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# Developing and implementing the four-dimensional aesthetic education framework in elementary education

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**Introduction:** Under the background of sustainable development, aesthetic education is becoming increasingly important in primary education programs. This study integrates the principles of sustainable development with aesthetic education and, based on the characteristics of primary education majors, proposes the "Four-Dimensional Aesthetic Education" (4DAE) framework. This framework includes four progressive dimensions: "Process Path," "Capacity Building," "Individual Growth," and "Value Orientation." It aims to build a coordinated system that connects aesthetic perception, educational ability, personal development, and value cultivation.

**Objective:** The study explores the feasibility and effectiveness of applying the 4DAE framework in the Art course for primary education majors, and examines its impact on students' overall competencies.

**Methods:** The participants were 49 first-year students majoring in primary education at a teacher training college in Jiangsu Province, China. A 12-week aesthetic education intervention was designed and implemented, focusing on the first dimension, which includes four sub-dimensions: "Perception and Experience," "Thinking and Judgment," "Practice and Innovation," and "Education and Transmission." Pre- and post-course paired questionnaires were used to assess changes in students' overall abilities.

**Conclusion:** The results showed that the 4DAE framework significantly improved students' artistic perception, critical thinking, creativity, and teaching communication skills ($p < 0.05$). The course satisfaction rate reached 90%, showing that the course design and content met student needs. The study suggests that the 4DAE framework helps improve curriculum structure and supports the development of pre-service teachers' core abilities. It also provides theoretical and practical guidance for implementing aesthetic education under the goal of sustainable development.

KEYWORDS

**four-dimensional aesthetic education framework, primary education program, art education, teaching practice, sustainable development**

# 1 Introduction

In the context of educational reform and sustainable development, the United Nations released the "2030 Agenda for Sustainable Development" in 2015, highlighting education as a key pathway to achieving sustainable development goals (Fischman et al., 2018). In 2019, the United Nations introduced the "ESD for 2030" framework (UNESCO, 2018). Under this framework, aesthetic education has become crucial for enhancing the quality of education (Tao and Tao, 2024).

Moreover, cultivating students' imagination and emotional cognition has gradually become a core goal of art education (UNESCO, 2024). In recent years, the Chinese government has issued several policy documents to support the advancement of aesthetic education. These include the "Opinions on Effectively Strengthening Aesthetic Education in Higher Education in the New Era" (Ministry of Education of the People's Republic of China, 2019), the "Opinions on Comprehensively Strengthening and Improving Aesthetic Education in Schools in the New Era" (Ministry of Education of the People's Republic of China, 2020), and the "Notice on the Comprehensive Implementation of the Aesthetic Education Immersion Action in Schools" (Ministry of Education of the People's Republic of China, 2023). These policies provide strong institutional and practical support for the integration of aesthetic education into the educational system. Aesthetic education not only plays a significant role in improving students' overall competence but also helps cultivate individuals with creativity and sustainable development awareness. This highlights its essential contribution to fostering socially responsible members equipped for future challenges (Malytska et al., 2022).

Higher education institutions pave the way for sustainable development. Among these, art education stands out as one of the most organic ways to convey information and values to human consciousness (Malytska et al., 2022). Although the creative domain in art education is a crucial aspect of individual development, its value in education remains underestimated (Muzyka et al., 2021). Several challenges persist in aesthetic education. These include insufficient overall framework design for courses, a lack of course resources, and limited diversity in aesthetic education resources (Gong et al., 2024). Moreover, in the era of sustainable development, the role of education extends beyond traditional knowledge dissemination. It now focuses on cultivating students' critical thinking, innovative abilities, and social engagement skills (Tao and Tao, 2024). Therefore, the training of future teachers must not only achieve an appropriate level of professional expertise but also develop their spiritual awareness, aesthetic culture, and artistic and aesthetic abilities (Nerubasska and Maksymchuk, 2020; Tomashevskyi et al., 2022).

Based on this, the study proposes the "Four-Dimensional Aesthetic Education (4DAE)" framework. It includes four progressive dimensions: process path, capacity building, individual growth, and value orientation. The framework aims to build a coordinated system that connects aesthetic understanding, teaching ability, personal development, and value formation. It addresses the current gap in aesthetic education for primary education majors, where there is a lack of systematic, multi-dimensional training paths and integration with sustainable development. This framework offers a new practical approach for aesthetic education and helps prepare future primary educators to meet complex social challenges and support the goals of sustainable development.

To test the effectiveness of the proposed framework, this study selected 49 first-year students majoring in primary education at a teacher training college in Jiangsu Province, China. A questionnaire survey was used to assess changes in students' abilities across the four dimensions before and after the course. A 5-point Likert scale was used for data collection. A normality test was conducted to determine the distribution of the data. If the data followed a normal distribution, a paired-sample t-test was used to analyze the differences. If the data did not meet the normality assumption, a non-parametric test (Wilcoxon signed-rank test) was used as a supplement. The study focused on the following three questions:

- Q1: Does the "Four-Dimensional Aesthetic Education (4DAE)" framework provide practical guidance for teaching?
- Q2: Can the "Four-Dimensional Aesthetic Education (4DAE)" framework significantly improve students' abilities in perceptual experience, critical thinking, practical innovation, and educational transmission?
- Q3: Does the teaching reform based on the "Four-Dimensional Aesthetic Education (4DAE)" framework gain students' recognition and satisfaction?

# 2 Literature review

## 2.1 Integration of aesthetic education into teacher education

In the current wave of educational innovation, the importance of aesthetic education is growing (Li and Sun, 2023). It not only provides students with rich aesthetic experiences but also enhances creativity and imagination. It is a key part of students' overall development (D'Olimpio, 2022). For example, music production has been used as an aesthetic experience in mathematics teacher education, where creating math-related songs helped improve students' expression and mathematical thinking (da Silva, 2020). In basic education, smart technologies have improved student performance in percussion and instrumental teaching (Li and Sun, 2023). In early childhood teacher education, integrated art courses have strengthened students' aesthetic attitudes (Park, 2021). Combining craft-making with science learning has helped students better understand children's learning experiences and improve their professional competence (Palmer and Elkin Postila, 2024). The integration of calligraphy and aesthetic education has improved pre-service teachers' ability to judge beauty (Wu et al., 2021). These studies mainly focus on course-based interventions, subject integration, and teaching skill development. However, few studies address the development of pre-service teachers' sense of educational responsibility, value formation, and awareness of sustainable development (Knif and Kairavuori, 2020; Molderez and Ceulemans, 2018).

## 2.2 Interdisciplinary integration and socio-cultural

The development of aesthetic education in higher education also faces many challenges, such as limited educational concepts and

incomplete curriculum systems. To address these problems, researchers have proposed innovative approaches such as accelerating curriculum development and creating diverse practical courses (Gao, 2023). For example, the "three-fold integration" strategy (comprehensive training, full coverage, and complete integration) aims to connect on-campus and off-campus resources and promote a holistic approach to aesthetic education (Wang et al., 2024). In terms of curriculum design, digital and intelligent technologies have supported aesthetic education. For instance, the integration of technology in image design courses has greatly improved students' aesthetic and creative abilities (Chen and Zhang, 2024). Open-source mathematics software has also been shown to support students' logical thinking and aesthetic literacy (Aktayeva et al., 2022). In vocational education, tools such as Adobe InDesign have made teaching more attractive and effective (Bian, 2021). In addition, emerging technologies such as virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) are reshaping the field of aesthetic education by enhancing emotional engagement and artistic creativity (Chen and Zhang, 2024; Zhou and Li, 2024). Although many studies highlight the positive impact of technology on aesthetic education (Shevtsova et al., 2023), most interdisciplinary integration remains at the "tool level," focusing mainly on the use of digital platforms and content delivery. There is limited attention to teachers' cognitive and behavioral responses in cross-cultural settings (Jónsdóttir, 2017; Knif and Kairavuori, 2020).

