

**COMPARATIVE STUDY OF THE DIGITAL  
GAMES-BASED LEARNING FOR ART AMONG  
COLLEGE SCIENCE AND ENGINEERING  
STUDENTS IN NINGXIA PROVINCE, CHINA**

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**UNIVERSITI SAINS MALAYSIA**

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by

**ZHOU SIBO**

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## LIST OF SYMBOLS

$\alpha$	Cronbach's alpha
p	Probability value
r	Pearson's correlation coefficient
$\omega$	Omega
KMO	Kaiser-Meyer-Olkin
KR-20	Kuder-Richardson Formula 20
$\Sigma$	Summation of all
M	Mean
SD	Standard Deviation
n	Sample size
N	Population size
$\chi^2$	The chi-squared
$\rho$	Correlation coefficient
t	t-value
H	Hypothesis
c	Total effect of the independent variable
a	Independent variable
b	Dependent variable
a*b(z)	The direct effect of a on b
a*b(p)	Mediated effect
Bootstrap CI	Confidence interval
F	F-test
Sig	Statistically significant
Cohen's d	Effect size
Kappa	Intra-rate Reliability

## LIST OF ABBREVIATIONS

AC	Abstract Conceptualisation
AE	Active Experimentation
ANCOVA	Analysis of Covariance
AR	Augmented Reality
CE	Concrete Experience
DBAE	Discipline based art education model
DDE	Game Experience-based Model
DGBL	Digital Game Base Learning
EDG	Educational Digital Games
EG	Easy Gaming
ELT	Experiential Learning Theory
EQ	Emotional Intelligence
EVG	Educational Video Games
GA&E	Game Amusement & Entertainment
GBL	Game Base Learning
GDE	Game deeply experience
GDSS	Gaming deeply Sensory stimulation
GMC	Goals, Motivations, Conflicts Model
GPS	Gameplay, Purpose, and Scope
HCI	Human-Computer Interaction
ICC	Intraclass correlation coefficients
IDE	Interdisciplinary Education
LASSI	Learning Motivation and Learning Strategies Inventory
MDA	Mechanical, Dynamic, and Aesthetic
MOE	Ministry of Education of the People's Republic of China

MOE	Ministry of Education of China
MR	Mixed Reality
NCGAS	New Computer Games Attitude Scale
NCGCUPAC	National General Colleges and Universities Public Art. Curriculum Guidance
NPC	Non-Player Character
NSF	National Science Foundation
PLE	Playful Learning Environment
PRC	People's Republic of China newspaper
RO	Reflective Observation
RPG	Role-Playing Game
SECT	Science and Engineering College Students
SG	Serious games
STEAM①	Science, Technology, Engineering, Art and Mathematics
STEAM②	A Digital Gaming Platform
STEM	Science, Technology, Engineering and Mathematics
VAIAK	Vienna Art Interest and Art Knowledge Questionnaire
VR	Virtual Reality
VS	Virtual Society

## **LIST OF APPENDICES**

- Appendix A Survey of Art Interest, Art history, Aesthetic, Art production & Art criticism
- Appendix B Survey of Game Interest, Game Sense, Emotion & Game Competencies Attitude towards Educational Digital Games
- Appendix C Informed Consent
- Appendix D Informed Consent Form for Quasi-Experimental Study

**KAJIAN PERBANDINGAN PEMBELAJARAN SENI BERASASKAN  
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KEJURUTERAAN DI WILAYAH NINGXIA, CHINA**

**ABSTRAK**

Pada masa ini, pendidikan seni antara disiplin semakin mendapat perhatian di China kerana ia membantu membangunkan kognisi kreatif, keupayaan menyelesaikan masalah, dan kebolehsuaian pelajar terhadap perubahan masyarakat pada masa hadapan. Pembelajaran berasaskan permainan digital (DGBL) dianggap sebagai alat yang berkesan untuk pengajaran dan melibatkan pelajar, yang biasanya menggunakan teknik naratif dan latihan pemikiran kritikal serta kompetitif untuk menarik perhatian pelajar dan menggalakkan penyertaan aktif. Walau bagaimanapun, terdapat sedikit kajian mengenai aplikasi DGBL dalam pendidikan seni. Oleh itu, kajian ini menyiasat minat terhadap seni, pembelajaran seni, dan kompetensi pembelajaran lain yang diperoleh dalam kalangan pelajar kolej sains dan kejuruteraan di Ningxia, China, melalui penggunaan DGBL. Penyelidikan ini menggunakan pendekatan kaedah campuran yang terdiri daripada empat komponen: (a) Tinjauan menggunakan persampelan bertujuan (n=407) untuk menilai tahap pengetahuan seni dan penglibatan permainan digital dalam kalangan pelajar; (b) Kaedah kuasi-eksperimen menggunakan persampelan kuota (n=40) untuk menilai kebolehlaksanaan dan keberkesanan permainan digital dalam pengajaran pengetahuan seni dan meningkatkan minat; (c) Temu bual (n=20) membincangkan kompetensi pembelajaran tambahan yang diperoleh oleh pelajar sains dan kejuruteraan melalui permainan pendidikan digital dalam persekitaran bilik darjah; dan (d) Latihan rangkaian neural untuk membangunkan model pembelajaran

