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Reflections of STEAM Education Concept on Art and Design Education in the Context of Digitalization

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Abstract: In the context of the digital age, this paper discusses the thoughts of STEAM education concept (science, technology, engineering, art, mathematics) on the reform of the teaching system in the field of art and design education. The reflection of STEAM education concept on art and design education can be carried out in two aspects. The first aspect is the core value of the discipline of art and design in STEAM education in terms of interdisciplinary integration, especially the importance of design thinking in interdisciplinary education. On the other hand, the STEAM education concept reflects the system construction of art and design education in cultivating interdisciplinary talents. Faced with the challenge of digitalization, art and design education urgently needs to update its teaching strategy and content. Through the combination of art and science, art and technology, art and project, and art and mathematics, a comprehensive interdisciplinary learning platform has been built, aiming to cultivate future talents with innovative consciousness and improve comprehensive quality.

Keywords: STEAM education; Art design; Design thinking; Interdisciplinary learning

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1. Introduction

The rise of the era of Industry 5.0 marks a new era of digital transformation, the core goal of which is to strengthen a closer collaborative relationship between humans and machines [1]. At the core of this philosophy is the concept of "human-centered" design by providing customized products and services to meet the specific needs of each person [2]. The vision of Industry 5.0 is to combine the innovative thinking of humans with the high efficiency and accuracy of intelligent machines to achieve this goal [3]. In this theoretical framework, the collaboration between man and machine is not just a symbol of the transformation of the manufacturing industry, but it also integrates the capabilities and technologies of individuals, thereby enhancing the competitiveness of the entire industry and its workforce. It should be noted that the core goal of Industry 5.0 is not to replace human resources but to enhance the integrated value of human expertise and technology [3]. Huang *et al.* pointed out that our ultimate goal is to stimulate the spirit of innovation in the industrial sector and

promote its development in a more people-oriented, adaptive, and sustainable direction [4].

In the face of the rise of Industry 5.0, a new concept of "Education 5.0" has also been proposed in the field of education, which aims to integrate digital technology with human social-emotional skills to improve overall well-being [5,6]. Education 5.0 differentiates itself from Education 4.0, which focuses primarily on technical competence and knowledge, by going beyond the boundaries of technology and placing people at the center of educational activities [7]. It focuses on developing competencies such as communication skills, leadership, determination, curiosity, understanding, critical thinking, and innovative thinking, etc. [8]. This development represents a potential opportunity to enhance welfare and social achievement in the context of digital transformation. To be an outstanding educator and learner in the Education 5.0 society, one must not only have excellent digital knowledge and innovative thinking but must also be able to meet the multiple needs of learners.

In the context of the digital age, the education sector is undergoing an unprecedented transformation, where the integration of digital technologies is not only changing the way teaching and learning are done, but also promoting the development of interdisciplinary education models, and STEAM education is an outstanding representative of this. Through the integration of science, technology, engineering, art, and mathematics, STEAM education aims to cultivate students' innovative abilities and comprehensive literacy [9]. At the same time, art and design courses, as an important means to cultivate students' creativity and aesthetic ability, also face the need for restructuring in the digital environment. The integration of STEAM education concept and art design courses can not only promote the mutual penetration of disciplines and the comprehensive application of knowledge but also provide a richer and more diverse learning experience. However, how to effectively implement this integration model to better serve the educational goals and meet the needs of students is an urgent problem to be solved at present.

2. STEAM education concept

STEAM education, or the interdisciplinary education model of Science, Technology, Engineering, Arts, and Mathematics, was first proposed at the Art-National Policy Roundtable in America in 2007, responding to a pressing need to upgrade students' interests and skills in the fields of science, technology, engineering, and mathematics (STEM) [10-12]. STEAM education grew out of STEM education, which focused on integrated instruction in the four fields of science, technology, engineering, and mathematics. Compared to STEM, STEAM education expands the scope of instruction, not only exploring the same scientific concepts but also enabling the application of knowledge through creative processes, inquiry, and problem-based learning methods. Through the inclusion of the arts, STEAM education further emphasizes the importance of interdisciplinary learning and aims to foster student engagement, innovative thinking, and problem-solving skills [13].

Industry-supported programs such as the 21st Century Skills (21CM) Accelerator program demonstrate the importance of STEAM education in developing "21st-century skills" such as teamwork, communication, and adaptability [14]. The study notes that practitioners of STEM education should embrace the arts to promote creative design and expressiveness in students. Arts education not only correlates expression with emotional arousal, but also stimulates imagination, breaks the mold, promotes open-mindedness, and enhances emotional awareness [15,16]. The arts provide a platform for students and teachers to express, communicate, create, imagine, observe, perceive, and think, and are an important part of the development of cognitive skills, including listening, thinking, problem-solving, matching form to function, and decision-making [17].

