THE EFFECTS OF MOBILE AUGMENTED REALITY (MAR) LEARNING SYSTEM IN DESIGN HISTORY CLASS ON PERFORMANCE, COGNITIVE LOAD AND MOTIVATION AMONG COLLEGE STUDENTS

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by

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Maugham once wrote in "The Moon and Sixpence," "I will strive with all my might to live this ordinary life." As I write these words, I might have done something extraordinary in this ordinary life.

Time has flown, and my student life has finally come to an end. Along this journey, there have been many people who pulled me out of the mire during difficult, confusing, and distressing times. Their kindness and generosity helped me navigate every challenge, allowing me to grow. I am profoundly grateful for the unwavering support of these remarkable people who have stood by me every step of the way.

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LIST OF ABBREVIATIONS

CLT	Cognitive Load Theory
CNKI	China National Knowledge Infrastructure
CTML	The Cognitive Theory of Multimedia Learning
ISMAR	International Symposium on Mixed and Augmented Reality
KR20	Kuder-Richardson 20
MAR	Mobile Augmented Reality
MART	MAR learning system with a printed textbook class mode
MuET	Multimedia electronic textbook class mode
SMQ-II	Science Motivation Questionnaire-II
SPSS	Statistical Package for Social Science
SI	Sliding Interface
WHI	Work Homepage Interface
WII	Work Introduction Interface

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KESAN SISTEM PEMBELAJARAN MOBILE AUGMENTED REALITY (MAR) DALAM KELAS SEJARAH REKA BENTUK TERHADAP PRESTASI, BEBAN KOGNITIF DAN MOTIVASI DALAM KALANGAN PELAJAR KOLEJ

ABSTRAK

Sejarah reka bentuk berfungsi sebagai asas pendidikan seni dan reka bentuk, terutamanya untuk pelajar sarjana muda universiti di China yang mempunyai kepakaran dalam seni dan reka bentuk. Kajian terdahulu telah menunjukkan bahawa mengintegrasikan teknologi dalam ke dalam kelas reka bentuk boleh menghasilkan hasil yang positif. Oleh itu, kajian ini bertujuan untuk menilai kesan pembelajaran sejarah reka bentuk melalui Teori Kognitif Pembelajaran Multimedia (CTML) dalam persekitaran realiti tambahan terhadap prestasi akademik, beban kognitif dan motivasi pelajar yang berbeza jantina. Dalam kajian ini, reka bentuk faktorial kuasi eksperimen 2 x 2 telah digunakan. Dua bentuk buku teks iaitu mod elektronik multimedia dalam kelas (MuET) dan mod buku teks bercetak dalam kelas (MART) digunakan sebagai pembolehubah tidak bersandar dalam kajian ini. Manakala, jantina pelajar (lelaki/perempuan) bertindak sebagai pembolehubah moderator. Motivasi, beban kognitif dan prestasi pelajar adalah pembolehubah bersandar. Seramai 121 pelajar daripada dua jurusan yang berbeza dari universiti terpilih dijadikan sampel kajian. Untuk tujuan analisis, statistik deskriptif dan inferensi telah digunakan. Untuk melihat perbezaan dalam prestasi akademik pelajar, beban kognitif, dan motivasi bagi kedua-dua kumpulan, teknik ANOVA telah digunapakai. Keputusan penyelidikan menunjukkan bahawa penggunaan MART telah menunjukkan hasil yang lebih baik berbanding dengan MuET berkaitan prestasi akademik pelajar. Ini menggambarkan,

CTML telah menyumbang kepada pengurangan beban kognitif pelajar dan meningkatkan motivasi pelajar yang menggunakan sistem pembelajaran MAR. Walau bagaimanapun, tidak terdapat perbezaan yang signifikan antara pelajar lelaki dan perempuan dari segi prestasi, beban kognitif, atau motivasi. Perbandingan antara MART berbanding MuET pula mendapati hanya pelajar perempuan menunjukkan prestasi yang lebih baik, beban kognitif yang lebih rendah dan motivasi yang lebih tinggi. Oleh itu, hasil akhir penyelidikan ini merangkumi reka bentuk dan pembangunan sistem pembelajaran inovatif yang bertujuan membantu pelajar kolej dalam mempelajari sejarah reka bentuk menggunakan teknologi realiti tambahan mudah alih yang menampilkan model 3D yang meningkatkan prestasi pelajar dengan ketara, mengurangkan beban kognitif dan meningkatkan motivasi.

