Journal of Multimedia Information System VOL. 10, NO. 3, September 2023 (pp. 259-270): ISSN 2383-7632 (Online)
https://doi.org/10.33851/JMIS.2023.10.3.259

Sustainable Development of Diversified Teaching Mode from Ecological Perspective: A Case Study on Metaverse-Based Landscape Oil Painting Course

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Abstract

Art can purify the soul and cultivate sentiment. Artists promote the dissemination and popularization of ecological awareness through the power of art. Painting has a strong visual aesthetic ideology and closely relates to people, nature, and society. Landscape oil paintings use visual metaphor and symbolic expression techniques to endow paintings with multiple and rich ecological concepts, conveying anxiety about various ecological imbalances in human society. However, the exploration of oil painting teaching has stopped in universities recently. Therefore, it is necessary to study the diversified landscape oil painting teaching mode from the perspective of ecology to promote its sustainable development. To further immerse students in nature and advance the sustainable development of oil painting teaching from an ecological perspective, teachers can utilize VR to create natural scenery by introducing the metaverse into the landscape oil painting course. However, in the 360-degree VR landscape sampling video, if the texture cannot be processed well, the student's experience will be significantly reduced. To this end, the texture synthesis of VR videos is studied. The simulation results show that the proposed texture synthesis method performs better in time and space, which undoubtedly improves the students' experience of watching VR landscape videos. Finally, this study uses questionnaires to examine the application effect of metaverse-based landscape oil painting courses. The experimental results demonstrate that metaverse-based landscape oil painting courses can increase students' sense of immersion, most strikingly, which is of great help to the improvement of grades.

Key Words: Metaverse, Landscape Oil Painting, Ecological Perspective, Diversified Teaching Mode, Sustainable Development, Texture Synthesis.

I. INTRODUCTION

Oil painting is a cherished art form that holds a prominent place in the realm of visual arts. It has long been recognized for purifying the soul, cultivating sentiment, and evoking profound emotions. Through art's power, artists have played a vital role in disseminating and popularizing ecological awareness, highlighting the interconnectedness of human society, nature, and the environment [1]. With its solid visual aesthetic ideology, landscape oil painting provides a unique platform for artists to convey ecological concepts, capturing the anxieties surrounding various ecological imbalances in our society [2]. However, despite the potential of landscape oil painting as a powerful tool for ecological expression and its close affinity with the natural world, the exploration and development of oil painting teaching in universities, especially concerning landscape oil painting, have been limited in recent years. Traditional approaches to oil painting teaching have stagnated, failing to keep pace with contemporary art education's evolving demands and opportunities.

This lack of exploration and development of oil painting teaching in universities poses significant challenges and missed opportunities [3-4]. Students are deprived of the chance to engage with the rich heritage and expressive possibilities of landscape oil painting, thereby limiting their artistic and ecological growth. The potential for interdisciplinary approaches, collaborations, and the integration of emerging technologies still needs to be explored, mainly hindering the advancement of landscape oil painting education. The importance of ecological perspectives in oil painting teaching methods becomes evident when considering the potential of art as a catalyst for change [5]. Paintings uniquely capture and convey the beauty, fragility, and interconnectedness of the natural world. Through the language of color, composition, and symbolism, artists can express their concerns about ecological imbalances, raise awareness about environmental issues, and inspire viewers to engage

Manuscript received August 17, 2023; Revised September 04, 2023; Accepted September 17, 2023. (ID No. JMIS-23M-08-033)
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in sustainable actions. By incorporating ecological perspectives into oil painting teaching methods, educators can empower students to become agents of change who use their artistic skills and creativity to address environmental challenges [6]. Through exploring ecological themes, students can develop a deeper appreciation for the interconnectedness of ecosystems, gain a sense of responsibility towards nature, and actively contribute to preserving and restoring the environment.

The significance of landscape oil painting lies in its ability to connect viewers with the environment on an emotional and intellectual level. As humans, we have an innate connection to the natural world, and landscape paintings tap into this primal connection, evoking a sense of wonder, tranquility, and contemplation [7]. They invite us to pause, reflect, and appreciate the beauty of our surroundings, fostering a deep appreciation for the ecological intricacies and the delicate balance of ecosystems. Beyond their aesthetic appeal, landscape oil paintings serve as a visual narrative, conveying ecological concepts and highlighting environmental challenges [8]. Artists use various techniques, such as visual metaphor, symbolic representation, and juxtaposition of elements, to depict environmental degradation, climate change, habitat loss, and other ecological concerns. By translating these complex issues into captivating visual compositions, landscape oil paintings engage viewers and ignite conversations about our role in protecting and preserving the environment. Moreover, landscape oil painting acts as a vehicle for ecological storytelling. Artists can capture not only the physical attributes of landscapes but also the intangible qualities, such as the spirit of a place or the emotions evoked by the natural world. Through their artistic interpretations, they can convey all living beings' interconnectedness, ecosystems' fragility, and the urgency of adopting sustainable practices. The relationship between landscape oil painting and ecological concepts is deeply intertwined. By infusing ecological awareness into their work, artists can inspire viewers to connect with nature, instill a sense of environmental stewardship, and encourage a shift towards sustainable lifestyles. The visual language of landscape oil painting has the potential to transcend cultural and linguistic barriers, making it a universal medium for communicating environmental messages and fostering a sense of shared responsibility for the Earth.