berasaskan permainan digital untuk pendidikan seni. Hasil kajian mengesahkan bahawa pelajar sains dan kejuruteraan secara umumnya mempunyai tahap pengetahuan seni yang lebih rendah tetapi menunjukkan kebiasaan dengan pembelajaran berasaskan permainan digital. Tambahan pula, kajian ini menunjukkan bahawa pembelajaran seni melalui permainan digital dapat meningkatkan pengetahuan seni mereka dengan berkesan (Cohen's  $d = 1.7174$ ) dan secara signifikan meningkatkan minat mereka terhadap seni (Cohen's  $d \approx 4.337$ ). Selain itu, kajian ini mencadangkan bahawa pembelajaran seni berasaskan permainan digital boleh membantu mereka memperoleh kompetensi pembelajaran penting lain, termasuk peningkatan kemahiran pengurusan diri, peningkatan pengalaman pembelajaran, dan pembangunan kemahiran proprioseptif. Kompetensi ini juga menyumbang kepada pemupukan imaginasi dan kreativiti, yang dapat meningkatkan potensi mereka dalam bidang sains dan kejuruteraan. Akhirnya, model pembelajaran seni berasaskan permainan digital yang dicadangkan dalam kajian ini menawarkan pandangan berharga untuk aplikasi akademik dan industri dan dapat membantu pendidik dalam meramalkan dan menilai kemajuan pelajar dalam pembelajaran seni.

**COMPARATIVE STUDY OF THE DIGITAL GAMES-BASED LEARNING  
FOR ART AMONG COLLEGE SCIENCE AND ENGINEERING STUDENTS  
IN NINGXIA PROVINCE, CHINA**

**ABSTRACT**

Currently, interdisciplinary arts education is receiving increasing attention in China, as it helps develop students' creative cognition, problem-solving abilities, and adaptability to future societal changes. Digital game-based learning (DGBL) is considered an effective tool for teaching and engaging students, typically employing narrative techniques and exercises in critical and competitive thinking to captivate students and encourage active participation. However, there has been little research on the application of DGBL in arts education. Therefore, this study investigates the interest in art, art learning, and other acquired learning competencies among science and engineering college students in Ningxia, China, through the use of DGBL. This research employs a mixed-methods approach, consisting of four components: (a) A survey using purposive sampling (n=407) to assess students' levels of art knowledge and digital game engagement; (b) A quasi-experimental method using quota sampling (n=40) to evaluate the feasibility and effectiveness of digital games in teaching art knowledge and enhancing interest; (c) Interviews (n=20) discussing the additional learning competencies gained by science and engineering students through digital educational games in the classroom environment; and (d) Neural network training to develop an art educational digital game-based learning model. The findings confirm that science and engineering students generally have lower levels of art knowledge but demonstrate a familiarity with digital game-based learning. Furthermore, the study shows that art learning through digital games can effectively

enhance their art knowledge (Cohen's  $d = 1.7174$ ) and significantly increase their interest in art (Cohen's  $d \approx 4.337$ ). Additionally, the study suggests that digital game-based art learning can help them acquire other essential learning competencies, including the enhancement of self-management skills, improvement in learning experience, and development of proprioceptive skills. These competencies also contribute to fostering imagination and creativity, which can increase their potential in science and engineering fields. Finally, the digital game-based art learning model proposed in this study offers valuable insights for academic and industry applications and can assist educators in predicting and assessing learners' progress in art learning.

# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

In China, higher education is particularly focused on technical and skills-oriented teaching, especially in science and engineering education (XNA, 2023, Sep; China Education News (CED), 2024a). However, this standardisation-focused approach to education has largely neglected the development of students' creativity, innovation and artistic literacy (Zhou, 2024). This educational limitation is gradually becoming problematic, resulting in students' lack of critical soft skills such as creative thinking, critical thinking, soft skills and problem solving (Pollard et al., 2017; Mozgalova et al., 2021; Sirajudin et al., 2021).

Interdisciplinary education has been shown to foster innovative thinking and adaptability in students (Wang et al., 2022). Estrada & Graham (2021) claim that the strategy of integrating art into the curriculum can effectively support the connection between different disciplines, making art not only a tool for learning, but also a way to integrate knowledge. By integrating the arts into STEM education, students can be helped to develop critical and collaborative skills in a richer learning environment. For example, STEM education also refers to the interdisciplinary combination of individual STEM disciplines (Li et al., 2020). By integrating arts education into science and engineering education, STEAM education can inspire students. Integrating arts with STEM subjects can improve student engagement, creativity, innovation, problem-solving skills, and other cognitive advantages (Hetland & Winner, 2004; Liao, 2016; NAEA, 2016; Root-Bernstein, 2015; Perignat & Katz-Buonincontro, 2019). The importance of interdisciplinary education research lies in

the fact that it explores a new model of interdisciplinary education that helps to cultivate interdisciplinary talents with both technical ability and creativity. Perignat and Katz-Buonincontro (2019) claim that there is a lack of knowledge about art history and diversity, and that knowledge of art production is often overshadowed by an emphasis on the end result or product. There is an overall lack of measurable learning outcomes in enhancing creativity, problem solving and arts education.