THE EFFECTS OF MOBILE AUGMENTED REALITY (MAR) LEARNING SYSTEM IN DESIGN HISTORY CLASS ON PERFORMANCE, COGNITIVE LOAD AND MOTIVATION AMONG COLLEGE STUDENTS

ABSTRACT

Design history serves as the cornerstone of art and design education, particularly for undergraduate students at Chinese universities specializing in art and design. Previous studies have demonstrated that incorporating immersive technology into design classes can yield positive outcomes. Therefore, this study aimed to assess the impact of learning design history through the Cognitive Theory of Multimedia Learning (CTML) within an augmented reality setting on students' academic performance, cognitive load, and motivation, based on gender differences. In this study, a 2 x 2 quasi-experimental factorial design was used. Both the multimedia electronic textbook in class (MuET) and the printed textbook in class (MART) are examples of the two classroom modes that were utilized as independent variables in the study of design history. The gender (male/female) was the moderator variable. The students' motivation, cognitive load, and performance were the dependent variables. 121 students from two distinct majors at a chosen university made up the study sample. To examine the gathered data, descriptive and inferential statistics were applied. The substantial differences in the students' academic performance, cognitive load, and motivation between the two groups were found using an ANOVA. The results of this research indicate that the utilization of MART has demonstrated superior outcomes in contrast to MuET with regard to students' academic performance. More to the point, CTML has also contributed to decreasing students' cognitive load and enhancing student motivation while utilizing the MAR learning system. When learning from class mode MART and MuET, there is no significant difference between male and female students in terms of performance, cognitive burden, or motivation. In the MART compared to MuET class modes, only female students show improved performance, lower cognitive load, and higher motivation. The final outcome of this research thus encompassed the design and development of an innovative learning system aimed at assisting college students in studying design history using mobile augmented reality technology featuring 3D models that significantly enhance student performance, reduce cognitive burden, and boost motivation.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Technologies like the Internet, communication tools, visualization, and simulation can enhance knowledge exploration, problem-solving, and collaboration. By using these tools, students can have a more authentic learning experience and gain a deeper understanding of a discipline as a unique "culture" shaped by different perspectives and ways of understanding the world (Jonassen et al., 2019). Augmented Reality (AR) is one of the key elements that play a crucial role in modern educational environments (Tzima et al., 2019; Abad-Segura et al., 2020). AR has been extensively implemented in real-world contexts including business, entertainment, medicine, education, and cultural heritage. Additionally, it has started to make inroads into educational settings including schools and higher learning institutions in recent times (Li & Tang, 2019). The quick growth of smart mobile devices over the past five years has increased the possibility that augmented reality may leave the experimental research stage and become a commonplace learning aid (Huang et al., 2016; Pedaste et al., 2020). Recent literature reviews have provided evidence of its effectiveness as a learning tool in various contexts (Alkhattabi, 2017; Ahmad & Junaini, 2020; Marienko, 2020; Kaur et al., 2020; Liono et al., 2021).

Using technology in the classroom is now a must, changing some learning processes to attain the desired results (Tzima et al., 2019). In most China universities, the setting in which the technology program is applied falls far short of the actual demands of the course of study due to a lack of appropriate teaching spaces, tools, and equipment causes (Silva & Rufino, 2021). It is challenging for pupils to go through the entire design process of learning (Jiang, 2014; Lynch et al., 2021). For design history classes, the instructor should note the students' active participation in class, and the students should emphasize the game-based edutainment potential, which undoubtedly supports the use of technological capabilities to enhance learning experiences about historical events (Watson et al., 2011; Chien et al., 2014; Challenor & Ma, 2019). Thus, researchers should also explore methods to integrate AR into regular school curricula. This is significant because the interactive, exploratory, and experimental nature of AR systems foster learning differs from the standard teaching approaches employed in classrooms (Wu et al., 2013; Kaur et al., 2020). Traditional teaching strategies concentrate on applying knowledge learned from textbooks and teachers to practical circumstances, while the process of AR learning, creates a dynamic learning environment that encourages active participation and deep exploration, which has the potential to enhance student's motivation and performance and also reduce the cognitive load (Wei et al., 2015; Hanid et al., 2020).

