera or a smartphone equipped with photogrammetry software was used; for small intangible cultural heritage items (such as embroidery samples and wood carving parts), a consumer-grade structured light scanner (such as the Revopoint POP series or the LiDAR scanning function built into the iPhone) was used to acquire three-dimensional data; for larger architectural components or patterns in the environment, a combination of ground-based LiDAR and UAV oblique photography was used to generate environmental point cloud data containing pattern information [11,12].

The collected raw data requires series of processing before it enters the decoding stage. For point cloud data, point cloud processing software is applied for denoising, stitching, and meshing to produce a high-precision digital surface model. For planar pictures, image processing algorithms are used for color correction and geometric distortion correction. Based on this, the concept of "pattern gene decoding" is put forward. This process is more than simply vectorized depiction, however, as it incorporates a deep analysis of the compositional logic of the pattern, its topological structure, proportional relationships, and cultural semantics. Specifically, computer vision algorithms are deployed to automatically detect the lines and boundaries of the skeleton in the pattern and extract the basic geometric units of the pattern. Subsequently, the arrangement patterns of these basic units are analyzed, such as two-dimensional continuity, four-dimensional continuity, centrifugal or centripetal composition, etc. Describe the pattern morphology in mathematics and form a parameter matrix. So, to quantify the complexity and morphological characteristics of patterns, this method proposes shape descriptors and texture feature extraction algorithms. Shape descriptors describe characteristics such as the tortuosity and fractal dimension of the pattern outline, whereas texture feature extraction is concerned with the density variations and the feeling of rhythm in the pattern. This process converts abstract pieces of culture into data that can be computed and modified digitally. In the phase of constructing the database the decoded patterns are categorized and stored regarding region and type, carrier and cultural semantics. This database not only stores the vectorize graphics, but it also correlates with the geometric parameters, material textures, and other cultural background textual information to provide a good data foundation for the following parametric design translation. Through this high-precision digital acquisition and genetic decoding, intangible cultural heritage patterns are removed from their material carriers, permanently preserved in the digital world and the preconditions for an adaptable use in designing landscapes created[13].

B. TECHNICAL APPROACHES FOR TRANSLATING PATTERN LANDSCAPES

After intangible cultural heritage patterns are digitally acquired and genetic decoding, this study then constructs an algorithmic translation path based on parametric design. This path is based on the generative design of the inherent geometric logic of the patterns. This process relies mainly on a parametric modeling platform, and establishes the relationship of mapping between the geometric characteristics of the patterns and the space elements of the landscape by writing algorithm scripts.