At the sociocultural level, aesthetic education plays a unique role in promoting social equity and cultural diversity (Tao and Tao, 2024). For example, community-based aesthetic projects help build social cohesion and preserve cultural memory (Szuścik, 2024). They also improve the aesthetic literacy and social participation of older adults (Tsai and Liu, 2020). However, most of these studies focus on aesthetic experience. Few explore how aesthetic education can foster students' creative thinking and problem-solving skills through interdisciplinary projects (Shevtsova et al., 2023).

## 2.3 The integration of art and design thinking

Integrating design thinking into upper elementary art education helps develop students' Four Cs—creativity, critical thinking, communication, and collaboration—while also enhancing their empathy (Montero, 2023). Art creation and design thinking are closely connected. Applying design thinking not only boosts students' creativity but also strengthens their critical thinking and problem-solving skills (Taşpınar, 2022). This offers practical solutions for teacher education by helping teachers effectively engage students' creativity and problem-solving abilities, ultimately improving teaching outcomes (Henriksen et al., 2020). At the same time, research shows that art students' interaction with digital technology reveals that familiarity with traditional digital art tools enhances their emotional and behavioral engagement in the classroom (Shiri and Baigutov, 2024). Art education, by fostering both expressive and cognitive skills, significantly improves students' creativity and critical thinking (Lukaka, 2023). Therefore, classroom teaching should go beyond simply delivering knowledge. It should focus more on cultivating students' innovative thinking and aesthetic awareness (Yuan and Peng, 2023). However, although there is growing attention to creativity and problem-solving, there is still a lack of a clear teaching framework or value assessment system.

## 2.4 The relationship between art and sustainable development

Participatory art forms, such as community art and site-specific art, provide students with opportunities to experience the interconnectedness between individuals, society, and the environment. Through these art forms, students gain a practical understanding of the close relationships between people, society, and the environment. This challenges traditional educational ideas and promotes more ecological educational practices (Illeris, 2017). Moreover, appreciating art helps students develop critical reflection and creative thinking. This fosters systems thinking by engaging both emotions and critical reasoning, allowing students to better understand complex issues related to sustainable development (Molderez and Ceulemans, 2018). In elementary visual arts education programs, preservice teachers explore equality through dialogue, collaboration, and process-oriented teaching methods. They reflect on power dynamics within teaching environments, helping them understand the link between equality and sustainable development (Knif and Kairavuori, 2020). Art courses use bodily perception and emotional experience as teaching methods. This approach enhances students' critical thinking and cognitive creativity—skills that are essential for building their awareness and ability to take action for sustainable development (Stoll et al., 2022). Although previous studies highlight the potential of emotional experience and artistic intervention in education for sustainable development, they lack in-depth analysis and systematic construction of how multiple artistic abilities work together to drive the formation of sustainability literacy (Molderez and Ceulemans, 2018; Trott et al., 2020). Therefore, exploring the internal mechanism by which multiple artistic abilities jointly promote sustainability literacy remains a current research gap and an important direction for future study.

## 2.5 Comparative analysis of 4DAE and contemporary educational models

In recent international education reforms, several frameworks—such as the Four C's, the OECD Learning Compass, STEAM, and TPACK—have provided important directions for 21st-century education. However, each focuses on different aspects. The Four C's emphasizes soft skills, especially creativity, critical thinking, communication, and collaboration (Trilling and Fadel, 2009). The OECD Learning Compass highlights future-oriented competencies by integrating knowledge, skills, attitudes, and values (Hughson and Wood, 2020). STEAM promotes interdisciplinary learning that combines science, technology, engineering, arts, and mathematics, aiming to foster innovation and practical problem-solving (Perignat and Katz-Buonincontro, 2019). TPACK focuses on teachers' ability to integrate technology into pedagogy and content knowledge to enhance instructional design (Choi and Young, 2021). While these frameworks have advanced educational modernization and competency-based

TABLE 1 A comparison between the 4DAE framework and other educational approaches.

| Model | Core characteristics | Similarities with 4DAE | Uniqueness of 4DAE |
|---|---|---|---|
| Four C's | It focuses on creativity, critical thinking, communication, and collaboration, and highlights the development of soft skills. | Aligned with the "Practice and Innovation" and "Thinking and Judgment" dimensions in the 4DAE framework. | The 4DAE framework adds the "Education and Transmission" dimension, highlighting values and teacher responsibility. |
| OECD learning compass | It emphasizes student agency and the reflection cycle, and promotes the integration of cognition, skills, and values. | Corresponds to the "Self-Growth" and "Value-Oriented" dimensions in the 4DAE framework. | The 4DAE framework focuses on teacher education and uses aesthetic education as a medium; it includes a structured four-level model: cognition, competence, personal growth, and values. |
| STEAM | It encourages interdisciplinary integration across science, technology, engineering, arts, and mathematics, with an emphasis on project-based learning and innovation. | Consistent with the "Practice and Innovation" dimension in the 4DAE framework. | The 4DAE framework places more emphasis on aesthetic experience and cultural value transmission, rather than a purely science- or technology-based approach. |
| TPACK | It focuses on the integration of technology, content, and pedagogy to enhance teachers' ability to use information technology in teaching. | Echoes the "Education and Transmission" dimension in the 4DAE framework, with a shared focus on teacher professional development. | The 4DAE framework highlights cultural inheritance and value formation, combining aesthetic education to improve teachers' overall competencies. |

learning in various domains, most of them still prioritize digital literacy, subject integration, or skill development. They often lack a coherent logic that brings together aesthetic experience, cultural inheritance, and the personal growth of teachers. In response, the Four-Dimensional Aesthetic Education (4DAE) framework places aesthetic education at its core. It proposes four progressive dimensions: learning process, competence development, personal growth, and value orientation. This framework seeks to connect aesthetic perception, educational capacity, developmental pathways, and value formation in a systematic way. In addition to fostering creativity, it emphasizes the teacher's role in cultural transmission and awareness of sustainable development, offering a distinctive model that combines integrative structure with cultural depth (Table 1).

# 3 Development

## 3.1 Framework construction of the "Four-Dimensional Aesthetic Education (4DAE)" framework

### 3.1.1 Theoretical basis of the "Four-Dimensional Aesthetic Education" framework

Sustainable development is a multi-dimensional concept that involves systemic transformation across economic, social, cultural, and ecological fields. Its core is to reshape the relationship between humans and nature and to promote sustainable ways of living at a global level (Jónsdóttir, 2017). The 2030 Agenda for Sustainable Development, adopted in 2015, officially included Sustainable Development Goal 4 (SDG4) in the global action framework (UNESCO, 2018). Based on this context, the "Four-Dimensional Aesthetic Education (4DAE)" framework is proposed in this study. It is grounded in the field of primary education and integrates education for sustainable development, art education theory, educational psychology, and socio-cultural theory to build a systematic framework for the development of art education (Figure 1).

The "Four-Dimensional Aesthetic Education (4DAE)" framework includes four interconnected dimensions. The first is the process-oriented aesthetic dimension. The second is the competency-building dimension. The third is the personal growth dimension. The fourth is the value-oriented dimension. These four dimensions are not separate or static. Instead, they form a dynamic progression from cognition to competency, from growth to values. Together, they create a developmental path that supports the integrated cultivation of aesthetic literacy and professional awareness for future primary school teachers.

#### 3.1.1.1 First dimension: aesthetic process from "Experience and Cognition" to "Communication and Expression"

This dimension is based on constructivist learning theory (Piaget and Cook, 1952; Vygotsky and Cole, 1978) and experiential learning models (Morris, 2020; Passarelli and Kolb, 2023). It emphasizes a dynamic aesthetic path built on perception, cognition, practice, and communication (Efgivia et al., 2021; Newman and Latifi, 2021; Efgivia et al., 2021; Newman and Latifi, 2021). In this process, learners reshape their understanding of aesthetics through "learning by doing" and "learning by sensing" (Sousa et al., 2023). This reflects Dewey's (1934) idea that art is experience, meaning that aesthetic activity is not only perceptual but also a deep interaction between the individual and their environment (Haubert, 2021; Silva and Cunha, 2021).