The emergence of the metaverse may redefine the way of learning [9]. Traditional classrooms imprison students' learning methods, while the technical support applied by metaverse in education mainly involves three aspects, namely augmented reality (AR), virtual reality (VR), and artificial intelligence. These three aspects can be viewed from different perspectives, bringing students a new learning experience. AR and VR allow students to obtain an immersive 3D interactive experience, which is the starting point for students to enter the virtual world [10]. With the VR headset, students can explore mysteries in a virtual environment. VR has created a digital world that incorporates virtual visual content. Infiltrating the metaverse into the landscape oil painting lesson, teachers can use VR to construct a natural landscape, allowing students to have a strong sense of immersion in nature. Students may better experience nature by being immersed in a realistic and practical situation along with three-dimensional image teaching, supporting the ecologically sustainable development of oil painting. This innovative teaching stimulates students' creative thinking, broadens their horizons, and enables students to make continuous progress and exploration. The combination of the metaverse and oil painting landscape teaching breaks the limitation of time and space in the current classroom, improves the ability of artistic expression to a certain extent, and provides a new form for modern oil painting teaching. From various aspects such as observation, picture composition arrangement, object-image relationship, and color relationship, it has produced diversified influences on the teaching method of oil painting landscape. However, these all require the blessing of immersion.

The study has several contributions to the landscape oil painting course research area. (i) Art education is pivotal in nurturing creativity, fostering critical thinking, and shaping the next generation of artists. In landscape oil painting, it is essential to develop teaching methods that not only impart technical skills but also incorporate ecological perspectives, harnessing the potential of art to raise environmental awareness and promote sustainable practices. This study aims to explore and develop a diversified teaching mode for landscape oil painting from an ecological perspective, utilizing emerging technologies like VR and the metaverse to enhance students' immersion and learning experiences. (ii) Integrating VR and the metaverse into the landscape oil painting course opens new avenues for engaging students in a deeper exploration of nature. By creating virtual environments replicating natural scenery, students can immerse themselves in realistic landscapes, observe minute details, and gain a more profound understanding of ecological elements. This immersive experience enables students to connect with nature in ways that traditional classroom settings cannot replicate, fostering a sense of empathy and appreciation for the environment. (iii) To ensure the effectiveness of the VR experience, it is crucial to address the challenge of texture synthesis in VR videos. Realistically rendering textures is crucial for creating an authentic and immersive environment. Therefore, this study will explore and propose a texture synthesis method specifically designed for VR videos, aiming to improve the realism and quality of the visual experience. Students can enjoy a more engaging and visually appealing VR landscape painting course by optimizing texture synthesis. (iv) The application and effective-

ness of metaverse-based landscape oil painting courses will be assessed through questionnaires. By collecting feedback from students, this study examines their sense of immersion in virtual environments, evaluating the extent to which the integration of VR and the metaverse enhances their learning experience. Additionally, the impact of the metaverse-based course on students' academic performance will be assessed, determining if the immersive and interactive nature of the course contributes to improved grades and overall achievement.

The rest of this study is organized as follows. Section 2 reviews the related works. Section 3 analyzes the sustainable development of diversified teaching modes of landscape oil painting courses from an ecological perspective and studies metaverse-based landscape oil painting courses. The experimental results are provided in Section 4. Lastly, Section 5 concludes this paper.