First the basic control geometry of the landscape space is set up. Based on the site's topographic map, functional zoning map and road system, a base model for the landscape design is established, including topographic surface, road system, planting area boundary and location of buildings. These base models will be used as the input geometrical constraints of the parametric algorithm. Second, through the decoded intangible cultural heritage pattern gene data in the parametric environment. Multiple mapping logics are designed for dealing with different landscape scene requirements. To ensure that the parametric mapping of intangible cultural heritage patterns effectively responds to the specific terrain conditions and functional zoning constraints of the site, rather than simply overlaying decorative meshes, this study introduces a site-constraint-first mapping strategy in the algorithm design. Specifically, the parametric script first reads the site's digital elevation model (DEM) data and divides the site into different response zones based on slope, aspect, and elevation changes: in areas with a slope greater than 15%, the pattern units are automatically aligned with the contour lines, and the unit density decreases as the slope increases to avoid visual distortion and construction difficulties caused by steep terrain; in flat areas, the patterns are allowed to be fully laid out according to the original intangible cultural heritage composition logic. For example, for paving design, the pattern units are adaptively arranged, and the number and size of the units are automatically calculated based on the paving area boundaries to ensure that the pattern covers the target paving area, while the gap width between units is automatically adjusted according to pedestrian density. Furthermore, for structures in the landscape (such as walls, pergolas, or railings), the algorithm dynamically adjusts the starting point and scaling ratio of the pattern mapping based on the terrain elevation and viewpoint analysis results of the structure's location. This ensures that the skeleton lines of the intangible cultural heritage patterns form a spatial correspondence with terrain feature lines (such as ridgelines and valley lines) or important landscape sightlines, rather than mechanically centering or repeating them. Simultaneously, combined with structural mechanics calculations, the thickness of the pattern lines is optimized to balance aesthetics and safety. When small-scale textile patterns (such as embroidery stitches and brocade patterns) are enlarged and applied to large-scale landscape spaces (such as plaza paving, building facades, and park topography), the preservation of their cultural effectiveness does not depend on a simple proportional scaling of the pattern's physical form. The cross-scale mapping logic proposed in this study follows the core principle of "gene extraction - logical mapping - scale adaptation": First, the "gene extraction" stage focuses on the topological structure and compositional rules of the pattern (such as geometric transformation logics like symmetry, rotation, and translation), rather than pixel-level pattern details; second, the "logical mapping" stage applies the extracted generation algorithm to the morphological generation of large-scale spaces, for example, transforming the continuous zigzag logic of the "meander" pattern in embroidery into path planning for landscape walkways, or transforming the "four-way continuous" arrangement rule of brocade into a layout algorithm for modular planting beds; finally, the "scale adaptation" stage fully considers the scale of human perception and movement speed, adjusting the visible level of pattern units—presenting the skeleton and rhythm of the pattern on a macro scale, and preserving or reconstructing the tactile and material texture details on a micro scale, thereby ensuring that people in large spaces such as parks and squares can fully interpret its cultural symbolic meaning through multi-scale spatial experiences (observing the form from afar and examining the texture up close).During the translating process, the patterns are adaptively changed according to the different properties of the landscape materials (like permeability, reflectivity and roughness). For example, in areas of a permeable paving, gaps between pattern-lines are increased to enhance permeability; in areas where visual guidance has to be emphasized, the line density and color contrast of the patterns are adjusted with the help of algorithms. The whole technical process of path is an iterative feedback process. Through the adjustment of parameters (scaling ratio, rotation angle and interference intensity etc.) the morphological changes of the patterns in the landscape space can be seen in real time, and it can achieve a perfect combination with site functions and ecological technologies while ensuring the recognizability of cultural genes[14,15].

C. CONSTRUCTION AND EXPERIMENTAL EVALUATION SYSTEM OF DIGITAL TEACHING MODEL

To effectively integrate the aforementioned digital acquisition and parametric translation technologies into landscape design education, this study constructed a digital teaching model that combines virtual and real elements and integrates industry and education, and designed a teaching experiment evaluation system to verify its effectiveness. This teaching model breaks away from the linear process of traditional landscape design teaching—"lecture-practice-evaluation"—and transforms it into a cyclical iterative process of "cognition-deconstruction-reconstruction-experience."

In the teaching implementation phase, the course is divided into three basic modules. The first module, "Cultural Cognition and Digital Acquisition," involves students visiting intangible cultural heritage sites or museums in groups. Under the joint guidance of teachers and intangible cultural heritage inheritors, they add cultural semantic annotations to the extracted geometric parameters and finally upload these patterns to a shared pattern database. The experimental group used handheld scanners and photogrammetry equipment to record on-site patterns, followed by point processing and vectorization decoding, and then uploaded the patterns to the shared pattern database. The control group also used handheld scanners and photogrammetry equipment for acquisition, but only performed traditional image vectorization processing, without introducing parametric encoding. This module aims to cultivate students' intuitive understanding of regional culture and their ability to digitally capture such culture. The second module, "Parametric Conversion and Design Generation," involves the experimental group learning parametric design logic based on collected pattern data and writing scripts to convert patterns into landscape design schemes. The control group used traditional CAD software for 2D drawing and 3D modeling, manually applying patterns directly to paving or facades without involving parametric mapping algorithms. During this process, the experimental group teachers primarily acted as technical advisors and creative guides, helping students explore the various application possibilities of patterns in space. The third module, "Virtual Reality Review and Immersive Experience," guided students in the experimental group to construct virtual scenarios of their design schemes using virtual reality technology, and to conduct virtual walkthroughs and reviews via head-mounted displays. The control group used traditional whiteboard presentations and PowerPoint presentations, without using VR equipment.