Eisner (2002) pointed out that aesthetic education should help students perceive and interpret complex aesthetic languages, improving their aesthetic judgment through creation and reflection (Eisner, 2002). Schiller (2016) emphasized that aesthetic education is a bridge between emotional and rational development (Schiller, 2016). In this dimension, students move from direct perception to deep understanding and expression. They also share beauty through educational practice. This process not only enhances emotional ability but also strengthens social and ethical awareness. It marks the starting point of the integrative function of aesthetic education.

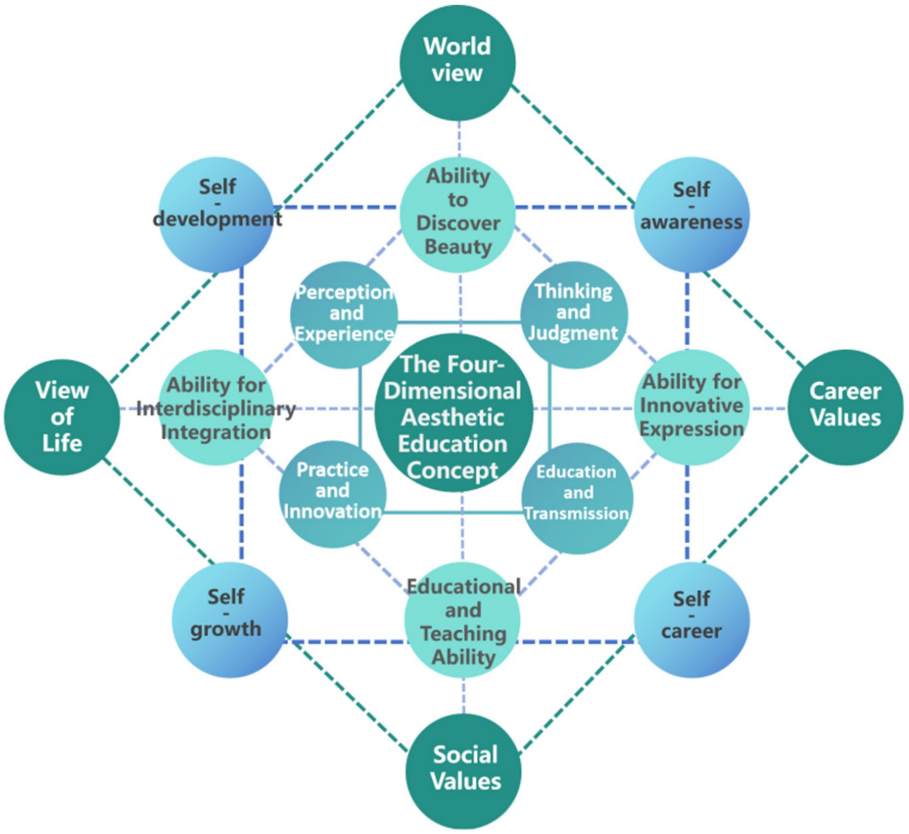


FIGURE 1
Four-dimensional aesthetic education framework diagram.

#### 3.1.1.2 Second dimension: integrated mechanism for developing core aesthetic competencies

This dimension focuses on the core competencies developed through aesthetic education practices. These include the ability to perceive beauty, the ability to express ideas creatively, teaching competence, and the ability to integrate knowledge across disciplines. It is based on the theory of multiple intelligences (Gardner, 1993), which suggests that aesthetic education is not only a form of artistic expression but also a process that integrates different types of intelligence, such as visual–spatial, linguistic, interpersonal, and intrapersonal (Cavas and Cavas, 2020). Ross (2015) argues that the development of aesthetic competence should include critical thinking, so that students can reflect on and recreate the beauty they perceive.

In addition, interdisciplinary teaching theory suggests that aesthetic education is an important space for promoting subject integration and knowledge transformation (Cohen et al., 2024; Kaynar and Kurnaz, 2024). Through project-based learning and experiential learning, students gradually develop a chain of teaching competencies that includes expression, guidance, design, and transfer (Almulla, 2020; Balleisen et al., 2024). Greene (1995) pointed out that the value of arts education lies in "releasing the imagination," helping students generate meaning and explore values within social and cultural contexts (Greene, 1995). This dimension builds on the practical path developed in the first dimension. It continues the aesthetic experience and transforms it into applicable teaching competencies and integrated literacy. It serves as a key foundation for future primary school teachers to develop professional teaching competence.

#### 3.1.1.3 Third dimension: transformative process from aesthetic experience to self-construction

The third dimension focuses on the role of aesthetic education in students' self-understanding, identity formation, and development of professional identity. It is based on humanistic educational thought (Maslow, 2023; Rogers and Freiberg, 1994) and developmental psychology theories on identity (Erikson, 1968). Aesthetic learning not only enhances students' ability to perceive and express beauty, but also serves as an important resource for understanding their emotions, values, and future directions (Feigenbaum, 2024).

Arts education has a unique advantage in stimulating learners' intrinsic motivation and building a positive sense of self (Muzyka et al., 2021). At the same time, the key to teachers' professional growth lies in using artistic expression and reflection to continuously shape self-awareness and educational beliefs (Jónsdóttir, 2017). Under the 4DAE framework, the individual growth dimension follows the emotional and ability-based development emphasized in the first two dimensions. It focuses on helping students internalize aesthetic experience as a source of personal meaning. In this way, it supports the developmental goal of becoming one's full self.

#### 3.1.1.4 Fourth dimension: the value construction mechanism from aesthetic ethics to social responsibility

The fourth dimension focuses on the deep connection between aesthetics and ethics. It argues that aesthetic education helps individuals grow in values, social awareness, and cultural identity. The global education policy of UNESCO (2024) emphasizes that education should cultivate learners with "global awareness" and a "sense of responsibility for sustainable development." Arts education is seen as a key way to achieve this goal. Kymlicka (1995) points out that in multicultural societies, education should help students build an open and inclusive public ethic (Kymlicka, 1995). Kohlberg's (1981) theory of moral development also shows that value formation is a process that gradually moves from emotional empathy to social responsibility (Kohlberg and Hersh, 1977). In this dimension, arts education not only shapes students' aesthetic taste but also serves as an awakening process for public ethics and professional responsibility. Its ultimate goal is to guide students from being "aesthetic subjects" to becoming "practitioners of values," who take on the responsibility to transmit, create, and defend beauty in society.

In summary, the "Four-Dimensional Aesthetic Education" framework starts with cognitive development, centers on ability building, follows the path of individual growth, and aims at value orientation. It forms a spiral and step-by-step educational structure. This framework not only addresses the core needs of aesthetic education in elementary teacher education under the context of sustainable development but also provides a comprehensive, open, and generative model for the development of future teachers' aesthetic abilities.

## 3.2 Implementation framework of the Four-Dimensional Aesthetic Education (4DAE) framework in the fine arts course

This course is guided by the Four-Dimensional Aesthetic Education (4DAE) framework and systematically reorganizes the fine arts course for elementary education majors. The overall course structure is divided into three modules: "Aesthetic Drawing and Feeling," "Aesthetic Enlightenment," and "Aesthetic Education." These correspond to the three core tasks of "Discovering Beauty," "Design Thinking Training," and "Practical Aesthetic Thinking." The course cultivates students' four-dimensional aesthetic abilities step by step Figure 2.