II. LITERATURE REVIEW

Numerous studies have highlighted the decisive role of art in disseminating ecological awareness. Art is a means of communication that transcends language barriers, evoking emotions and inspiring change. Artists have used various mediums to raise environmental consciousness, including paintings, sculptures, installations, and performance art [11-12]. The works explore climate change, biodiversity loss, and human ecosystem impact. The visual nature of art allows viewers to engage with these issues on a visceral level, fostering empathy and motivating action. Art and design have emerged as arenas for examining the lasting consequences of technology and modernity, particularly in the ecological crisis and the Anthropocene epoch. Regarding this, in [13], the author presented a concise evaluation of how these concerns are being approached within the cultural domain. The author posited that artworks encompassing critical, conceptual, and speculative design hold significant potential for effectively engaging with the challenges of the Anthropocene. According to the findings in [14], collaborations between arts, humanities, and science have significant potential to foster connections between scholars, the general public, and the environment. Moreover, such collaborations can cultivate a sense of inspiration and empathy towards the natural world while also inducing shifts in awareness that can lead to an increased likelihood of engaging in pro-environmental behavior. In [15], the authors demonstrated a transdisciplinary approach firmly rooted in the confluence of the arts and sciences, aiming to raise awareness and enhance comprehension about the pressing issue of biodiversity loss. Landscape oil painting provides a unique platform for exploring ecological themes due to its inherent connection to nature. Artists have used this medium to depict natural landscapes, flora, and fauna, raising environmental awareness [16-17]. Through symbolism, composition, and color choices, artists convey messages about the fragility of ecosystems, the impacts of human activity, and the need for conservation. Landscape oil painting enables viewers to connect emotionally with the natural world, encouraging a deeper appreciation for its beauty and emphasizing the importance of its preservation [18].

Universities' current state of oil painting teaching must often address ecological themes [19]. Traditional approaches to oil painting instruction often focus on technical skills and art historical contexts, neglecting the integration of environmental concepts. Furthermore, more attention should be given to interdisciplinary approaches or cross-department collaborations that could enrich oil painting courses with ecological perspectives. This oversight hinders the development of a comprehensive understanding of art's environmental implications and inhibits art's potential to drive sustainable change. The primary focus of reference [20] was to underscore key elements of fine art, namely drawing and landscape painting, while also providing scientific and methodological guidance for effectively structuring suitable art lessons and developing proficiency in drawing, painting, and landscape composition. The evaluation methods currently in use to assess the teaching proficiency of college-level art instructors are deemed unsuitable, lacking in organization, and incomplete, as per the findings presented. To solve these problems, reference [21] put forward a novel model to evaluate the adaptive teaching ability of college art teachers.

There is a pressing need for sustainable development in oil painting teaching in universities. Exploring innovative teaching methods explicitly tailored to landscape oil painting is essential. By incorporating ecological perspectives into oil painting courses, educators can foster a deeper understanding of artistic practices' environmental impact and promote sustainable art-making approaches. This includes engaging students in critical discussions about ecological imbalances, integrating environmental themes into art assignments, and exploring the use of environmentally friendly materials and techniques. Embracing sustainable development in oil painting teaching enables students to become conscientious artists who use their skills to address environmental challenges and contribute to a more sustainable future. The symbiotic relationship between information technology and graphics is essential in art pedagogy. To comprehensively facilitate the process of art instruction, the authors have implemented machine vision feature parameters utilizing image recognition technology in both art instruction and simulated visual effects [22]. Within the realm of the art design, research and exploration into the instructional methodologies employed reveal the limita-

tions of traditional teaching approaches in providing optimal learning experiences for students. These limitations manifest in several ways, such as the diminished sense of "presence" in online learning due to the epidemic's impact, resulting in a weakened efficacy of teaching outcomes and the inadequately organized group learning dynamics within the courses. Consequently, in response to these challenges, the authors proposed three avenues for innovative application of art design courses in their work [23] by leveraging the pedagogical strategy of Xirang games. These paths include fostering interactive experiences on a shared screen to enhance presence, facilitating interactions between tangible individuals and virtual images, and implementing the formation of interest-based collaborative learning groups. The study conducted by the authors in [24] examined the existing landscape of higher education institutions in the field of art. It explored the utilization of data mining methodologies within the system to evaluate the caliber of pedagogical practices.

III. METHODOLOGY

3.1. Sustainable Development of Diversified Teaching Mode of Landscape Oil Painting Course from Ecological Perspective

Recently, oil painting teaching, especially landscape oil painting teaching, has developed rapidly in universities. The cultural and artistic atmosphere of oil painting is powerful, which positively improves students' aesthetic capability and can also play a specific role in cultivating students' sentiments. More and more frequent emergence of diversified teaching modes positively impacts oil painting teaching in universities [25]. Although many measures have been adopted in oil painting teaching in some universities, many problems have some adverse effects on the development of diversified teaching modes in universities, mainly including the following aspects. (i) The cultural education of students needs to be taken more seriously. In landscape oil painting teaching, some teachers pay too much attention to cultivating students 'professional skills, which leads to the relatively weak cognition of some students' basic knowledge of oil painting and hinders the development of students' creative thinking ability. (ii) Some teachers need to understand innovative landscape oil painting courses, such as the metaverse-based landscape oil painting courses proposed in this study.