With the development of science and technology, digital games have gradually become an important leisure activity for students, and their application in the field of education has attracted more and more attention (Gros, 2007; Yang et al., 2012). As an educational tool, Digital Game-based Learning (DGBL) is used in management (Yang, 2015; Hoyng, 2022), Finance (Carenys et al., 2017), language learning (Zheng, 2012), and healthcare (Frøland, 2022; Erhel, 2013) and other fields have achieved remarkable results. However, in the field of art education, DGBL has relatively little exploration (Yang, 2015). DGBL uses narrative, problem solving, and competitive elements to stimulate learning interest and engagement (Cagiltay, 2007; Gee, 2003). Research shows that it can promote cognitive development, enhance learning motivation and broaden attention (McFarlane et al., 2002). The purpose of this study is to explore the application of digital games in interdisciplinary art education, so as to enhance students' interest in art and learning efficiency, and thus enhance the creativity and innovation ability of science and engineering students.

Science and engineering students often lack art education background (Cao, 2023; Tutt,2014), which can limit their development in understanding technical symbols, images, innovative abilities, and imagination (Anis Rahmawati, 2017; Georgina Barton,2019; Gurnon et al., 2013), which reflects their lack of artistic and literary literacy, will also hinder technical learning.

The introduction of art education through digital games helps to stimulate these students' artistic interest and enhance their creative thinking. The importance of the study is that it provides a new way for science and engineering students to develop artistic literacy while studying technology, so as to achieve a more well-rounded development. Izadi (2017) claims that integrating arts education with science education can increase students' engagement and understanding, thereby creating a richer learning experience. Tallman (2013) claims that the boundary between science and art can be eliminated in the integration of the two disciplines. Integrating visual arts into a science curriculum can enhance students' scientific imagination and attract students who are less interested in science, thereby increasing scientific understanding (Gurnon et al., 2013). Turkka et al. (2017) proposed a teaching model for integrating art in science teaching, advocating an integrated approach based on content and activities to enhance students' scientific expression and creativity.

Finally, the digital games enhance the learning process by promoting visualization, experimentation, and creativity (Behnamnia et al., 2020), which aligns with art education. This study aims to explore the application of digital games in interdisciplinary science, engineering and art education to enhance college students' interest and efficiency in art learning. This consequently helps in fostering their creativity, innovation and soft skills in science and engineering. Furthermore, the research will also discuss other learning abilities that learners acquire through art educational digital games. Finally, based on the experience characteristics of educational digital games, namely play and learning, the study will develop a model. Based on Kolb's experiential learning theory, this model explains the process of

college students' art learning from digital games base learning through three "experience learning cycles.

## **1.2 Research Background**

### **1.2.1 Interdisciplinary Education**

Interdisciplinary education is becoming increasingly important in today's society because it can nurture students' innovative thinking, problem-solving abilities, and adaptability to future societal changes. For example, a study by the National Science Foundation (NSF) in the United States suggests that students who receive interdisciplinary education perform better in innovation compared to those who receive traditional education. Interdisciplinarity (IDE) is believed to lead to higher innovation rates (Vogel et al., 2013). Interdisciplinary education (IDE) involves integrating knowledge and methods from different disciplines to address complex problems or propose novel solutions. Interdisciplinary education can cultivate students' innovative thinking (Khan & Wells, 2023), problem-solving abilities (Kim, Kim, 2016), and adaptability to future societal changes (Roucher & Lovano-Kerr, 1995).

In recent years, with the advancement of the economy and technology, interdisciplinary education has gained increasing attention. Many countries' higher education systems prioritize interdisciplinary education and holistic learning, such as the United States (Roucher & Lovano-Kerr, 1995; Eagan et al., 2002), South Korea (Kim & Kim, 2016), Germany (Cook & Furstenberg, 2017), Canada (Khan & Wells, 2023), among others. Additionally, these countries' institutions offer a wealth of interdisciplinary courses and programs. The United States is considered a representative country that emphasizes the integration of STEM (Science,

Technology, Engineering, and Mathematics) and the arts as well as interdisciplinary education. Korean scholars have proposed an interdisciplinary theory known as STEAM, which focuses on the development of multiple dimensions including mathematics and the arts (Kim & Park, 2012). On the other hand, interdisciplinarity contributes to solving today's complex problems because it is believed that interdisciplinary approaches aid in comprehensive understanding (Morcol, 2006). This belief has led to increased interest in interdisciplinary higher education over the years (Spelt et al., 2009). In contrast to traditional higher education, which focuses on domain-specific knowledge and general skill development, this form of higher education also aims to develop cross-cutting skills. Cross-cutting skills include changing perspectives, synthesizing knowledge from different disciplines, and dealing with complexity. Some German universities offer interdisciplinary programs in science and the arts, encouraging students to venture into different fields (Spelt et al., 2009).