First, learning techniques that align with pupils' interests and encourage active participation in their lessons can raise student engagement, effort, and ultimately, success (Kaur et al., 2020). However, the lack of motivation could be a significant barrier to learning progress (Khan al., 2019). Because the ability to deliver extremely interactive experiences is one of AR's key features, it is the ideal method for generating a context that is based on real-life learner activities that can greatly promote students' motivation (Chang et al., 2010; Anuar et al., 2021). AR benefits empower educators and designers to overlay virtual graphics onto physical objects, enabling students to engage with digital content through hands-on manipulation (Billinghurst & Dünser, 2012), which can offer a respectable degree of realism and engagement as well as realistic contextual learning opportunities that connect practice to theory (Liestol, 2011;

Pedaste et al., 2020). Dede (2009) and Hanid et al. (2020) also pointed out that immersion can facilitate the acquisition of knowledge through engagement with authentic, real-life situations and environments. Such experiential and immersive learning experiences are known to kindle enthusiasm, curiosity, and motivation, as students witness the direct correlation between their efforts and meaningful outcomes.

Moreover, AR has been shown especially effective at raising engagement among students, encouraging an optimistic attitude, and raising performance (Alnajdi, 2022). The visual and experiential nature of AR enables learners to comprehend intricate design principles more instinctively, thereby enhancing their comprehension and recall. Some believe that AR has the potential to be an effective teaching technology that can significantly improve students' academic performance (Dede, 2009; Estapa & Nadolny, 2015; Chen, 2019 Alnajdi et al. 2020) claim that AR makes learning more dynamic and pleasant by enabling us to see and learn from real-life situations, as well as by assisting students in understanding how theories apply. Besides visual learners who can benefit from the vivid interaction that allows them to comprehend complex concepts through dynamic and relatable representations, kinesthetic learners can engage in hands-on interactions with virtual objects, fostering a deeper understanding through active exploration. In areas in which it has been applied, it has been demonstrated to facilitate the acquisition of knowledge, raise test performance, inspire students, and encourage teamwork (Sotiriou & Bogner, 2008; Radu, 2014; Buchner et al., 2022).

Furthermore, cognitive load as a key variable in this study is grounded in its critical role in determining learning efficiency and effectiveness. The Cognitive Load theory (CLT) was created in the late 1970s, it is a theory that describes how learning and cognitive capacities interact with one another, to better comprehend how pupils pick up problem-solving skills (Sweller 1976). In a plethora of studies conducted within the realm of education and technology, AR has consistently demonstrated its potential to significantly alleviate the cognitive load (Buchner et al., 2022). In AR environments, like the design history MAR learning system, reducing cognitive load allows students to engage more deeply with the material. According to Buchner et al. (2022), AR has the ability to keep cognitive load at a minimum, or even reduce it further, thereby releasing working memory resources and improving the learning process. AR enables learners to seamlessly share their expertise and experiences with others in a virtual setting, allowing for more direct and interactive communication. Students can share their acquired information and experiences in the real world by fusing their learning environments with AR (İbili, 2019; Elford et al., 2022). Therefore, the design history MAR learning system can be used to lessen the cognitive load by substituting active participation and exploration for passive reception of knowledge among students.

The major objective of this study is to integrate design history content with AR technology to enrich the learning and educational experience. Through the synergy of AR's immersive capabilities and multimedia's enrichment to create a multifaceted learning environment emerges one that is poised to inspire, engage, and empower students in their exploration of design history.

1.2 Background of Study

In today's social environment of digital media interconnection, the continuous emergence of audio, video, digital applications, and intelligent products, mobile media has been applied widely, AR, virtual reality (VR), and mixed reality (MR) as widely intelligent digital technologies at the present stage, combined with their advantages of visual presentation and human-computer interaction, exerts a huge influence on education. Therefore, more and more educators are using these technologies in creative design classes, particularly using AR, to increase student learning motivation and creativity as well as the effectiveness of creative design instruction (Jesionkowska et a., 2020).