3. The role of art and design majors in STEAM education

The integration of the arts not only injects new elements into STEAM education but also provides opportunities to cultivate innovative thinking talents in the future by promoting interdisciplinary talent cultivation and combining them with emerging fields such as engineering and medicine. The integration of STEAM education with art and design courses is based on the concept of interdisciplinary education, with the aim of breaking the boundaries of disciplines and promoting the integrated application of knowledge and skills. This integration has been widely used in educational practices at all levels of educational institutions, proving its effectiveness in improving students' ability to innovate, think critically, and work in teams [9,18].

The integration of the arts is considered key to stimulating divergent thinking and innovative thinking, which are essential for the innovative needs of the 21st century. However, there are inconsistencies and conceptual ambiguities in the education community regarding the definition of the "A" in STEAM education. The definition of "art" in STEAM has been interpreted in a variety of ways, including understanding art as a specific form of visual art, aesthetic literacy, broadly encompassing various arts and humanities disciplines, etc., or even as a synonym for project-based learning, technology-based learning, or design-based learning [12]. This conceptual confusion creates further challenges in practice, especially for educators from non-arts backgrounds, where finding effective strategies to integrate the arts into the curriculum can be challenging [20]. At the same time, the integration of art and technology in subjects dominated by science and engineering also faces challenges, as students are often used to projects that fit the traditional scientific definition and are uncomfortable with incorporating artistic elements [21].

In recent years, non-arts educators have struggled to find strategies to reintroduce the arts to enhance students' creativity and innovative thinking in STEM programs [20]. The role of the arts in enhancing cognitive skills such as spatial reasoning, abstract thinking, divergent thinking, creative self-efficacy, openness to experience, and curiosity has been widely recognized [15,16,22]. Design thinking as a method of creative problem-solving[23], aligns with the goal of STEAM education , which is to develop students' creativity and real-world problem-solving skills through participation in STEAM learning.

In STEAM education, the use of design thinking is not only feasible, it is a very critical method. Rooted in constructivist learning theory, it uses a carefully planned process to motivate learners to embrace uncertainty and encourage them to let go of the pursuit of only absolute answers in favor of deductive reasoning about incomplete answers [24]. This teaching strategy not only helps students to analyze and think deeply and internalize knowledge and perspectives, but also attaches particular importance to the development of communication and cooperation skills with teams, which are indispensable elements in the constructivist educational perspective. In the teaching mode of STEAM, the importance of problem definition in daily life is first clarified, followed by the cultivation of problem-solving strategies and methods of teamwork to complete challenges [25,26]. Design thinking emphasizes that the focus should be on meeting the needs of users, encouraging learners to actively listen to and use the information they gained, while conducting in-depth discussions and exchanges within the team, building a more complete knowledge system and further expanding its development potential through collective efforts, so as to solve the problems of users' needs. Therefore, the integration of design thinking into STEAM education not only shows the great possibilities of the integration of art and science, but also successfully promotes the integration and application of interdisciplinary knowledge, thus injecting a strong impetus into the training of innovative talents.

By adopting design thinking, educators can encourage students to engage in more real-world practices, deepen their understanding of STEM fields, and stimulate their innovation and creativity [27]. The application of design thinking, such as through the combination of environmental education and science education, has

been proven to be effective in fostering innovative thinking, creativity, and problem-solving skills in students [28]. Further research, such as that of Guaman-Quintanilla *et al.* discussed the positive effects of implementing design thinking courses in higher education settings on enhancing first-year students' problem-solving and creative skills [29]. Ananda *et al.*, by combining design thinking with STEAM Project-Based Learning (PBL) and applying it to the reoxidation-reduction process of chemistry, has effectively developed students' critical thinking skills, as well as the competencies needed in the 21st century. Design thinking is seen as a pedagogical framework that promotes students' participation in designing and solving real-life human-centered problems [30]. Studies have found that when students engage in design-based STEAM learning, they experience a significant boost in creative confidence. Possaghi further explored the application of combining design thinking (DT) with emerging technologies (ET) in computer science, demonstrating the potential of innovative teaching as it approaches STEAM disciplines [31]. Meanwhile, Kijima and Sun inspired the next generation of female youth to take an interest in the fields of Science, Technology, Engineering, Art, and Mathematics (STEAM) by applying design thinking, demonstrating that design thinking not only increases students' interest in the fields of STEAM, but also enhances their creative confidence, empathy, and sense of collaboration [32].

Thus, by applying design thinking, not only can the attractiveness of STEM courses be significantly enhanced, but it can also effectively strengthen students' key 21st-century skills such as innovative thinking, critical thinking, and teamwork. This means that art and design are not just a useful complement to STEAM education, they are a critical part of STEAM education and play a vital role in nurturing innovative talent.