To ensure a fair comparison of teaching methods rather than tool differences, both groups used the same brand of digital camera and basic CAD software. The only variable was that the experimental group introduced parametric design instruction, VR review, and a cyclical iterative process of "cognition-deconstruction-reconstruction-experience," while the control group followed the traditional linear teaching process of "teacher lecture-student practice-whiteboard review."

In order to scientifically measure the effectiveness of this teaching model, a multi-dimensional quantitative evaluation system was built. This system consists of two components: objective process data recording; and subjective outcome evaluation. Objective data collects primarily the time investment of the students for each phase, software operation records, number of modifications on schemes and indicators of complexity of pattern translation (number of nodes and change of surface curvature range). Subjective evaluation involves a combination of expert and student self-evaluation. The expert scoring criteria are divided into four main indicators, "cultural inheritance", "spatial coordination", "technological innovation", "ecological integration" and several secondary indicators. For comparative research, an experimental group and a control group were established in this research. The experimental group adopted the aforementioned fully digital teaching model (including parametric design script writing and virtual reality immersive review). The control group used widely used standard digital design software (AutoCAD, SketchUp, etc.) for 2D drawing and 3D modeling, but did not involve parametric design script writing or virtual reality immersive review; that is, it mainly focused on traditional computer-aided design (CAD) teaching, supplemented by hand-drawn sketches.

Before the teaching experiment began, two groups of students were subject to pre-tests, which were used to measure their design fundamentals and their knowledge of intangible cultural heritage, which eliminated the impact of differences in the basic knowledge at the two groups of people on the results. During the teaching process, the student participation and collaboration were tracked by observation logs. After the experiment, the final design results of both groups were gathered and blind reviewed by three knowledgeable senior landscape design professors. The significance of score differences was tested with the help of statistical software. Simultaneously, in-depth interviews and questionnaires were conducted with the students of the experimental group to obtain the subjective feedback of their experience of using digital tools, change in learning interest, change in their understanding of intangible cultural heritage. This rich evaluation system guaranteed the comprehensiveness and objectivity of teaching effectiveness evaluation, which verified the advantages and disadvantages of the digital empowered teaching model from multiple aspects such as technological effectiveness, cultural inheritance and design quality, which provided data support for the subsequent teaching reform.

IV. RESULTS AND DISCUSSION

A. ANALYSIS OF DIGITAL ACQUISITION ACCURACY AND TRANSLATION EFFICIENCY

Statistical analysis of objective data produced during the teaching experiment showed great advantages of digital acquisition and parametric translation technologies to advance the accuracy and efficiency of design. In the process of intangible cultural heritage patterns collection, the experimental group used 3D laser scanning and photogrammetry to obtain point cloud data with abundant geometric details. Compared to the control group (mostly photography and manual measurement data), the data of the experimental group had significantly improved geometric accuracy. For quantification of this difference, 20 samples of each group were randomly chosen in this study and the measuring errors of the sample's key feature dimensions were compared. The results showed that the average error of the experimental group's measuring done by digital equipment was controlled within 0.5 mm, the average error of the control group was done by manual methods was reached 2.31 mm. The benefits of the digital methods were even greater when working with complex curves, and openwork patterns. The experimental group was able to record the topological structure of the patterns in a complete form, while the control group usually had to reduce the detail, according to the result information was lost. Figure 1 visually illustrates the difference in accuracy between the two methods in pattern feature extraction, confirming the overwhelming advantage of digital acquisition in geometric fidelity.