### 3.2.1 The "Aesthetic Drawing and Feeling" module (first and second dimensions)

The Aesthetic Drawing and Feeling module focuses on the first dimension of perception and experience, and through basic design training, involves the second dimension of creative expression. This module targets first-year students and emphasizes cultivating their aesthetic perception ability. It helps them discover and understand the diversity of beauty in daily life. Students learn that beauty is not only found in artworks but is also closely related to the harmony between humans and nature. This builds a systematic cognitive framework of beauty. The course content covers exploration of fine arts (features and functions) and aesthetic perception (aesthetics and self). It develops students' awareness and responsibility for sustainable beauty, guiding them to pay attention to the aesthetic elements in themselves and their

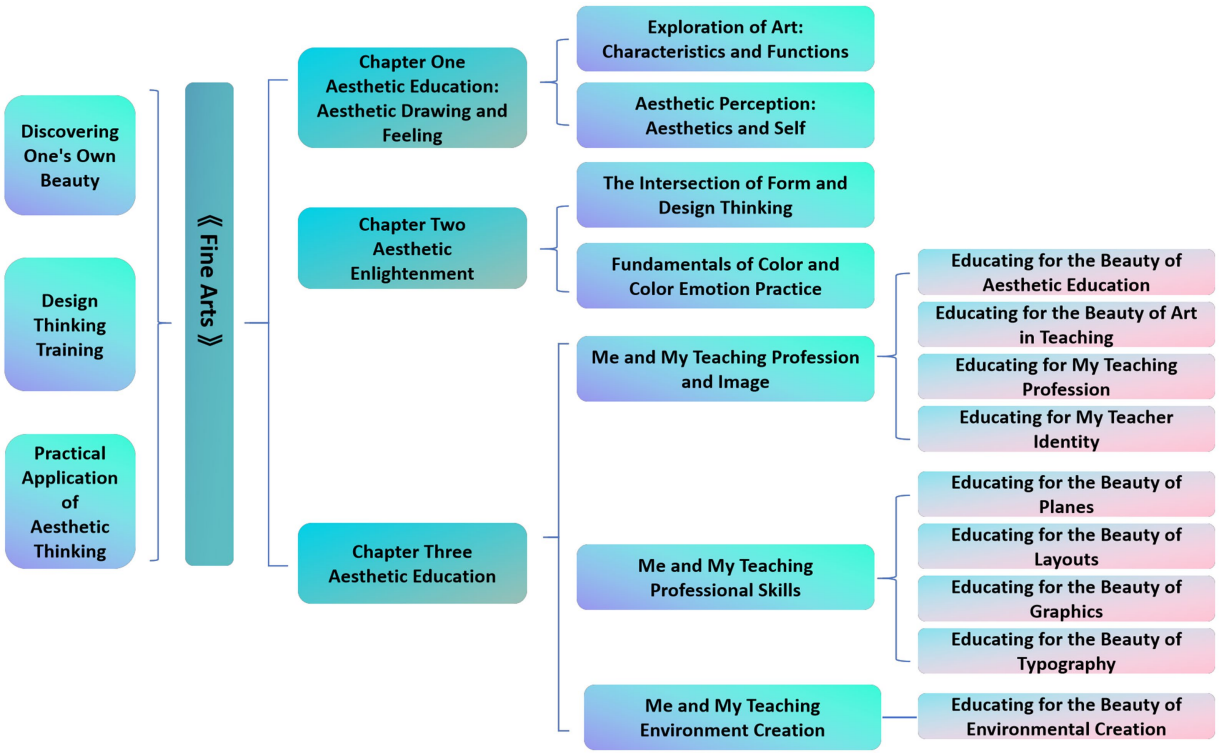


FIGURE 2
The overall framework for the implementation of the "art" course.

surroundings. This helps to make up for the lack of aesthetic education during exam-focused schooling.

### 3.2.2 The "Aesthetic Enlightenment" module (first and second dimensions)

This module combines design thinking training and focuses on developing students' innovation skills. The course covers the intersection of form and design thinking, as well as the basics of color and color emotion practice. Through creative form-making and color expression, it expands students' visual thinking and creative abilities. While mastering basic art skills, students also develop awareness and the ability to act for sustainable development as future elementary school teachers.

### 3.2.3 The "Aesthetic Education" module (second, third, and fourth dimensions)

The Aesthetic Education module fully develops the third dimension's focus on self-growth and teacher professional awareness. It also extends to the fourth dimension's value construction and educational transmission abilities. This module responds to the practical needs of elementary art education and centers on the "My Teacher and I" series to achieve integrated implementation of the course themes (see Figure 3). By deepening students' understanding of the teaching profession through the series "My Teacher and I: Professional Identity," "My Teacher and I: Professional Skills," and "My Teacher and I: Environment Creation," the module ultimately focuses on individual students. It helps students form sustainable reflection on self-awareness, self-growth, self-development, and self-career. This process gradually promotes the improvement and maturity of personal values, social values, and professional values, encouraging students to grow and progress continuously in their teaching practice.

The overall course framework focuses on the interdisciplinary integration of fine arts education. It uses design thinking training and comprehensive creative tasks to guide students to incorporate knowledge from different subjects into their teaching. This approach makes fine arts teaching not only about skill development but also about promoting students' interdisciplinary understanding and thinking. At the same time, the course content emphasizes students' independent exploration and creative thinking training. By combining case analysis, classroom practice, and other methods, it encourages students to continuously reflect on and improve their teaching strategies. This process injects the concept of sustainable development into future elementary teacher education.


FIGURE 3
"Me and my teacher" series structure diagram.

## 4 Methodology

### 4.1 Research design and objectives

This study involved 49 first-year students enrolled in the Primary Education program at a teacher training college in Jiangsu Province, China. The course lasted 12 weeks, with a total of 32 class hours. The aim was to evaluate the effectiveness of applying the Four-Dimensional Aesthetic Education (4DAE) framework in the Fine Arts curriculum. The focus was on changes in students' core competencies across the four dimensions before and after the course.

During data collection, the research team ensured that participants fully understood their rights. Students were clearly informed about the purpose, content, and confidentiality measures of the study. All participants joined voluntarily and were free to withdraw at any time without any negative impact on their academic performance or other rights.

To examine the statistical significance of changes in students' competencies before and after the course intervention, a normality test was first conducted for each dimension. The Shapiro–Wilk (S–W) test was used to determine whether the data followed a normal distribution. Based on the results, different statistical methods were applied: the paired-sample t-test was used for data with normal distribution, while the Wilcoxon signed-rank test was used for non-normal data. All analyses were performed using SPSS 26.0 to ensure the reliability and reproducibility of the results.

After the course ended, a course satisfaction survey was conducted to evaluate how well the course content, teaching methods, and instructional outcomes met students' learning needs. All collected data were analyzed through statistical methods to ensure the objectivity and validity of the findings.

### 4.2 Questionnaire design and validation

This study was based on the theoretical framework of Four-Dimensional Aesthetic Education (4DAE), which includes four key dimensions: perception and experience, reflection and judgment, practice and innovation, and education and transmission. A 12-week Fine Arts course intervention was designed and implemented for students in a primary education program, and a pre- and post-course paired questionnaire was developed focusing on the first dimension of the framework.