### **1.2.2 Art Education**

Arts education develops students' aesthetic, creativity (Belluigi, 2009) and expressive skills. These abilities are also important for science and engineering undergraduates, as they could help them to better understand and solve problems (Spuzic et al., 2016; Timo Jokela & Maria Huhmarniemi, 2018). For example, a study showed that students with arts education performed better in problem solving than those without arts education. In terms of art education, according to Barkan (1962), art is no longer taught by a series of strict exercises. Based on literature, art refers as free expression, where everyone can learn to express. While spontaneity is the key and art experience are very valuable for development, art education is to

teach all mankind. Similarly, digital games focus on improving/enhancing college science and engineering students' experience, interest, and environment. From the existing researches, digital games not only have made constructive progress in attracting interest or participation (Bartle, 1996), it also contributes to stimulating positive emotion (Yan, 2014); enhancing learning application (Deubel, 2006), and improving teaching strategies (McFarlane et al., 2002). Moreover, art education, based on experience such as game experience, could be more effectively capturing learners' attention. As Knight (2001) argues, Western higher education programs are increasingly focused on complex learning outcomes and the development of 'soft skills', interpersonal skills, emotional intelligence, creativity, critical thinking, and reflective skills. Meanwhile, "The 'Future Jobs Report' has elevated the importance of 'creativity' to the third position from 2020 (Caratozzolo et al., 2019) (Table 1.1). Caratozzolo et al. (2019) argue that activities related to art criticism and aesthetic judgement could enhance creative thinking. In other words, engineering students need to develop creative thinking skills in order to acquire the ability to innovate, respond to risks and integrate perspectives.

Table 1.1 Ranking changes in skills needed in the workplace over the last 5 years

<b>Top 10 Skills in</b>	
<b>2020</b>	<b>2015</b>
1 Complex Problem Solving	Complex Problem solving
2 Critical Thinking	Coordinating with Others
<b>3 Creativity</b>	People Management
4 People Management	Critical Thinking
5 Coordinating with Others	Negotiation
6 Emotional Intelligence	Quality Control
7 Judgment & Decision Making	Service Orientation
8 Service Orientation	Judgment & Decision Making
9 Negotiation	Active Listening
10 Cognitive Flexibility	<b>Creativity</b>

**Source:** Future of Jobs Reports, see in Caratozzolo et al. (2019)

Barton et al. (2015) stressed that education is adopting more creative ways, using games, especially simulation, to achieve greater learning outcomes more effectively. As Parks (2008) reminds us that the teaching method of reconstructionism leads to meaningful and transformative education. In this way, students need to realize that art exists in culture. However, when the acting and simulation of the virtual society (VS) convey information to the experiencer (students), the experience has already happened. This being a convenient way to help students learning and thinking about the art within the world around him in different ways. Van Lier (2004) reports that the art education curriculum shall emphasize on generating students' interest and providing learning experience, particularly the contextual and quality-driven experience based on the purpose of the learning activity. Quality-driven experiences, such as cultivating the appreciation of art, music, and sports, are in fact the source of human inspiration and desire.

However, the art education in China focuses more on the standardized production of art. This standardized approach to art education limits students' creativity, responsiveness, and critical thinking. The limited exposure to all relevant aspects of art results in an inadequate art education, leading to an incomplete understanding and appreciation of the subject. In that case, digital games for art education may be one of the effective ways to foster student's interest in art learning. This study research digital games as tools to help students in higher education regain interest in arts learning.

### **1.2.3 Digital Game (Serious Games) and DGBL**

#### **1.2.3(a) Digital Game (Serious Games)**

The development of digital games is growing very rapidly. The STEAM is a digital platform developed and designed by the inventor Bram Cohen. It is currently one of the world's largest comprehensive digital game publishing platforms. Players can buy, download, discuss, upload and share games and software on STEAM. There are about 30000 games available on STEAM. According to STEAM platform, in China, the number of users in the digital game market has reached 660 million. Chinese digital game players are mainly young people (China Game Industry Report 2022). Ding and Li (2021) claimed that 98% of vocational college students have played games in Jiangsu Province. The game industry provides transformative tools that meet the learning needs of digital-native students, supporting both cognitive and experiential growth through interactive platforms.

Students are now mostly skilful in using smart phones and computers in China. Most of them use internet and play digital games very frequently. In addition, the price of virtual reality equipment has been reduced. More colleges are affordable to set up virtual equipment in classrooms as the supporting hardware for e-learning. This has also laid the foundation for digital education and digital game-based learning, as the widespread availability of equipment has brought about practical technical convenience. Digital games have become a new form of educational tools. Many digital educational games are used in different education levels for teaching different fields of knowledge. This study explores digital games for interdisciplinary education, exploring how art education digital games help in attracting and engaging

science and engineering college students to get interested into learning and understanding art.