The data is a direct result of the high precision and efficiency of the digital tools in the information collection process. While experimental group had to take some time to make equipment arrangements and process data for collecting single pattern samples, it ultimately saved almost half the time compared with the traditional manual measurement and drawing methods. Furthermore, the level of detail retention rate was 96.5%, which was much higher compared to 72% for the control group. This proves the concept that digital technology can convert patterns of intangible cultural heritage to become digital assets with greater fidelity to form the basis for the later high quality design. Simultaneously, the high-precision data will reduce the design reworking because of measurement error, which indirectly increases the whole design efficiency. Analysis reveals that digital collection is not simply an upgrade in the technology, but also a change in attitude. It helps students to pay more attention to the geometrical essence of the objective things instead of subjective assumptions, and it also improves the scientific rigor and accuracy of students' design results.

B. CULTURAL SEMANTIC EXPRESSION AND SPATIAL FORM EVALUATION OF DESIGN OUTCOMES

The final design submissions from both groups of students were blind expert reviewed and scored. The results saw revealing the significance of effectiveness of the digital empowerment model in promoting the depth of design culture and spatial innovation. The scoring was done on a 100-point score, based on several dimensions, such as the cultural semantic expression, spatial form harmony and technological application innovation. Statistical analysis indicated that the results of the experimental group were significantly higher than the control group in both "cultural semantic expression" and "spatial form innovation" indicators. The data did pass the significance test, and this meant that this difference was not accidental, but rather represented a major improvement that was being realized because of the changing of the model of teaching. The results can be seen in Table 1.

To ensure the objectivity and repeatability of the evaluation of the "spatial morphology harmony" indicator, this study has established a rigorous operational definition for it: This indicator comprehensively measures three quantifiable sub-dimensions—(1) Morphological self-similarity: using fractal geometry algorithms, the difference between the landscape elements (such as paving texture and building outlines) generated in the design scheme and the source intangible cultural heritage patterns in the fractal dimension is calculated, and the difference is required to be controlled within 0.3; (2) Spatial visual integration: based on isovist analysis in spatial syntax, the visual connectivity and integration between key landscape nodes are measured, and the integration value of the core area is required to be greater than 1.5 to ensure the logical coherence of the spatial morphology; (3) Spatial rhythm and rhyme: by performing Fourier transform on the curvature changes of the landscape interface outline, the regularity of its wavelength is analyzed to quantitatively evaluate the rhythm and harmony of the spatial sequence. All three review experts accepted this set of quantitative scoring standards and conducted blind review scoring accordingly.

At the level of cultural semantic expression, after experiencing the complete process from digital collection to cultural semantic annotation and then to parameterization, the students in the experimental group developed a deep understanding of the compositional logic, cultural connotation and symbolic meaning of intangible cultural heritage patterns. Their designs were no longer simple pasting of patterns, but had the ability to extract the genes of the patterns, such as their skeleton and proportions, and turn them into the planar layout of the landscape, topographical undulations, or structural forms. For example, some students took the skeleton of the meander image from some traditional embroidery of the local area, converted it to the wayward curve of a landscape walk, with the help of parametric algorithms, and arranged rest rooms at the key nodes to reproduce it, giving the whole site an inherent feeling of cultural rhythm. This "spiritual resemblance" design was highly praised by the expert reviewers. In contrast, while the designs in the control group also made use of intangible elements of cultural heritage, they were mostly restricted to the imprinting of patterns on the surface of walls in the landscape or paving patterns without establishing an overall spatial atmosphere and the cultural expression seemed rather

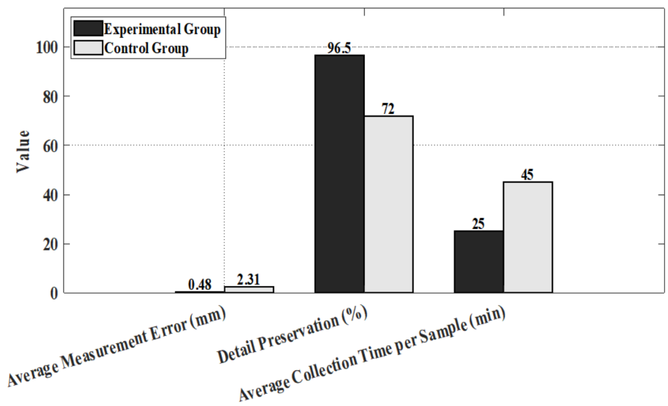

FIGURE 1. Comparison of accuracy between digital acquisition and traditional measurement in pattern feature extraction.

stiff and superficial.