The gradually expanding environmental problems have already extended from the external environmental crisis to the depths of people's hearts. How to effectively suppress the ecological imbalance in all aspects of nature, society, and spirit, improve the living environment and lifestyle of human beings, and reconstruct the value of existence and the meaning of life are all ecological issues that human beings must seriously consider [26]. In changing teaching methods and improving diversified teaching, the first thing to emphasize is ecology. The increasingly harsh environment guides the development of diversified landscape oil painting courses. The ecological imbalance is created into a picture world via the landscape oil painting teaching, which is the desperate cry of human society's development. It sounds the alarm for those people who are still unaware of the ecological dilemma in the joy and awakens the concept of building environmental protection. From the ecological perspective, landscape oil painting teaching has promoted the popularization of ecological concepts with its rich and vivid content, meticulous and unique depiction, and the transmission of deep ecological connotations. As an essential carrier of art, painting has the characteristics of traveling through time and space and can realize the most expansive sharing and communication. Therefore, the natural, social and spiritual ecological crisis presented in the landscape oil painting teaching from the perspective of ecology enables students to resonate in their hearts, thereby enhancing human's concept of environmental protection and ultimately promoting the harmony between man, nature, and social development.

The existing teaching methods have needed to be revised to meet the actual needs of the current landscape oil painting teaching in universities. Under such circumstances, universities should change the current teaching mode and seek innovation in landscape oil painting teaching [27]. To assist students and enable them to discover the wonderful things around them, teachers should coordinate their efforts with the actual situation. Additionally, in terms of teaching methods, we should try our best to make the class not monotonous and boring but more active to stimulate students' interest in learning oil painting. Landscape oil painting works generally express the inner thoughts of the creators, and the works are usually integrated with the creators' views and ideas, as well as their innovative thinking. Through the works, we can see the students' pursuit and yearning for a better life. Under the diversified teaching mode, students' innovation ability will be significantly improved. Universities must abandon rigid and outdated teaching concepts. Only in this way can the diversified teaching mode play a role.

The oil painting has been developed since the 14th century. As one of the essential painting carriers, oil painting is presented to everyone visually. It is in the hands of generation after generation of artists constantly innovating and exuding dazzling brilliance. Today's society is diversified, so artistic creation also presents diversity. Landscape oil painting, on the one hand, can reflect the attractiveness of today's society. On the other hand, it shows different creation meth-

ods due to the integration of various elements, which makes oil painting more prosperous and more wonderful.

The commercialization trend in the consumer age is a problem all art types face. Works of art are facing new changes in production, consumption, communication, and transaction modes and are developing from traditional production and consumption modes to digital and multimedia [28]. Oil painting is also facing the problems of pure art creation, mass oil painting consumption, and the impact brought by digitalization. It should include the market development of the landscape oil painting industry, the development of landscape oil painting talent, and the landscape oil painting communication platform and technique. The benign inheritance and sustainable development of landscape oil painting should be realized from both internal and external aspects.

Students should be given opportunities and platforms to show their talents as much as possible. For example, the government or universities can hold national and provincial landscape oil painting competitions, and the judges can invite some art scholars who are reasonably accomplished in oil painting creation. In this way, more talented young painters in oil painting can be tapped to help them improve their artistic creation ability and further promote the development of landscape oil painting.

Landscape oil painting is a cultural and creative industry. Therefore, according to the current development of landscape oil painting, it is necessary to rationally deal with the relationship between artistry and commercialization from the perspective of cultural and creative art industries to promote breakthroughs in landscape oil painting. The 21st century's social economy has grown quickly, and we have entered the fast-moving consumer goods market [29]. The public is more willing to regard works of art as a feast of entertainment rather than a feast of art. However, it should be emphasized that the primary and most basic mission of oil painters is innovation and creation. Oil paintings can be commercialized, but creative concepts and behaviors must stay within artistry and be replaced by commercialization. By rationally dealing with the relationship between artistry and commercialization and taking this as a breakthrough, we can better create landscape oil paintings with artistic and commercial value.

In response to the demand for talents in landscape oil painting, universities should comprehensively consider the positioning and the current reality when designing curriculums. A teaching system that satisfies professional standards, adheres to the demands of the discipline's dynamic development, and is capable of reflecting student characteristics and the benefits of the discipline should be developed based on a combination of social demands for the growth of the oil painting business. To improve students' comprehensive abilities, it is also required to modify adjust the teaching material in accordance with the demands of relevant industries and introduce new teaching modes. Additionally, universities must enhance the practicality and expansibility of curriculum content and develop students' subject skills. Teachers must inspire and guide students to explore so that students can create artworks that meet people's aesthetic requirements in exploration and learning activities.

To sum up, landscape oil painting, or the oil painting industry, as a new type of cultural, entrepreneurial industry, is not only a key development content in modern art but also a hopeful way to improve the level of artistic creation. From the perspective of long-term development, only from the central idea expressed by oil paintings, conduct a comprehensive and objective analysis of its current living conditions, and actively explore and find new sustainable development paths to solve the unavoidable bottleneck in the development to ensure the long-term and stable development of landscape oil painting.