Educational digital games are also called serious games (SG). "Serious games" (SG) is a concept proposed by Abt in 1987. Serious games are defined as games with a clear and thoughtful educational purpose, which are designed not just for entertainment (Abt, 1987). Nevertheless, this does not mean serious games should not be entertaining.

As mentioned by Duke (2014):

*"Games are the language of the future. A new form of communication has suddenly appeared, which has had a huge impact in many places and in many problem situations."* (Duke, 2014, P.3)

One of the earliest pioneers in the field of educational digital games (EDGs) is Papert (1993), who was a mathematician and computer scientist that aspire to adopt and apply technology to transform education. In his book, "Mindstorms: Children, Computers, and Powerful Ideas," Papert introduced the 1980 concept of the Logo programming language, which was designed to teach children about programming and problem-solving. Logo was used to develop some of the earliest EDGs, such as Turtle Graphics and Terrapin LOGO.

In terms of educational game data, Metaari (2019) released the "2019-2024 Global Education Game Market Research Report," which highlights that game-based learning has become mainstream. According to the report, related products and services are expected to experience a five-year compound annual growth rate (CAGR) of 33.2%. By 2024, revenue is projected to increase more than fourfold, exceeding \$24 billion. These statistics underscore the high engagement of young people with

digital games, illustrating the potential for educational games to capture student interest and foster deeper learning in subjects like art.

The game industry has significantly influenced educational practices by providing engaging tools that support interactive and experiential learning. With technological advancements and the popularity of digital games among young people, the industry now plays a critical role in enhancing educational methods and fostering digital literacy.

### **1.2.3(b) Developing of Digital Game-Based Learning**

The concept of DGBL is credited to Mark Prensky (2001). Prensky (2001) argued that games are a powerful tool for learning and can be used to teach a variety of subjects and skills. Subsequently, researchers conducted research from the aspects of instructional design, digital game design, game history, experience, and the application of serious games. Meanwhile more and more researchers have explored the value and educational effects of serious games from different aspects of serious games. Among the existing research, digital games are applied for educational subjects, such as second language (Zheng, 2012), management (Yang, 2015; Höyng, 2022), finance (Carenys et al., 2017), and medical health (Frøland, 2022; Erhel, 2013). Meanwhile, some scholars research on the aspects of participants'/players' reaction, cognition, emotion, etc. For example, in terms of stimulating interest, Panoutsopoulos and Sampson (2012) research claims that learning through digital games can attract and motivate people at all ages. In terms of experience, the "Flow" theory of Csikszentmihalyi (1975) is widely used to explain the digital gameplay experience. Akinsola and Animasahun (2007) claimed that digital games are a teaching tool while educational digital games create a unique learning environment.

In terms of cognition and motivation, many researchers have pointed out that digital games can influence learning by influencing cognitive process, motivation, and forming social evaluation (Felicia, 2009; Wilson, 2009; Baker, 2010; Emin-Martinez & Ney, 2013). This study explores how to teach art knowledge using digital games, which are becoming very attractive to students in today's digital era.

During the COVID-19 pandemic, the adoption of digital games in education has rapidly developed in China (Ding & Li, 2021). Universities or higher learning institutions have actively applied digital approach in teaching and learning, through video games, E-learning and others. Gradually, digital or virtual education has become a practical option or solution towards effective teaching and learning. China's digitization development is rapid. Today, everyone could easily access to Internet in most areas of China. Colleges are mostly well equipped with updated computer lab and internet infrastructure. Besides study the E-learning content, scholars research how students learn (Downes, 2005), looking into Digital Game-based Learning (DGBL) or Game-based Learning (GBL). More researchers are focusing on learning engagement (Cagiltay, 2007; Gee, 2003; Liu & Lin, 2009) and learning efficiency in DGBL (Connolly et. al., 2012). Although both DGBL and e-learning are educational tools based on digital systems, DGBL is more oriented towards the understanding and depth of learning content, whereas E-learning is more oriented towards the transmission and delivery of learning content (i.e. the establishment of learning channels) (Khan & Joshi, 2006). Therefore, DGBL focuses more on the depth and understanding of learning.