TABLE 1. Comparative Analysis of Expert Scores for Two Groups of Design Works

Evaluation indicators	Experimental group (mean score ± standard deviation)	Control group (mean score ± standard deviation)	P-value (T-test)	Significant difference
Cultural semantic expression	88.5 ± 3.2	76.4 ± 4.5	<0.001	Extremely significant
Spatial form harmony	85.2 ± 3.8	82.1 ± 4.1	0.028	Significant
Technological application innovation	90.1 ± 2.5	70.5 ± 5.2	<0.001	Extremely significant
Ecological integration	83.6 ± 4.0	84.0 ± 3.9	0.812	Not significant

According to the statistical results in Table 1 , the experimental group scored 88.5 and 90.1 points respectively in "cultural semantic expression" and "technological application innovation," significantly higher than the control group's 76.4 and 70.5 points, with P values less than 0.001, demonstrating highly significant differences. This fully demonstrates the significant advantages of digital teaching models in cultivating students' cultural translation and technological application abilities. In terms of "spatial morphology coordination," the experimental group also scored slightly higher than the control group, with a significant difference, indicating that parametric design helps students better handle complex spatial relationships. It is noteworthy that there was no significant difference in scores between the two groups in the "ecological integration" indicator (P=0.812). This is because the cultivation of ecological awareness depends more on the depth of the curriculum's teaching of ecological principles than simply on changes in design tools. This also suggests that future teaching reforms need to integrate parametric design with ecological performance simulation more deeply to achieve a dual improvement in technological innovation and ecological benefits. Overall, digital empowerment has effectively enhanced the cultural character and expressive power of design works, enabling the inheritance of intangible cultural heritage patterns to go beyond the level of patterns and delve into the spatial logic.

C. EFFECTIVENESS EVALUATION OF TEACHING MODELS IN IMPROVING STUDENTS' ABILITIES

In order to further investigate the effect of digital teaching models on the comprehensive ability of students, questionnaire survey and learning outcomes were carried out on the experiment group students and analyzed. The questionnaire employed a five-point Likert scale, including learning interest, spatial understanding, interdisciplinary integration ability, and cultural confidence, etc. The results of the survey demonstrated the vast majority of students had a positive attitude towards the digitally empowered teaching model, which they believe this model significantly contributed to their learning motivation and professional competence. (See Table 2.)

In terms of spatial understanding, the introduction of virtual reality (VR) technology was considered one of the biggest highlights by students. Through immersive experiences students were able to feel the scale, material textures and light and shadow variations of the landscape spaces they designed as if they were actually there. This intuitive perceptual experience succeeded in compensating the shortcomings of traditional two-dimensional drawing in expressing the space. Many in the students feedback said that in the VR environment, they had found that the proportions of certain landscape structure seemed too oppressive in real observation or some ways out could be too narrow. These discoveries led them to be proactive in optimizing their designs. This self-correcting process, based on perception, benefitted the students considerably in controlling scale and proportion, leading to greater insight into analyzing sites and trying to design the site.

In the regard of interdisciplinary integration, parametric design needs students to merge mathematical logic, algorithmic and artistic design. While this is a challenging process, this is also a process that stimulates their great desire to explore. Students are not only required to learn how to use the design software, but they are also required to understand the basic programming logic and geometric algorithms. This interdisciplinary challenge reconfigures the structure of students knowledge to some degree, giving them the power to solve complex design problems with the use of computational thinking. Survey data indicates that after a semester of training data reflected a stronger logical analysis skills and systems thinking in the experimental group of students when facing complex site design challenges.