4. Reflection on STEAM education concept on art and design education

In recent years, the acceleration of globalization and technological change has made social issues increasingly complex and pluralistic [33,34]. Art and design education, as an important field for cultivating innovative talents, has shown unprecedented vitality and challenges. With the rapid development of science and technology, art and design education not only needs to update its teaching content, but also needs to actively integrate emerging digital technologies in order to cultivate subject knowledge, skills, and ways of thinking, such as creativity, adaptability, and empathy [32,35,36]. However, in the process of this transformation, art and design education is facing many challenges, including the disconnect between traditional teaching methods and contemporary technological developments, the failure of educational models to adapt to market demands [37], and the weakness of practical teaching [38]. In the face of these challenges, STEAM's educational concept brings us a whole new way of thinking. STEAM education emphasizes the interdisciplinary integration between science, technology, engineering, art, and mathematics, offering a new perspective on the innovation and development of art and design education.

4.1. Improving the depth and breadth of teaching through the integration of art and science

The integration of art and science in teaching can not only broaden students' knowledge horizons, but also improve the depth and breadth of teaching. Mr. Chung-dao Lee, a famous scientist, once likened art and science to two sides of a coin, arguing that "their relationship is closely related to the duality of wisdom and emotion" [39]. With its intuitive and emotional qualities, art can make abstract scientific concepts more vivid and easy to understand. At the same time, the rigor of science also brings new perspectives and means to artistic creation, further promoting the growth of innovative thinking. For example, through the application of the Tyson polygon principle in the field of interior design [40], such as the School of Social Sciences of National Taiwan University designed by Toyo Ito (**Figure 1**), a series of regular spirals and the ceiling shape and the water cube (**Figure 2**) were generated using the Tyson polygon algorithm through cross-evolution. Therefore,

the integration of art and science not only helps to cultivate students' innovative ability and critical thinking, but also promotes the integration of interdisciplinary knowledge to provide students with a more comprehensive education.

Figure 1. College of Social Sciences, National Taiwan University

Figure 2. Water cube

4.2. Enhancing the ability to use digital technology to solve problems through the integration of art and technology

With the continuous progress of digital technology, the combination of technology and art has gradually become an indispensable and important part of art and design education. The development of technology provides new means and platforms for the creation and expression of art, such as virtual reality (VR), augmented reality (AR), and generative artificial intelligence (AIGC). By mastering these advanced digital technologies, students can not only express their creativity more freely, but also overcome the challenges faced by traditional art creation and improve efficiency [41,42]. In addition, the adoption of technology can help students to interpret artistic creation more deeply, while developing their critical thinking and aesthetic judgment skills. The combination

of art and technology not only enhances students' skills in solving practical problems, but also opens up new horizons and approaches for art and design professional education.

4.3. Strengthening students' ability to transform their theoretical knowledge into practice through the integration of art and projects

Project-based teaching methods can effectively transform theoretical knowledge into practical skills [43]. Students can solve practical problems by combining art with practical projects and applying their acquired knowledge in real or simulated project environments. For example, in the studio teaching mode, teachers will lead students to participate in actual project design or design competitions. This teaching strategy based on project cooperation not only encourages students to complete the design task together, but also encourages them to create works with both innovative thinking and practical application value. Lv *et al.* pointed out that this process not only helps students better understand the connection between professional knowledge and market needs, but also significantly improves their skills in practical operation, teamwork, and project management [44]. Therefore, integrating art education with practical projects can not only improve students' multifaceted abilities in an all-round way, but also lay a solid foundation for their future career path.

4.4. Exploring the logic and aesthetic principles in art education and improving the comprehensive teaching quality through the integration of art and mathematics

Mathematics plays a vital role in the creation of art, not only giving precise proportion and structure, but also helping students to deeply understand the spatial relationships and the beauty of form in works of art. Taking "Geometry of Art and Design" as an example, drawing techniques that apply geometry not only effectively separate spaces but also accurately show the size, proportion, and order of design elements [45]. In addition, the introduction of mathematical concepts such as the golden ratio and the principle of symmetry can guide students to explore and understand the various forms of beauty in design theory, such as harmony, balance, and rhythm. In this way, students applying mathematical principles in design practice can not only create harmonious and beautiful works, but also significantly improve their logical thinking and problem-solving skills. More importantly, this combination of art and mathematics not only improves the aesthetic quality of design works, but also deepens students' understanding of aesthetic laws in design and promotes the deep understanding and application of design aesthetics.

5. Summary

The educational philosophy of STEAM emphasizes integration and cooperation between different disciplines, which is essential for talent cultivation in the field of art and design. This paper analyzed the main problems existing in the art and design major of Chinese universities and the necessity and urgency of interdisciplinary talent training. Through the combination of art and science, technology, engineering, and mathematics, it not only provides interdisciplinary learning opportunities for art and design students, but also lays a solid foundation for their innovative thinking and problem-solving skills in the future society. In view of the current state of art and design education and the challenges it is facing, the cultivation of interdisciplinary talents in art and design majors requires the joint efforts of educational decision-makers, school administrators, teachers, and all sectors of society to discover more inclusive and forward-looking educational models to promote the innovation and development of art and design education.

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