Although the 4DAE framework includes four interconnected developmental layers—core competencies, applied abilities, personal growth, and value orientation—this study was constrained by the short duration of the course (12 weeks), which limited the possibility of capturing the long-term development required for the second

TABLE 2 Questionnaire constructs and items in the pre-test and post-test phases of the art course.

| Pre-course | Post-course | Corresponding dimension |
|---|---|---|
| 1. I often read books or articles related to art, design, or aesthetics. | 1. Do you think your ability to perceive art works has improved through this course? | Perception and experience |
| 2. I enjoy finding elements of beauty in everyday life, such as appreciating natural scenery, architecture, or the design of everyday objects. | 2. During the course, have you paid more attention to the details of art works, such as color, shape, texture, etc.? | |
| 3. I like to share my appreciation of art and creative works on social media. | 3. Through the study of the art course, have you improved your understanding and experience of different forms of art (e.g., painting, sculpture, installation art, etc.)? | |
| 4. I am able to appreciate art in various styles and forms. | 4. Has this course helped you improve your critical thinking ability regarding art works? | Thinking and judgment |
| 5. I believe that works of art reflect the characteristics of society and culture. | 5. Are you able to independently think and judge the aesthetic value of art during the creation process? | |
| 6. I have a positive attitude toward artistic creation and believe that everyone has the potential to create. | 6. Through the study of this course, have you become more confident in expressing your views and evaluations of art phenomena? | |
| 7. I know how to use light and shadow effects to enhance the expressive power of an artwork. | 7. Has this course inspired innovative thinking in your art creation? | Practice and innovation |
| 8. I know how to use proportion and scale to control the visual effects in an artwork. | 8. Are you able to flexibly apply the art creation techniques learned in the course to your actual creations? | |
| 9. I know how to apply different color theories to create works with various emotional effects. | 9. In art creation, have you learned how to solve creative problems through design thinking? | |
| 10. I believe that art is of great importance to personal life. | 10. Do you think this course helped you understand the social function and responsibility of art education? | Education and transmission |
| 11. I believe that art can establish deeper emotional connections between people. | 11. Through this course, have you learned how to communicate art education concepts to others (such as students or peers)? | |
| 12. I believe that art is one of the most important forms of human emotional and spiritual expression. | 12. Are you able to apply art education concepts in future teaching to enhance students' aesthetic literacy and creativity? | |
| 13. I believe that artistic creation is a beneficial way of emotional release. | 13. Do you think this course has significantly helped you improve your aesthetic literacy and educational abilities? | |

(interdisciplinary integration), third (personal growth), and fourth (value construction) dimensions.

In addition, the participants were first-year students in a primary education program, who were still in the early stages of building teaching skills and educational perspectives. Therefore, focusing on the development of the first dimension was more practical and meaningful. Finally, this study aimed to examine observable cognitive, behavioral, and instructional outcomes, in order to provide empirical support for the application of the 4DAE framework.

In designing the questionnaire, the study used two sets of items with different wording but consistent dimensions, aimed at comparing student performance before and after the course. The pre-course questionnaire was based on students' high school learning background. During its development, special attention was given to students' prior exposure to the arts, to ensure that the questions matched their existing knowledge. This helped to gain a comprehensive understanding of their aesthetic awareness and cognitive abilities related to the four dimensions of the 4DAE framework before the course began.

The post-course questionnaire focused more on students' progress after the intervention. It emphasized reflection on course content, self-assessment of ability development, and the transfer of learned skills to future educational settings. The item design placed greater weight on applied ability and learning outcomes following the course (see Table 2).

The questionnaire used a 5-point Likert scale: "Strongly agree" scored 5 points, "Agree" 4 points, "Neutral" 3 points, "Disagree" 2 points, and "Strongly disagree" 1 point. By quantifying students' agreement levels on each dimension, statistical analysis compared students' abilities before and after the course to verify the course's impact on ability improvement.

To test the questionnaire's applicability and measurement quality under the "Four-Dimensional Aesthetic Education (4DAE)" framework, reliability and validity analyses were conducted separately for the pre-course and post-course questionnaires. The Cronbach's alpha coefficients were 0.867 (pre-course) and 0.933 (post-course), both above 0.8, indicating high internal consistency and reliability suitable for empirical educational research. The KMO values were 0.802 (pre-course) and 0.793 (post-course), meeting Kaiser's criterion, showing that the data were appropriate for factor analysis. The cumulative explained variances were 70.49 and 68.70%, both above 60%, demonstrating good structural validity and that the questionnaire effectively reflected the latent structures of the measured dimensions. Relevant data are shown in Table 3.

TABLE 3 Reliability and validity analysis of pre- and post-test questionnaires.

| Indicator | Pre-test | Post-test | Evaluation criteria |
|---|---|---|---|
| Sample size | 49 | 49 | ≥30 acceptable |
| Cronbach's $\alpha$ | 0.867 | 0.933 | >0.8 excellent reliability |
| KMO measure of sampling adequacy | 0.802 | 0.793 | >0.7 suitable for factor analysis |
| Cumulative variance explained (%) | 70.49% | 68.70% | >60% indicates good structural validity |

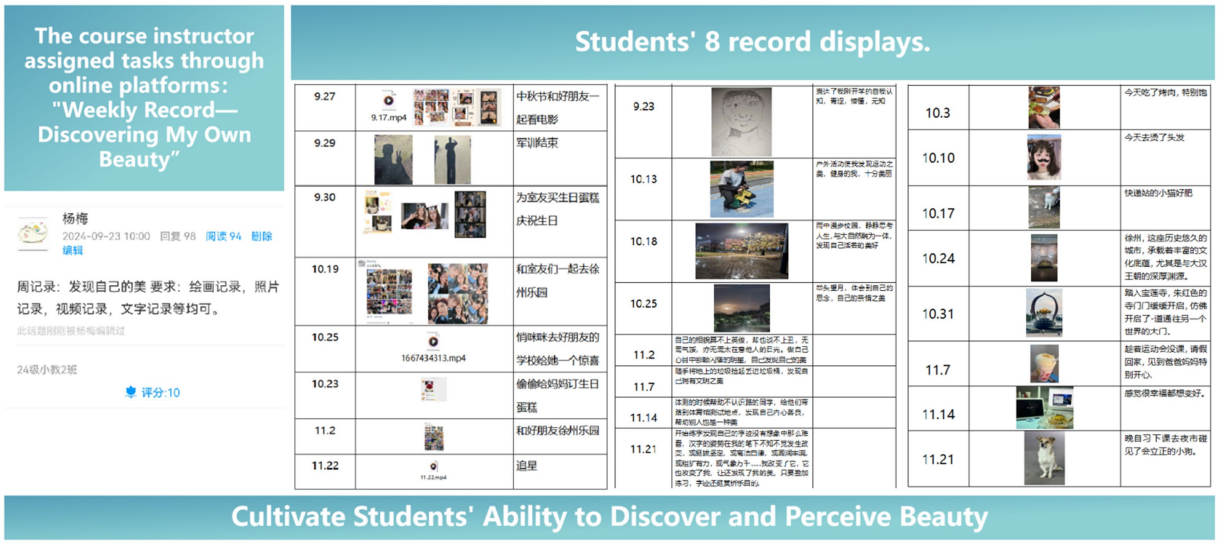


FIGURE 4
"Weekly record—discovering my own beauty" activity.

## 4.3 Instructional design based on the 4DAE framework

### 4.3.1 Instructional design for dimension one

The first dimension of the 4DAE framework emphasizes students' ability to perceive, understand, express, and communicate beauty in real-life contexts. It encourages the integration of aesthetic experience with ecological awareness and social responsibility, reflecting a multi-layered understanding of art education (Eisner, 2002).

The course includes the activity "Weekly Journal: Discovering Your Own Sense of Beauty," which guides students to complete eight aesthetic observations based on daily life. Students write short reflections to develop their perceptual and critical thinking abilities. They also present their experiences through drawing, photography, or writing, turning personal insights into collective sharing. This process reflects the goal of the "Education and Transmission" dimension. Compared to traditional art courses, this course places more focus on real-life settings and emotional engagement, aiming to enhance students' aesthetic literacy and awareness of sustainable values (Figure 4).

### 4.3.2 Instructional design for dimension two

The second dimension of the 4DAE framework focuses on enhancing students' artistic literacy and practical ability in interdisciplinary contexts. It highlights the use of design thinking and social issues to extend the application of artistic expression (Taşpınar, 2022).

The course includes a debate task on the topic "Does hand-copied poster work have educational value?" Students are guided to explore this topic from different perspectives such as art education, curriculum reform, and student development. They collect information, organize arguments, and connect their views with their understanding of primary education. This process helps them develop both teaching skills and artistic expression. Through a cycle of thinking, debating, reflecting, and transforming, students build their overall competence while linking personal expression to educational purpose. The activity supports the goal of sustainable development and reflects the value orientation of educational equity (Figure 5).