Furthermore, the digital teaching model has had a subtle impact on cultural confidence and regional identity of the students. By collecting and translating the intangible cultural heritage pattern from their hometowns, traditional culture knowledge by students recurs from textual information in books to tangible and interactive digital model. This deep sense of participation leads to a strong sense of pride in their local culture, and this dedicates them to more consciously seek the expression of their regional characteristics in their designs.

TABLE 2. Questionnaire survey results on the effectiveness of the digital teaching model among students in the experimental group

Survey dimensions	Strongly agree (%)	Agree (%)	Generally (%)	Disagree (%)
It enhanced learning interest and initiative.	66.7	26.7	6.6	0
Enhanced understanding of spatial scale and proportion	60.0	30.0	10.0	0
Improved logical thinking and algorithm application skills	56.7	33.3	10.0	0
It deepened the understanding and recognition of intangible cultural heritage.	73.3	20.0	6.7	0
It improved the efficiency of collaboration with team members.	50.0	36.7	13.3	0

As shown in Table 2, the experimental group students showed high level of satisfaction towards all of the indicators with an average score of 4.3 or higher (out of 5). The highest was for "deepened understanding and recognition of intangible cultural heritage" at 4.7 where 73.3% of the students chose "strongly agree." This result further confirms the effectiveness of the two-level decoding strategy of "geometric extraction + cultural semantic anchoring" proposed in this study. Students not only learned to use digital tools to capture the shape of patterns, but also understood the cultural meaning behind the shapes under interdisciplinary guidance, thus achieving the organic unity of technical means and cultural inheritance. This strongly gives credence to the effectiveness of the "learning by doing" cultural inheritance strategy proposed in this study. Through digital technology, the intangible cultural heritage patterns have been no longer the ancient people's outdated symbol, but became the design material and innovation tool in the hands of students. This role transformation causes the gap between the younger generation and traditional culture to be very narrow. Meanwhile, the evaluators' high score of "enhanced learning interest and initiative" also imply that digital technology is in line with the learning habits of today's digital native students and can successfully spur their creative potential. Although some students did not feel comfortable with "logical thinking and algorithm application ability" in the beginning, some students did accept the value of this thinking training after some guidance. In summary, the digitally empowered teaching mode, not only shows good effectiveness in technical skill teaching, but also is an effective way of developing tender core competence and shaping cultural value, which is an effective paradigm for the cultivation of landscape design talents in the new era.

V. CONCLUSION

This research focuses on the application of digital technology in landscape design education, specifically examining how the intricate patterns of textile intangible cultural heritage and regional weaving traditions can be integrated into environmental aesthetics. By utilizing digital tools to extract and reconstruct traditional textile motifs, the study explores new ways to embed artisanal craftsmanship and regional cultural narratives within the physical structures of modern landscape projects. By building a full innovative system of teaching, which include the digital acquisition, the parametric translation, the immersive review, and the multidimensional assessment of the teaching process, it checks the efficacy of the digital technology in increasing the depth of the cultural heritage transmission and the quality in teaching the design. The results show that the digital acquisition process based on 3D scanning and point cloud processing technology can record the geometric genes of intangible cultural heritage patterns with extremely high precision, which can solve the problems of information loss and low efficiency of traditional methods. The success with the parametric algorithm-based translation path to achieve the mapping of the logic of two-dimensional patterns to three-dimensional landscape spatial elements, achieve the leap of cultural symbols from the plane to space, from imitation to generation, greatly enrich the morphological language and cultural connotation of landscape design. Furthermore, the teaching model and assessment system incorporating virtual reality technology can greatly improve students' learning interest, spatial perception, and interdisciplinary integration by allowing them to virtually manipulate complex textile weaving structures and traditional dyeing processes. This immersive approach strengthens their sense of identity with local culture as they engage directly with the digitized heritage of the textile industry through interactive, high-fidelity simulations.

AUTHOR CONTRIBUTIONS

Lusha Li designed, collected and analyzed the data, and drafted the manuscript. Lusha Li conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Lusha Li participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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