Meanwhile, many researchers have attempted to integrate computer games into school curricula to improve learning outcomes (Lee & Cheng, 2009; Deng, Wu, & Chen & Peng, 2020) because DGBL combines educational and entertaining

elements. DGBL often uses storytelling, problem-solving, and competitive elements to engage learners and maintain their participation (Cagiltay, 2007; Gee, 2003; Liu & Lin, 2009). Furthermore, researchers are no longer satisfied with merely exploring learning efficiency. They also interested in other educational outcomes obtained during the digital gameplay process, such as promoting cognitive development (Rebetez, 2007), stimulating learning motivation (Liu & Lin, 2009), and broadening students' attention breadth and depth (McFarlane, Sparrowhawk, & Heald, 2002). Researchers also began to focus on theoretical discussions in the gaming field (Li & Tsai, 2013). Li and Tsai's research claims that cognitive and constructivist theories have long been the primary theoretical foundations for game-based learning. However, behaviourism and sociocultural perspectives are gradually gaining scholars' attention, becoming emerging theoretical paradigms. This suggests that people have gained a deeper understanding of the effectiveness of digital games in promoting scientific knowledge and conceptual learning. Some started to emphasize various dimensions of outcomes such as problem-solving skills, emotions, engagement, and social context learning. This implies that DGBL is constantly evolving as a more effective learning method to learners. For example, "Minecraft Edu" is an educational version based on the game "Minecraft," which allows students to build and explore various historical events and geographic concepts in a virtual environment. By interacting with the game, students not only enhance their geographical knowledge but also develop teamwork and problem-solving skills. Additionally, "ASTRA" is a digital game related to medical health, enabling students to learn about healthcare knowledge. "Monopoly" is a frequently used and referenced digital game in the field of finance, helping students learn about financial concepts. "Starry Knight" is a digital game focused on art history, aiming to assist participants

in learning and experiencing the artworks and experiences of Vincent van Gogh. Commercial digital games such as "Second Life" and "Papers, please" are also explored as educational tools for discussing applications in humanities subjects. These examples highlight the diverse applications of digital games in education and their positive impact on disseminating disciplinary knowledge.

Digital games not only offer entertainment but also serve as valuable teaching and learning tools that contribute to students' cognitive development and knowledge acquisition. While DGBL has been widely researched across subjects like finance, language learning, and healthcare, its potential in art education remains largely unexplored. This study seeks to fill this gap by examining the role of art-focused digital games in enhancing creativity and understanding among science and engineering students. By exploring the interdisciplinary application of DGBL in art education, this research aims to provide insights that contribute to both educational technology and curriculum design, particularly within China's vocational and higher education systems. This approach not only addresses a previously unstudied area but also aligns with China's educational emphasis on digital integration and innovative teaching methods.

Finally, the widespread adoption of digital technology has reduced geographical and educational cost barriers. Consequently, this study will be conducted in vocational colleges and universities across Ningxia province, China, where digital game-based learning can potentially enhance interdisciplinary education. Although focused on the Chinese education system, the findings may also offer insights for other contexts where educational technology and digital integration are valued.

Additionally, Ningxia province was intentionally chosen as the study location due to its position in northwestern China, an area with relatively underdeveloped educational infrastructure. According to Hai (2023), education in this region faces challenges such as insufficiently targeted content, limited diversity in teaching methods, and narrow educational channels. For science and engineering students in Ningxia, it is especially crucial to diversify their educational experiences and move beyond homogeneous learning styles. Enhancing their imagination and problem-solving skills is equally essential. Therefore, this study focuses on this region.

### **1.3 Problem Statement**

The science and engineering industry plays a pivotal role in China's development (Chinese Academy of sciences, 2022). As more and more students pursue higher education in science and engineering, the population of these students has become an important talent pool in China (Ministry of Education, 2018; 2019; 2020). It was reported that there are 11,500 vocational schools and colleges in China, with an enrolment of 28.57 million students, mostly contributing to modern manufacturing, emerging industries, and modern service sectors (China Youth Daily, 2020). These graduates constitute a substantial portion of the workforce supporting various industries across the country (People's Daily, 2021). As enrolment of science and engineering students in China's tertiary institutions continues to rise, a major issue has arisen. The overemphasis on standardized teaching and learning of science, technology, engineering, and mathematics (STEM) knowledge and skills while neglecting the arts has significantly hindered the development of students' creativity, innovation, and problem-solving abilities. Higher education in China predominantly focuses on skill-based teaching to meet the skilled employment demands of society.

(Ministry of Education of the People's Republic of China, 2006). The emphasis is on equipping students with technical or skilled application abilities to ensure they can enter the workforce immediately after completing their programs.

In this situation, the researcher effectively highlights the importance of integrating art (i.e., digital games) to complement and enrich the education of science and engineering students within the STEM (Science, Technology, Engineering, Mathematics) framework. However, it is concerning that the inclusion of the arts, as promoted by the STEAM (Science, Technology, Engineering, Arts, Mathematics) model, was notably absent from the discussion.

### **1.3.1 Lack of Creativity and Innovation in Standardized Education**

This omission is significant, given the growing body of literature and research that supports the value of incorporating the arts to foster creativity, critical thinking, and holistic problem-solving in education.

China's STEM education is highly standardized, focusing on equipping students with technical skills that prepare them to quickly enter the workforce. However, this skill-based model constrains students' development in creativity and problem-solving—qualities that are increasingly important for adapting to complex, real-world challenges. The adoption of Western educational frameworks in Eastern contexts has sometimes resulted in an overemphasis on standardization, which may limit innovation. For example, Western concepts such as learner autonomy can face cultural and institutional resistance in Eastern educational environments, creating barriers to innovative teaching practices (Dardjowidjojo, 2006). Furthermore, the examination-centered education system reduces students' motivation to engage in

creative learning, which impacts their self-confidence, resilience, and ability to take calculated risks—traits that are vital for fostering innovation (Kim, 2011; 2021).