3.2. Metaverse-Based Landscape Oil Painting Courses

Metaverse is a visual immersion technology with great potential, and the application of metaverse in education will be a subversive educational revolution. Metaverse can effectively avoid silence in class and the limitation of classroom time and space [30]. The essential thing in the metaverse-based landscape oil painting courses is ensuring an immersive experience effect. When the teacher plays the landscape sampling video, it is necessary for the students to feel the landscape from multiple angles. The premise of drawing is to feel, and the metaverse increases immersion for students while feeling. Students can only go to the designated location to create specific landscape oil paintings due to time and space restrictions. The strong sense of the experience of the metaverse ensures the feasibility of painting in the classroom. Texture synthesis is the core method of the video content production process under VR technology.

In the production of VR landscape sampling content, a group of cameras or a camera device including multiple cameras and sensors and audio sensors are used to collect sound-visual scenes in the real world. Devices such as cameras and sensors output digital video and audio signals [31]. Generally, cameras can capture the content of the surrounding 360-degree directions. For VR video processing, the VR video images at the same time are stitched, projected, and mapped. The texture synthesis of projected image frames generates an encapsulated frame. For a three-dimensional plane or curved surface, after setting parameters such as the position and direction of the viewpoint, the line-of-sight direction, and the position of the projection plane, the projection transformation matrix is represented by a triangular

mesh, which can be used to deduce the three-dimensional coordinates of the grid in the three-dimensional plane or curved surface in reverse. After the triangular mesh on the two-dimensional plane is determined by projection, a continuous scaling field is assigned to it. That is, a scaling factor is assigned to each triangle patch to ensure that the scaling factor between adjacent triangle patches has continuous variability. Let S_i represent the distance from each triangle patch in the 3D landscape to the viewpoint, and all S_i can be integrated into a threshold value of a discrete function $S(i)$. The viewing distance S_i and S_{i+1} between any adjacent triangle patch i and $i+1$ are determined, and the difference φ_i between them can be expressed below.

$$\varphi_i = |S_i - S_{i+1}|. \tag{1}$$

Then, the upper limit value $\max\varphi$ of φ_i can be obtained by Equation (1).

Let the length factor of the reduction degree of the interactive input sample image be $minScale$. When the $minScale$ is 0.4, it means that the size of the sample changes gradually in $[0.4,1]$. Based on $minScale$, pyramid reduction is carried out for a given texture sample image to obtain a multi-level scaled sample image. These scaled sample images are the basis for obtaining corresponding sample images by scaling factor in the scaling field in texture synthesis.

The primary function of the surface texture vector field is to control the basic direction of the texture on the surface. Let $A = \{a_1, b_1, c_1\}$ and $B = \{a_2, b_2, c_2\}$ represent two vectors, respectively, and θ represents the angle between vector A and vector B, then

$$\cos\theta = \frac{a_1 \times a_2 + b_1 \times b_2 + c_1 \times c_2}{\sqrt{a_1^2 + b_1^2 + c_1^2} * \sqrt{a_2^2 + b_2^2 + c_2^2}}. \tag{2}$$

With any axis as the center, a triangle patch is rotated at a certain angle, and the size and shape of the triangle patch do not change after rotation. Let AB denote any axis, (Xa, Ya, Za) and $\{a, b, c\}$ denote the coordinates of point A and the direction vector of AB, respectively. Thus, a triangle patch rotated θ degrees around the axis AB corresponds to the three vertices of the triangle patch multiplied by the matrix W, as follows.

$$W = T_A \times W_x \times W_y \times W_z \times W_x^{-1} \times W_y^{-1} \times T_A^{-1}, \tag{3}$$

where T_A represents the translational coordinate system, and A represents the origin of the new coordinate system. W_x and W_y are the AB axis rotated by an appropriate angle around the *X*-axis and *Y*-axis of the new coordinate system. Then the AB axis coincides with the *Z*-axis of the new coordinate system. W_z rotates θ degrees around the AB axis, and W_x^{-1}, W_y^{-1}, T_A^{-1} represent the inverse transformation, thereby restoring AB to its original position.

Rotate each triangle patch so that the *Z*-axis coordinates of its three vertices are the same. $A(x_0, y_0, z_0)$, $B(x_1, y_1, z_1)$, and $C(x_2, y_2, z_2)$ represent the three vertex coordinates of the triangle patch ABC respectively, and $n = \{a, b, c\}$ represents the normal vector of the triangle patch.

Rotate points B and C around point A and the vector parallel to *XOZ*-plane, so that the normal vector of the triangle patch is parallel to *XOZ*-plane. Rotate points B and C around point A and the vector parallel to the *Y*-axis, so that the normal vector of the triangle patch is parallel to the positive direction of the *Z*-axis. After each triangle patch on the curved surface is rotated, each normal vector is parallel to the Z-axis. The rotated triangle patch can be understood as being on the same plane, simplifying the vector field calculation process. Set the mean value of n vectors to be consistent with the sum of these n vectors, and perform unitization processing on n vectors.