### 4.3.3 Third dimension teaching design

The third dimension focuses on students' self-awareness and professional growth. It emphasizes deepening understanding of personal potential and career positioning through art practice. This course centers on project-based learning, highlights students' active role, and combines hands-on activities with systematic thinking training to implement the "learning by doing" approach.

In the "Modeling and Design Thinking Interaction" unit, students complete a brainstorming task where they propose innovative uses for everyday objects. Through multiple rounds of discussion and revision, they improve divergent thinking, collaboration, and creativity. The course also guides students to integrate sustainable development ideas

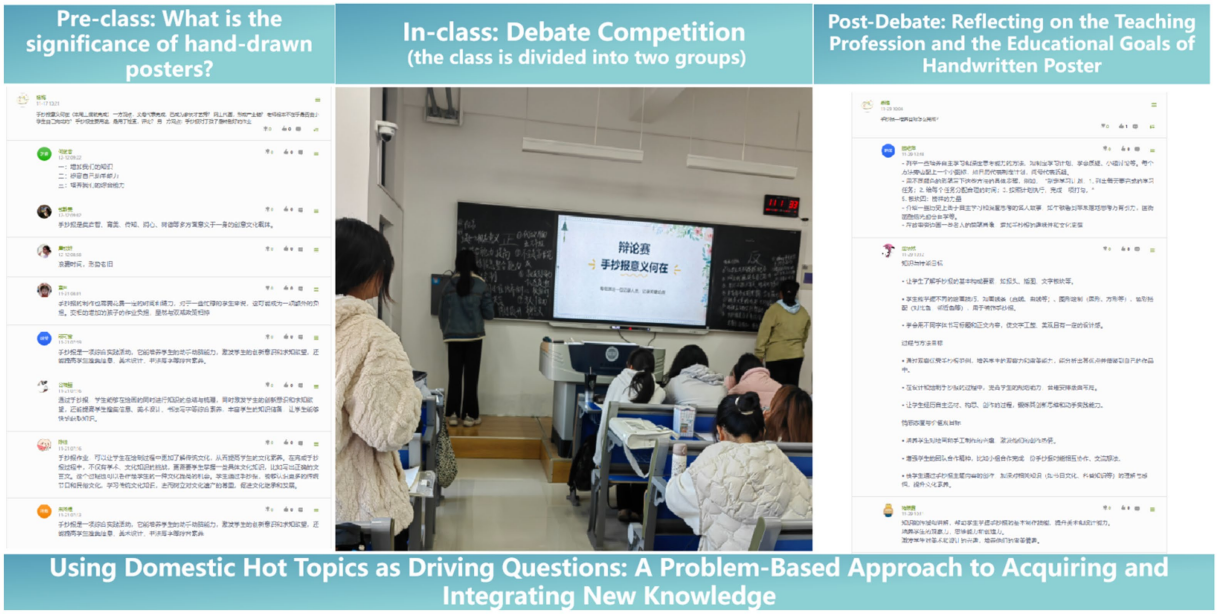


FIGURE 5
Designing lesson activities with driving questions.


FIGURE 6
Project-based learning model—design thinking training.

into their practice, such as redesigning with discarded materials and creating eco-friendly art projects. These connect art skills with elementary teaching, producing creative and environmentally conscious teaching activities (Figure 6).

The course not only enhances students' artistic innovation and teaching adaptability but also encourages self-reflection to clarify their future roles as educators. It motivates them to guide children in understanding the relationship between humans and nature, art and

the environment, cultivating awareness of sustainable education and educational innovation. This helps students shift from "learning to teach" to "teaching to appreciate beauty." This process reflects the internal mechanism of art teacher identity formation. Through reflective practice in educational settings, students gradually build a stable and value-oriented sense of professional identity (Muzyka et al., 2021).

### 4.3.4 Teaching design of the fourth dimension

The fourth dimension focuses on the development of students' values. It emphasizes their responsibility in future education to transmit culture and guide values. This dimension leads students to combine artistic aesthetics with ecological ethics and social care, cultivating future teachers with awareness of sustainable development.

The course centers on the "Me and My Teacher" project. It integrates simple drawing training with creative design of elementary school teaching materials. Using mind maps and interdisciplinary association, it stimulates students' value reflection. In the creative process, students pay attention not only to visual expression but also to how to guide children to understand the ethical relationships between humans, nature, and society. This shows the value education function of aesthetic education.

The course establishes a multiple evaluation system combining self-assessment, peer review, and teacher evaluation. It encourages students to reflect and give feedback on aesthetics, education, and values. At the same time, extended assignments require students to redesign teaching content from the perspective of future teachers, thinking about how to cultivate children's ecological awareness, aesthetic judgment, and social responsibility through art lessons (Figure 7).

## 4.4 Data analysis methods

To ensure the scientific rigor and accuracy of data analysis, this study used the Shapiro–Wilk (S-W) test to examine the normality of data distribution across the four dimensions, suitable for sample sizes less than 50. The results showed that "Thinking and Judgment" ($p = 0.065$), "Practice and Innovation" ($p = 0.271$), and "Education and Transmission" ($p = 0.341$) did not violate the assumption of normal distribution ($p > 0.05$). Therefore, parametric statistical methods were applied to these dimensions. However, the $p$-value for the "Perception and Experience" dimension was 0.04, which is below the significance level of 0.05 (Table 4). This indicated a non-normal distribution, requiring the use of non-parametric statistical methods for analysis. Based on the normality test results, appropriate statistical methods were selected according to the data distribution. For the dimensions of "Thinking and Judgment," "Practice and Innovation," and "Education and Transmission," which met the normality assumption, a paired sample t-test was conducted to assess changes in students' abilities before and after the course. The hypotheses were set as follows:

> *Null hypothesis ($H_0$):* There is no significant difference in students' ability scores in this dimension before and after the course.

> *Alternative hypothesis ($H_1$):* There is a significant difference in students' ability scores in this dimension before and after the course.

For the "Perception and Experience" dimension, which did not follow a normal distribution, the Wilcoxon signed-rank test was used. This ensured the robustness and accuracy of the statistical analysis. Through these methods, this study aimed to objectively evaluate the course's impact on students' ability development and verify the achievement of the course design goals.

### 4.4.1 Paired sample t-test analysis

To further examine the impact of the course on students' ability development, this study conducted paired sample t-tests on three dimensions—"Thinking and Judgment," "Practice and Innovation," and "Education and Transmission"—which met the normality assumption. The results are as follows (Table 5).

Dimension of Thinking and Judgment: Before the course, the mean score for this dimension was $M = 12.88$, with a standard deviation of SD = 1.628. After the course, the mean score increased to $M = 14.43$, with a standard deviation of SD = 1.061. The paired sample t-test results showed $t = -5.801$, $p = 0.000$ ($p < 0.05$), indicating a statistically significant difference between pre- and post-course scores. These results suggest that the course had a significant positive effect on improving students' critical thinking and judgment skills. Therefore, the null hypothesis ($H_0$) is rejected, and the alternative hypothesis ($H_1$) is accepted.

Dimension of Practice and Innovation: Before the course, the mean score for this dimension was $M = 9.39$, with a standard deviation of SD = 2.216. After the course, the mean score significantly increased to $M = 14.24$, with a standard deviation of SD = 1.217. The paired sample t-test results showed $t = -13.046$, $p = 0.000$ ($p < 0.05$), indicating a statistically significant difference between pre- and post-course scores. These findings reveal that the course effectively stimulated students' creative potential through artistic creation and practical activities, promoting the transformation of theoretical knowledge into practical skills. Therefore, the null hypothesis ($H_0$) is rejected, and the alternative hypothesis ($H_1$) is accepted.