### **1.3.2 The Need for Cultural and Individual Diversity in Teaching Approaches**

The standardized approach prevalent in China's education system often overlooks the importance of cultural and individual diversity, which are essential for cultivating a dynamic and engaging learning environment. Research suggests that standardized teaching methods, which prioritize uniformity over diversity, can suppress students' unique traits and motivations, limiting opportunities for individual expression and engagement (Coriñaupa Vargas, 2020). When education systems lack inclusiveness, students are less likely to develop distinct perspectives, a skill crucial for innovative thinking (Pango, 2015). As a result, homogeneous teaching practices reduce students' engagement and limit the diversity of personalities within the classroom, potentially impacting their ability to adapt to varied professional environments (González-Peiteado & Pino-Juste, 2015).

### **1.3.3 Challenges Stemming from Homogenized Education and Limited Interdisciplinary Exposure**

A standardized, homogenized education often constrains students' learning by neglecting interdisciplinary and creative subjects like the arts. The lack of interdisciplinary education, particularly in art, contributes to common stereotypes that science and engineering professionals possess limited emotional intelligence and interpersonal skills. This stereotype not only hinders their personal development but can also impact on the broader technological and scientific sectors (People's Daily,

2021). Limited exposure to subjects outside of STEM results in a narrower educational experience, which affects students' communication, empathy, and adaptability when interacting with others from diverse fields (Newell, 2007; 2009).

This specialization may make it difficult for individuals to communicate, empathize, and understand others effectively within their fields. Interdisciplinary education provides a potential solution by exposing university students to a wide range of subjects, broadening their perspectives, enhancing critical thinking and problem-solving skills, and improving communication abilities. These are essential components of soft skills. However, the overemphasis on standardized, skill-based STEM education has constrained the development of students' creativity, innovation, and problem-solving abilities.

#### **1.3.4 The Role of Art Education in Fostering Creativity, Emotional Intelligence, and Communication Skills**

Art could transcend its traditional confines for non-art students and evolve into an inclusive domain accessible to everyone. Integrating art into science and engineering education can play a pivotal role in fostering students' aesthetic sensibilities and expressive abilities. This interdisciplinary approach has the potential to broaden perspectives, enhance critical thinking, and develop problem-solving skills essential for science and engineering fields (Hu, 2018). According to Yan (2021), the limited emphasis on art education in these fields contributes to low levels of emotional intelligence, as science and engineering students often lack the opportunity to develop skills for self-expression and emotional understanding, which are crucial for effective interpersonal interactions (Zhao, 2014). Art education can enable individuals to cultivate an appreciation for diverse perspectives, develop

expressive capabilities, and strengthen their communication skills. For instance, a programmer exposed to art education may enhance their creativity and expressive abilities, fostering positive relationships and teamwork skills (Yan, 2021).

The choice of digital games as a tool for learning art stems from the transformation occurring within art education itself. Traditionally, art education has focused on developing technical drawing skills. However, contemporary art education increasingly emphasizes self-expression as a core component, with studies highlighting that self-expression through art is essential for personal and professional growth (Daly, 2015). Evidence suggests that, within China's educational framework, art education remains in an early stage, still largely focused on technical skills rather than expressive development. For science and engineering students, the objective of art education should shift from mastering drawing skills to cultivating creativity, imagination, and problem-solving abilities skills more relevant to their fields of study (Schulte, 2018; Lu & Zhang, 2018; Sun & Wang, 2022).

Therefore, modern art education, particularly when combined with interdisciplinary approaches, can play a critical role in bridging this gap. It provides science and engineering students with valuable opportunities to develop emotional intelligence, communication abilities, and interpersonal skills, all of which are indispensable in today's collaborative work environments (Hu, 2018; Yan, 2021; Zhao, 2014).

Later in this research, the researcher also highlights the importance of four dimensions: art history, art criticism, aesthetics and art production, in order to measure art knowledge amongst the science and engineering students. This is rising further confusion about the correlations between art knowledge or interest amongst

the science and engineering students, and how significant digital game-based learning approach in solving the issue.

### **1.3.5 Educational Challenges Specific to Ningxia Province**

Ningxia Province, being remote and economically underdeveloped, faces unique educational challenges that distinguish it from more affluent regions like Beijing and Shanghai. Data from 2023 indicates that Ningxia's R&D funding in higher education is significantly lower than that of major cities (Table 1.4). With only 91,783 units of total R&D funding, including 34,880 units from government sources and 18,368 units from non-government sources, the region's financial support for higher education is dwarfed by that of Beijing (3.84 million units) and Zhejiang (3.20 million units) ((Information Network of Humanities and Social Sciences in Chinese Colleges and Universities (INHSSCCU), 2023a). This lack of funding impacts on the availability of teaching resources, the quality of educational programs, and opportunities for innovation.