The search-match process is to extract the matching area in the texture grid [32]. According to the texture direction vector of the current triangle patch to be textured, search in the reverse order of the scan lines in the sample texture, and determine the texture coordinates with the highest similarity to the texture value of the matching area template, which is used as the texture coordinate value of the current triangle patch to be textured. At the bottom of the texture space, the adjacent triangles are rotated in the same direction to obtain the matching template. The scan-line method searches the sample texture space according to the corresponding step size. The texture coordinates with the highest consistency with the textured triangle are obtained.

To verify the practical application effect of VR landscape sampling content texture synthesis, a simulation analysis was carried out. The simulation used a self-built texture sample dataset and selected water ripple and grass texture samples in the texture sample dataset for texture synthesis, as shown in Fig. 1. As seen from Fig. 1, using the proposed method to synthesize large-area similar textures can truly achieve no texture deformation, and solve the issues of boundary discontinuity and periodicity of synthesized textures in texture synthesis. At the same time, using the proposed method for texture synthesis can also achieve a high perspective effect, which is of great help to VR landscape oil painting courses and increases the immersion of students watching VR landscape videos.

This study uses Laplacian image-based geometry texture synthesis [33] and optimized texture-by-numbers synthesis method [34] as baselines for comparison. The spatio-temporal performance of the suggested method and the baselines are compared using the synthesis of grass texture sam-

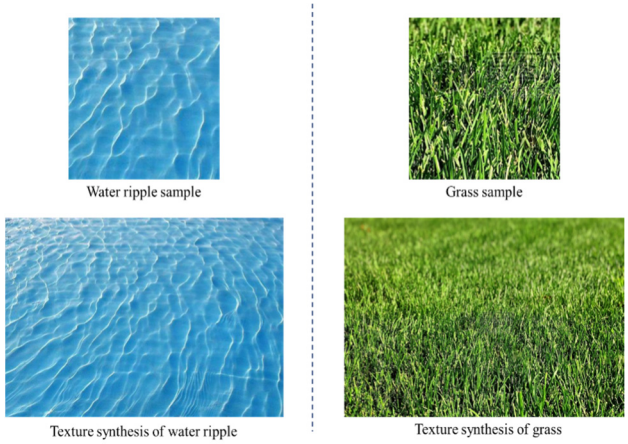

Fig. 1. Texture synthesis effect.

ples as an example, and the results are presented in Tables 1 and 2. Table 1 shows that, in terms of synthesis time, the suggested technique outperforms the baselines due to the real-time synthesis of the proposed method in the process of landscape rendering without complex preprocessing for texture samples, improving the efficiency of texture synthesis. Table 2 shows that the proposed method requires less storage space for texture synthesis, and the storage space is reduced by more than 50% compared with the baselines. The proposed method performs well in synthesis time and file size after synthesis, which undoubtedly improves the students' experience watching VR landscape videos.

IV. EXPERIMENT AND RESULTS ANALYSIS

4.1. Effect Analysis in Classroom

To analyze the teaching effect of the diversified teaching mode of the ecological perspective, and then study the application value and influence of metaverse-based landscape oil painting course, evaluate the application effect, and put forward corresponding suggestions to serve the landscape oil painting teaching better. In this study, two classes of fine arts major in the School of Fine Arts of Xinxiang University are selected as experimental objects. One class is the experimental group, and the other is the control group, with 25 students in each of the two classes. This study tested the application effect of metaverse-based landscape oil painting courses in the form of questionnaires. The Likert scale was used for survey research, with 1−5 representing strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree [35]. The questionnaire is investigated from seven dimensions, namely perceived usefulness (PU), perceived ease of use (PEU), perceived immersion (PIM), behavioral intention (BI), learning interest (LI),

Table 1. Temporal performance simulation results.

Number of triangle patches	The propose Method (s)	Laplacian texture image-based geometry texture synthesis (s)	Optimized texture-by-numbers synthesis (s)
512	5.13	18.90	11.34
1,024	7.84	23.45	14.70
1,535	11.02	29.62	17.55
2,048	15.46	37.66	22.91
2,560	19.56	54.12	30.66
3,072	23.57	80.33	51.78
3,584	27.89	99.26	79.34
4,096	31.26	129.52	110.42

Table 2. Spatial performance simulation results.