Dimension of Education and Communication: Before the course, the mean score for this dimension was $M = 17.98$, with a standard deviation of SD = 2.046. After the course, the mean score increased to $M = 19.12$, with a standard deviation of SD = 1.467. The paired sample t-test results showed $t = -2.988$, $p = 0.004$ ($p < 0.05$), indicating a statistically significant intervention effect of the course. These results suggest that the course positively impacted students' educational and communication skills, contributing to the enhancement of their teaching abilities. Therefore, the null hypothesis ($H_0$) is rejected, and the alternative hypothesis ($H_1$) is accepted.

In summary, the results of the paired sample t-tests support the alternative hypothesis ($H_1$), showing that there were significant differences in students' ability scores across the "Thinking and Judgment," "Practice and Innovation," and "Education and Transmission" dimensions before and after the course. This confirms that the course had a positive impact on developing students' key competencies in these areas.

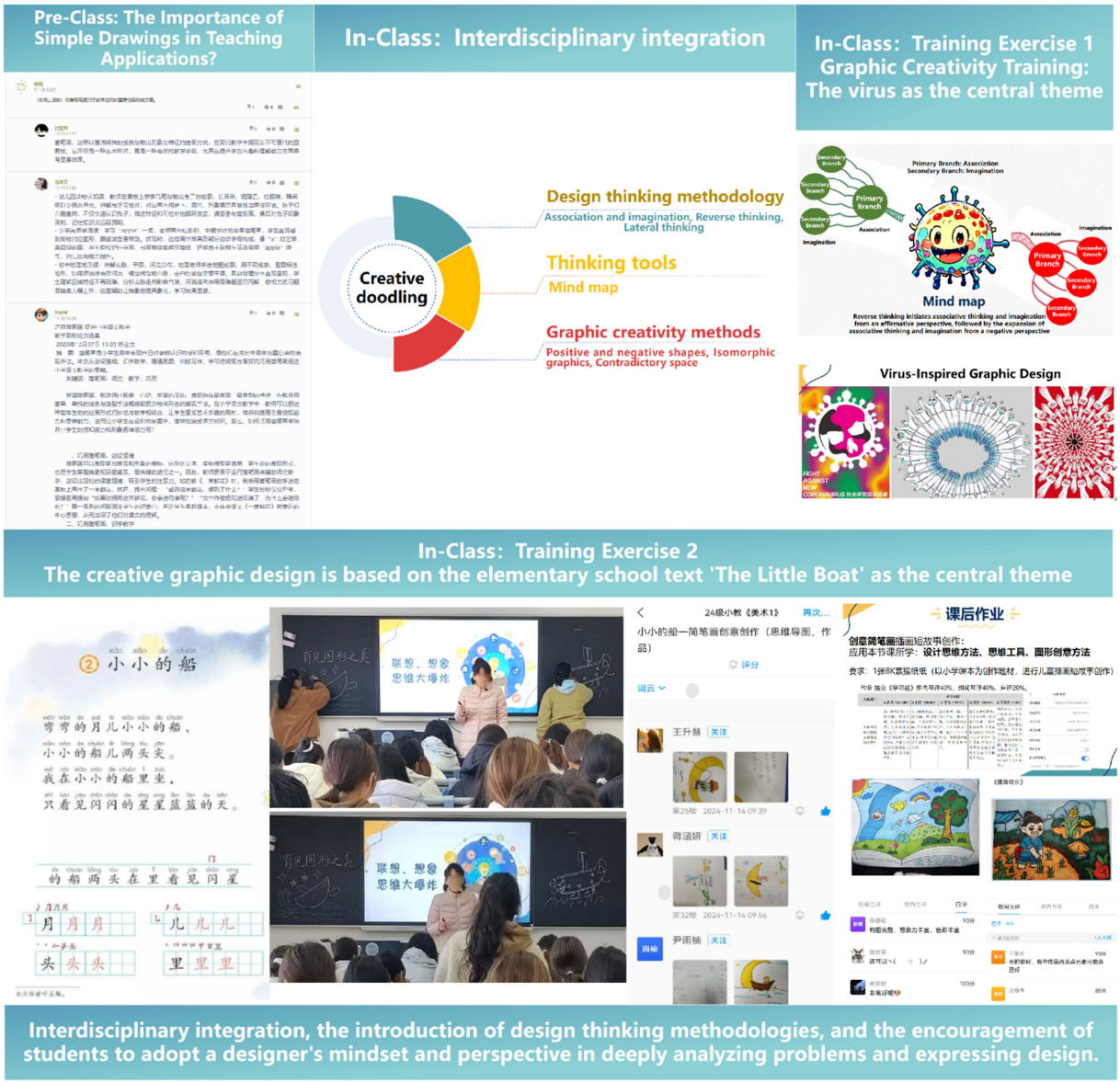


FIGURE 7
Design of multidisciplinary integration project activities based on design thinking.

TABLE 4 Test of normality.

| Group | Shapiro–Wilk (S–W) | | |
|---|---|---|---|
| | Statistics | Degrees of freedom | *p* |
| Perception and experience | 0.926 | 49 | 0.004 |
| Thinking and judgment | 0.956 | 49 | 0.065 |
| Practice and innovation | 0.971 | 49 | 0.271 |
| Education and transmission | 0.974 | 49 | 0.341 |

TABLE 5 Paired sample t-test analysis.

| Group | *N* | M ± SD (before) | M ± SD (after) | *T* | *p* |
|---|---|---|---|---|---|
| Thinking and judgment | 49 | 12.88 ± 1.628 | 14.43 ± 1.061 | −5.801 | 0.000 |
| Practice and innovation | 49 | 9.39 ± 2.216 | 14.24 ± 1.217 | −13.046 | 0.000 |
| Education and transmission | 49 | 17.98 ± 2.046 | 19.12 ± 1.467 | −2.988 | 0.004 |

### 4.4.2 Wilcoxon signed-rank test analysis

To further examine the impact of the course on students' "Dimension1" abilities, this study employed the Wilcoxon signed-rank test. This non-parametric test is suitable for data that do not meet the assumption of normal distribution and effectively evaluates differences in paired sample medians.

The Wilcoxon signed-rank test results showed $z = -6.053$, $p = 0.000$ ($p < 0.05$), indicating a significant difference in students' abilities in this dimension before and after the course. Further analysis of the median and interquartile range (P25, P75) revealed that the pre-course median was $M = 11$ (P25 = 9, P75 = 12), while the post-course median increased to $M = 15$ (P25 = 15, P75 = 15). These results suggest that students' "Dimension1" abilities improved significantly by the end of the course (Table 6).

## 4.5 Course satisfaction survey

Based on the post-course questionnaire survey, the main feedback data are as follows: Students showed a high level of satisfaction with the course content, teaching methods, and classroom interaction. They also fully acknowledged the course's positive impact on their professional skills. These results indicate the effectiveness and success of the course reform. However, there is still room for improvement in teaching resources and the overall course experience (Table 7).

# 5 Discussion and conclusion

## 5.1 Theoretical reflections and educational significance

This study applies the Four-Dimensional Aesthetic Education (4DAE) Framework to explore its practical pathways and educational outcomes in aesthetic education for primary education majors. Through a 12-week empirical study, the feasibility and effectiveness of the framework were initially confirmed. The data show that students in the experimental group significantly improved in core competencies, including aesthetic perception, critical thinking, creative expression, and educational communication ($p < 0.05$). The satisfaction survey also showed that students highly valued the course in terms of content design, interaction, and professional development. These results suggest that the framework responds well to the growing educational demand for integrated competencies, value formation, and interdisciplinary learning.

The findings address three key issues: (1) The 4DAE framework is both practical and systematic in guiding curriculum design and implementation; (2) The course structure successfully integrates four dimensions—perceptual experience, critical thinking, practical innovation, and educational transmission—forming a pathway that balances skill development and value cultivation; (3) Student feedback shows the framework aligns with their professional learning needs, encouraging active participation and fostering value recognition.