Furthermore, the number of personnel involved in social science research in Ningxia is limited, with a total of 5,855 people compared to Beijing's 29,204 (Table 1.2). These figures emphasize the disparity in educational capacity and resource allocation, which can lead to limited exposure to interdisciplinary learning and art education (Information Network of Humanities and Social Sciences in Chinese Colleges and Universities (INHSSCCU), 2023c).

Specifically, data from 2023 shows that Ningxia has only 83 scientific research achievements, far lower than Beijing's 3403, Zhejiang's 43932, and

Shanghai's 2137 (Information Network of Humanities and Social Sciences in Chinese Colleges and Universities INHSSCCU, 2023b). This significant gap indicates the limitations of Ningxia in academic output and research reports, which directly affects its overall competitiveness in education and technological development. The scarcity of scientific research achievements not only affects academic reputation, but also impacts the attractiveness and innovation capability of local higher education.

This context underscores the urgency of addressing educational gaps in Ningxia, making it a representative case study for exploring how digital game-based learning (DGBL) can supplement traditional STEM education by incorporating art to enhance creativity and problem-solving abilities.

Table 1.2 Research and Development in the Humanities and Social Sciences in Higher Education (Social Science Activity Staff)

Province and City Name	Total	Social science activity personnel (Person)		
		High level	Intermediate	Beginner
Beijing	29204	21336	18026	2625
Zhejiang Province	43932	23098	29520	6512
Shanghai	42068	12091	13925	3187
Ningxia Province	5855	1496	1026	2223

Table 1.3 Overview of Humanities and Social Sciences Research and Development in Higher Education Institutions (Research and Development Achievements)

Province and City Name	Total	Research and Development Achievements		
		Works (Department)	Academic papers (articles)	Research and Consulting Report (Article)
Beijing	3403	3403	31416	3345
Zhejiang Province	43932	1858	20913	6835
Shanghai	2137	2137	13925	4053
Ningxia	83	1024	77	2223

Province

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Table 1.4 Income from Humanities and Social Sciences Research and Development Funds in Higher Education Institutions

Province and City Name	Total	R&D funding income for the year	
		Government funding investment	Non governmental funding investment
Beijing City	3837785.007	1820425.5	1375950.305
Zhejiang Province	3204802.525	859177.679	1065910.436
Shanghai City	2632267.084	1290314.942	703662.579
Ningxia Province	91783.508	34880.468	18368.507

### 1.3.6 Research Focus and Importance

Therefore , Despite the potential benefits of interdisciplinary and art education, these concepts are still in the exploratory phase in China's higher education system, particularly among science and engineering students. This study focuses on students at Ningxia University of Science and Technology, specifically those engaged in interdisciplinary learning involving art disciplines (Khan & Wells, 2023). Although these students may encounter challenges or lack of initial interest in art-related knowledge, this research aims to explore methods of encouraging them to learn art through art education digital games. The ultimate goal is to support cultivation of talents with not only direct employability skills but also creativity and innovative thinking through digital game for art education. It is crucial to address the lack of emphasis on art education in China's higher learning institutions (Zhang, 2017). While higher education institutions continue to expand, there is a growing concern about the overall quality of students or graduates in China (Ministry of Education, 2020). At colleges, most of the arts courses or programs are arranged as public compulsory courses (Liu, 2020). However, many college science and engineering students fell asleep and play with mobile phones while attending arts classes (Zhao, 2014; China Youth Daily (CYD), 2017; Sherri Gordon, 2024). The

low classroom interaction and lack of interest among students are the main issues. To address these issues, there is a need to strengthen interdisciplinary education and art education for science and engineering students, providing them with holistic educational experiences (Singh, 2021). Such initiatives could enhance the overall quality of education and develop students with a well-rounded set of competencies (Khan & Wells, 2023).

In summary, these research questions collectively emphasize that China's replication of Western educational methods, structuring them without adapting them, can lead to an educational environment that lacks the vitality and creativity needed for students' innovative development (Lu & Zhang, 2018; Sun & Wang, 2022; Schulte, 2018). This suggests that the diversity of DGBL approaches is a new exploration for creating a stimulating and inclusive learning environment. Rigid and homogenized teaching methods can hinder students' unique individuality and cultural expression, which suggests that there may exist more distinct advantages of educating diversity in interdisciplinary arts education in DGBL to help students develop qualities such as students' ability to think, collaboration, curiosity, exploration, and cultural exchange (CED, 2024). Ultimately, this study aims to bridge the current gaps in China's science and engineering education by fostering a more dynamic, inclusive learning environment. By leveraging digital games for art education, this research seeks to cultivate creativity, innovation, and critical thinking qualities essential for addressing the challenges of a rapidly evolving global workforce. Addressing these issues is not only crucial for individual student development but also imperative for enhancing the broader educational landscape in China. Through this approach, the study aspires to provide valuable insights for