Number of triangle patches	The proposed method	Laplacian texture image-based geometry texture synthesis	Optimized texture-by-numbers synthesis
512	1.31	1.58	1.70
1,024	2.18	2.66	2.58
1,535	2.68	4.30	4.73
2,048	3.67	5.93	5.74
2,560	5.29	7.02	7.36
3,072	6.01	9.15	10.08
3,584	7.76	11.26	14.56
4,096	9.09	14.20	2.23

perceived of wearing (PW), perceived of communication (PC), each dimension contains one or two items, as shown in Table 3. The items in the scale refer to mature scales with high reliability and validity in related research, refer to many papers, and combine the application effects of metaverse-based landscape oil painting courses with being tested for specific designs. Statistical analysis was carried out on the returned questionnaires through SPSS23.0, and the results are shown in Table 4.

The analysis of the statistical data can be summarized as the following results.

(1) Students can feel the help of metaverse-based landscape oil painting courses for painting.
(2) Most students can master the use of VR device proficiently without spending too much effort, and VR device is easy to use.
(3) Students in the metaverse-based landscape oil painting courses have an immersive feeling, a good sense of immersion, and can concentrate more than in traditional classrooms.
(4) Students are delighted with the effect of metaverse-based landscape oil painting courses, have a high use intention, and are willing to continue to use it in their future studies.
(5) Metaverse-based landscape oil painting courses are of great help to enhance students' interest in learning.
(6) Most of the students can wear VR glasses normally in the landscape oil painting courses, but a few students experience dizziness and other discomforts.
(7) Metaverse-based landscape oil painting courses help students participate in classroom discussions and group communication.

Table 3. Questionnaire measurement items.

Dimension	Number	Item
Perceived usefulness	PU_1	Improve learning efficiency
	PU_2	Abundant means of learning
Perceived ease of use	PEU	Easily operated
Perceived immersion	PIM_1	Focus while watching
	PIM_2	Better than on-the-spot investigation
Behavioral intention	BI_1	Suggest others to use
	BI_2	Extension to other courses
Learning interest	LI	Improve learning interest
Perceived of wearing	PW	Feeling dizzy
Perceived of communication	PC	Conducive to discussion

4.2. Examination Results Analysis

The two classes selected for this study did not perform significantly differently from one another. Next, an independent sample student's *t*-test was used to determine whether there was a significant difference in student performance between the experimental and control groups after using the metaverse-based landscape oil painting teaching method [36]. Among them, the control group used the previous teaching method, while the experimental group used the metaverse-based one. Table 5 shows that the average score of the experimental group is 83.7200, the average score of the control group is 75.200, the standard deviation of the experimental group is 8.49274, and the standard deviation of the control group is 10.23474. The standard deviation is small, indicating that the degree of dispersion of scores is small, and the scores are relatively concentrated;

Table 5. Descriptive statistics of the score of the experimental group and the control group.

Group type	Number of students	Mean	Standard deviation
Experimental group	25	83.72000	8.49274
Control group	25	75.20000	10.23474

Table 4. Questionnaire measurement items.

Item	Strongly disagree (%)	Disagree (%)	Neither agree nor disagree (%)	Agree (%)	Strongly agree (%)	Mean (%)	Standard deviation (%)	Variance (%)
PU_1	1.2	1.2	4.9	56.1	36.6	4.26	0.717	0.541
PU_2	3.7	1.2	6.1	54.9	34.1	4.15	0.877	0.768
PEU	2.4	9.8	15.9	47.6	24.4	3.82	0.995	0.991
PIM_1	1.2	3.7	9.8	42.7	42.7	4.22	0.861	0.741
PIM_2	6.1	2.4	12.2	36.6	42.7	4.07	1.079	1.204
BI_1	1.2	1.2	4.9	47.6	45.1	4.34	0.741	0.549
BI_2	1.2	6.1	7.3	45.1	40.2	4.17	0.900	0.810
LI	2.4	2.4	6.1	42.7	46.3	4.28	0.879	0.772
PW	3.7	8.5	12.2	46.3	29.3	3.89	1.042	1.087
PC	1.2	4.9	7.3	45.1	41.5	4.21	0.871	0.759

the degree of dispersion of the scores of the students in the control group is relatively large, and the scores are relatively scattered.

The results of the independent sample t-test between the experimental and control group are shown in Table 6. As seen from Table 6, the Sig of Levene's test [37] result of the equality of variances is more significant than 0.05, indicating that the variances of the two classes are equal, so the test results only need to focus on the line "Equal variance assumed." The test results show that Sig is less than 0.01, indicating that the difference is significant, so it can be explained that there is a significant difference in the score of the experimental and control groups. While the average score of the experimental group is higher than the average score of the control group, indicating that metaverse-based landscape oil painting courses have a specific effect and are helping to improve students' scores.