## 5.2 Implementation challenges and coping strategies

### 5.2.1 Challenge 1: structural tension between instructional time and teaching scope

The 4DAE framework sets multidimensional and in-depth learning goals, which place higher demands on curriculum structure and implementation. However, the art course is limited to only 32 class hours, which is not enough to support spiral and progressive cognitive development. This may lead to fragmented teaching (Biggs, 1996; Bruner, 2009). To address this issue, the research team adopted a "theme integration + project task cluster" model. Based on project-based learning (Almulla, 2020) and experiential learning theory (Passarelli and Kolb, 2023), the design embeds multiple dimensions into real-life tasks. In addition, extended assignments such as learning portfolios and independent research increase the flexibility of learning and deepen reflective engagement.

TABLE 6 Test statistic[a].

| Group | *N* | *M* (P25, P75) | *Z* | *p* |
|---|---|---|---|---|
| Before | 49 | 11 (9, 12) | −6.053[b] | 0.000 |
| After | 49 | 15 (15, 15) | | |

[a]Wilcoxon signed-rank test.
[b]Based on negative ranks.

TABLE 7 Course satisfaction survey.

| Title | Satisfaction | Neutral | Score |
|---|---|---|---|
| 1. How satisfied are you with the course content this semester? | 100% | 0% | 4.9 |
| 2. Do you think the course content aligns with the needs of your major? | 100% | 0% | 4.7 |
| 3. Are you satisfied with the teacher's teaching methods? | 100% | 0% | 4.8 |
| 4. Do you think the interaction in the class is sufficient? | 100% | 0% | 4.8 |
| 5. Do you think this course has helped improve your professional skills? | 90.0% | 10.0% | 4.7 |
| 6. How satisfied are you with the teaching and auxiliary resources provided for the course? | 90.0% | 10.0% | 4.7 |
| 7. How satisfied are you with the overall art course this semester? | 90.0% | 10.0% | 4.7 |

### 5.2.2 Challenge 2: limited student understanding of aesthetic and sustainability education

Many pre-service teachers enter the course with a skill-oriented mindset. They often lack a deep understanding of the cultural and social values of aesthetic education, which limits their engagement in the dimensions of critical thinking and creativity (Eisner, 2002; Kymlicka, 1995). To respond to this challenge, the course uses guided observation and reflective journaling to help students connect with beauty in everyday life. These activities support emotional engagement and value formation through experience (Dewey, 1934). In addition, structured tasks such as group co-creation and educational debates strengthen students' understanding of the relationships among art, society, ecology, and education (Freire, 2012). This supports a step-by-step pathway for developing aesthetic awareness (Bruner, 2009).

### 5.2.3 Challenge 3: difficulty in building the value dimension within a short-term course

The 4DAE framework emphasizes the development of students' life views, worldviews, and professional values. It aims to guide students from being aesthetic learners to becoming value practitioners who can carry the responsibility of expressing, creating, and defending beauty in society. However, the course in this study lasted only 12 weeks. Although the four core dimensions were included in the design, the limited time made it difficult to support the long-term understanding and internalization of the value dimension.

To address this challenge, the research team designed a "staged value-building pathway." This included three steps—cognitive awareness, value reflection, and educational practice—within the course's three main modules. It also introduced tasks such as "professional role simulation" and "future teacher identity reflection" to help students form an initial interest in teaching and a basic sense of professional identity. This strategy is in line with Vygotsky and Cole's (1978) theory of the zone of proximal development, which emphasizes a dynamic balance between teacher support and student internalization (Vygotsky and Cole, 1978).

Since the short course duration limited the development of the value dimension, it is recommended that teacher education programs embed the 4DAE framework into the full process of "coursework–internship–reflection–research." This approach can help form a continuous professional development chain that includes cognitive growth, skill formation, and value internalization (Sutamrin et al., 2022), allowing for sustained transmission and deepening of educational ideals.

## 5.3 Theoretical extension and educational implications

In recent years, educational research has gradually shifted from skill-based art instruction to a competency-oriented model that focuses on integrated development (Hee Lee and Shvetsova, 2019). This shift highlights the role of arts education in promoting creativity, critical thinking, and social engagement (Lukaka, 2023). However, most existing studies focus on a single connection, such as between curriculum and technology or between curriculum and theory. For example, some research explores the integration of art education with digital tools (Bian, 2021; Stoll et al., 2022; Palmer and Elkin Postila, 2024; Shiri and Baigutov, 2024), while others focus on linking art education with interdisciplinary theories (Lee et al., 2025). These studies often lack a systematic approach to combining multiple educational goals and methods.

The 4DAE framework responds to these gaps. It draws on ideas from project-based learning (Illeris, 2017), contextual teaching (Krasovska et al., 2020), and education for sustainable development (Molderez and Ceulemans, 2018), and integrates them into a coherent and localized model. This study shows that the 4DAE framework not only focuses on knowledge and skill development but also supports the formation of students' values and their sense of social responsibility. It aligns closely with the goals of education for sustainable development (ESD).

At the level of life values, the framework encourages students to engage in self-reflection and self-understanding through course tasks, such as the "Me and My Teacher" series, helping them build positive values and develop interest in education. At the level of social values, it promotes attention to social issues and enhances students' sense of public responsibility as future educators. At the level of professional values, it strengthens students' identification with the teaching profession and supports their growth into responsible teachers.

This study provides two main implications for curriculum development and education policy. First, it offers a replicable structure for curriculum reform in teacher education, shifting the focus from "art skill training" to the combined development of aesthetic literacy and teaching competence. Second, the practical logic and outcomes of the 4DAE framework provide empirical support for including arts education in teacher qualification training. This supports a policy-level redefinition of the role of arts education in basic education.

## 5.4 Limitations and future directions

This study has theoretical and practical value, but several limitations need to be addressed in future research: (1) the sample size was small ($N = 49$) and came from a single institution, which limits the external validity of the findings (Hennink et al., 2020). (2) The short intervention period made it difficult to capture deeper developments in personal growth and value formation (Orosz et al., 2017). (3) The data relied mainly on self-reported student questionnaires, which may lead to subjective bias (Nilsen, 2020). (4) The course was delivered by the researcher, which may have caused a researcher effect that influenced the neutrality of the results (Berger, 2015).

To reduce these biases, future studies could take the following approaches. (1) Mixed-method research could be used, combining classroom observation, interviews, and teaching portfolios to improve reliability (Berger, 2015). (2) Control groups and delayed post-tests could be included to strengthen causal inference (Orosz et al., 2017). (3) Sampling across multiple institutions could improve generalizability and representativeness (Nilsen, 2020). (4) Longer intervention periods and longitudinal follow-up could be used to observe students' dynamic development in each dimension over time.

In conclusion, this study provides preliminary evidence for the potential of the "4D Aesthetic Education" (4DAE) framework to integrate competence-based education, value development, and sustainability goals in higher education. The teaching model constructed in this study expands the theoretical landscape of art education and offers empirical support for improving aesthetic literacy and promoting curriculum transformation in primary teacher

education. Future research could further explore the application of this framework in interdisciplinary and cross-level educational contexts, helping transform the 4DAE concept into a sustainable system of teaching practice.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

## Ethics statement

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Xuzhou First People's Hospital, the affiliated hospital of China University of Mining and Technology (Protocol code xyy11[2025]056, approved on March 21, 2025). Written informed consent from the participants or participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

## Author contributions

MY: Writing – review & editing, Methodology, Investigation, Formal analysis, Supervision, Software, Writing – original draft, Validation, Resources, Data curation, Conceptualization, Visualization. JZ: Writing – review & editing, Supervision. WY: Supervision, Writing – review & editing. YY: Supervision, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

## Publisher's note



## Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2025.1601869/full#supplementary-material

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