It can be seen from Fig. 2 that after the metaverse-based landscape oil painting courses, the scores of the students in the experimental group and the control group were significantly different in each grade. All the experimental group students' scores were above 60 points, and the scores were concentrated between 80−89 points. There are seven students with a score above 90, and the number of students with low scores is small. The students' average score is 8.52 points higher than that of control group. The control group's students' results were mostly between 70 and 79 points. The number of high-scoring students was small, and two students failed. Analyzing the number of students in each grade shows that metaverse-based landscape oil painting courses can improve students' interest in learning and performance.

Previous studies in art education have explored integrating technology, particularly VR, in teaching practices. These studies have consistently highlighted the positive impact of interactive and immersive learning environments on student engagement and learning outcomes. Our research aligns with these findings, as we observed a notable enhancement in students' immersion and sense of presence when incorporating the metaverse and VR technology into

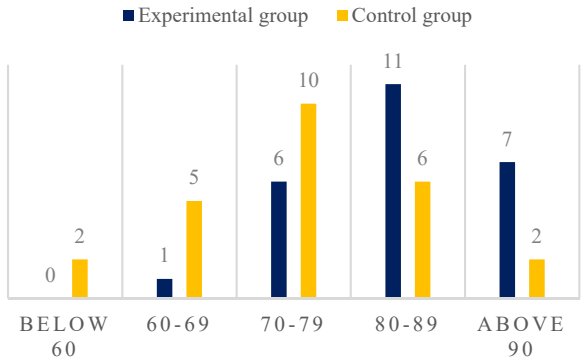

Fig. 2. Score statistics.

the landscape oil painting course. These results further support the notion that technology can be a valuable tool in facilitating experiential and active learning in art education.

Furthermore, our investigation of texture processing in 360-degree VR landscape sampling videos and the development of a curved surface texture synthesis method is an area that has garnered attention in computer graphics and virtual reality research. While a limited number of studies explicitly focus on texture synthesis in the context of VR landscape videos, our approach aligns with the broader literature on texture synthesis techniques. The promising outcomes of our proposed method in enhancing the students' viewing experience align with previous research that emphasizes the significance of high-quality and realistic textures in immersive environments.

Regarding incorporating ecological concepts in the landscape oil painting course, our study is part of a growing body of research exploring the intersection of art education and environmental awareness. Numerous studies have emphasized the potential of art to promote ecological consciousness and foster sustainable behaviors. Our findings support these existing studies by showcasing the effectiveness of integrating ecological themes and concepts into the curriculum. Using landscape oil paintings, which inherently convey ecological imbalances and concerns, we provide students with a medium to creatively express and explore environmental issues.

Table 6. Independent sample *t*-test results for the experimental group and the control group.

	Levene's test for equality of variances		*t*-test for equality of means						
	F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
								Lower	Upper
Equal variance assumed	.875	.354	3.203	48	.002	8.52000	2.65990	3.17191	13.86809
Equal variance not assumed			3.203	46.421	.002	8.52000	2.65990	3.16721	13.87279

V. CONCLUSION

This study explores the sustainable development of a metaverse-based ecological diversified teaching mode using the landscape oil painting course as an example. The study's objectives were fulfilled through a comprehensive analysis of the sustainable development of landscape oil painting courses based on an ecological perspective diversification teaching mode, as well as the investigation of texture processing in 360-degree VR landscape sampling videos. To address the issue of texture processing, a curved surface texture synthesis method was adopted, which effectively synthesized textures based on their directions. The proposed method achieved texture synthesis by integrating scaling factors by searching the sample texture space according to scan line order and determining matching texture coordinates. The simulation results demonstrated the successful performance of the suggested texture synthesis method in improving the temporal and spatial aspects of students' viewing experience of VR landscape videos. Furthermore, the application impact of metaverse-based landscape oil painting courses was examined through questionnaires. The experimental results highlighted the significant enhancement of students' sense of immersion, ultimately impacting their academic performance positively.

However, this study does have some limitations. The main limitation is insufficient teaching resources for landscape oil painting VR. Adequate teaching resources are crucial for practical teaching activities. There is a need for more VR art teaching resources, specifically landscape oil painting VR teaching resources. Consequently, teachers are required to invest significant time in collecting and curating VR teaching resources related to the course content. Education reform heavily relies on technological support, and with the application of the metaverse in education and teaching, its effectiveness has garnered attention from various stakeholders. The use of VR technology offers practical advantages for the teaching of landscape oil painting. While this study provides a preliminary investigation into the sustainable development of diversified teaching methods in landscape oil painting courses, it acknowledges several limitations. As science and technology progress, the metaverse is poised to bring more innovation and advancement to landscape oil painting courses. In conclusion, this study contributes to understanding and promoting sustainable development in art education by integrating ecological perspectives and metaverse-based teaching approaches. Future research should address the limitations identified in this study and explore further advancements in leveraging technology for landscape oil painting education.

ACKNOWLEDGMENT

This work is supported by China National Arts Fund Project (Granted No. 2020-A-06-(092)-523).

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