AR has a rather brief timeline, originating in the 1960s when computer scientists and researchers embarked on their initial investigations into utilizing technology to enrich reality. The fundamental principle behind AR is to enable users to perceive the actual physical environment while simultaneously integrating virtual things that are superimposed upon or blended with the actual things in the world (Azuma, 1997). However, it wasn't until the advancements in hardware and software technologies in the 21st century that AR became a viable option for education and learning. Recently, AR has become progressively popular in the realm of education, with more and more schools and universities adopting AR learning systems to enhance the learning experience (Garzón, 2021). AR has been shown to improve students' engagement, motivation, and understanding, and it has the potential to modify how instructors educate and learn (Chang et al., 2020). Students are no longer satisfied with merely experiencing basic images and videos through mobile devices, they want to seek more sensory stimulation and enrichment, such as immersive 3D.

Design history, a burgeoning topic that grew in popularity in the 1970s and 1980s and was frequently taught in art and design institutions, is a vital component of design education. It is intrinsically linked to the course's basic instructional motivation—serving as a backdrop for practice-based design education. In China, design history is more well-established in Taiwan due to the impact of the Japanese educational program, but it is expanding rapidly in Chinese design history in light of the massive recent tremendous growth of the PRC design sector (Wong, 2011), and plans for a BA degree in design history (Wong, 2012). Recently, design history textbooks have grown into a common test in applications for higher education, and increasing numbers of pupils are studying such textbooks on design history to get ready for examinations of master for design programs, thus, many universities offer survey courses on both "the world design history" and "Design history in China". Several top universities, such as Tsinghua University's Academy of Art & Design, approach design history as a scholarly field.

Although top-tier colleges and art academies in China provide undergraduate programs in design art history and studies, pupil involvement in graphic books about Western nations' design work is significantly stronger than their interest in text-based (Wong, 2011). However, the traditional teaching method of design history is usually used in words, resulting in an increased cognitive load and making it difficult for students to conduct a multi-dimensional and systematic exploration of the content of design history, which diminishes student motivation to learn. (Li & Luo, 2008). Thus, design history curriculum reform has become the new focus of attention and research of teachers in China colleges and universities (Chang, 2015; Wu, 2021; Yi et al., 2020), such as interactive classroom design (Fang, 2018; Ju, 2017).

According to Huang et al. (2022), it has been determined that design history courses in China are evolving with the times and incorporating innovative techniques to engage and educate students. The trend highlights the importance of utilizing technology and media to improve the process of instruction and learning, and more academics will use contemporary technologies to improve design history curricula in the future. However, the project of design history classes for university students through AR is not found, only Xu and Gu (2019) studied the possibility of empowering traditional publications with augmented reality technology, and proposed and realized an augmented reality empowerment program for traditional books represented by the book " A History of Modern Design."

"A History of Modern Design" is one of the required theoretical courses for design majors in universities (Wang, 1989; Gill et al., 2023), which makes it significant. It covers a wide range, including the history of modern architecture, the history of industrial product design, the history of graphic design, the history of fashion design, the history of advertising design, and so on. In each category, there are derived theoretical branches. The diversity of design categories covered in the course suggests its relevance to various design disciplines. The implication is that understanding the historical context of design is fundamental for design students, and can inform and enrich their practical design work in their future careers. However, a significant number of students encounter difficulties in attaining satisfactory grades with a large system (Wang, 2022). One of the universities in China has faced such problems, despite the relatively small class size, only around 35 students and 3 to 5 individuals fail each semester. The real issue is when compared to other design classes, it is apparent that the proportion of students who fail in this particular course is significantly higher. Failing in this course might impact students' academic progress, affect students' confidence and motivation, and potentially lead to delays in their degree completion.

This trend is troubling, and the reasons behind this phenomenon could be multifaceted, researchers have initiated investigations and conducted interviews with students to understand their perspectives on the challenges they face in the course. According to the students interviewed, a common sentiment emerges—they find the content of the course to be overly complex, leading to difficulties in comprehension. The cognitive load associated with the extensive and intricate subject matter is reported to be exceptionally high (Larmuseau et al., 2019), contributing to a lack of motivation to engage with the material and leading to poor academic performance (Mauliya et al., 2020). To address this challenge, one potential solution is to introduce new teaching technologies, such as the use of new technology for studies within classroom environments like AR technology, many studies have certified that AR could offer positive capabilities that can provide significant and positive support for instruction (Wahid et al., 2024), particularly in the context of mobile augmented reality (MAR) learning systems, due to its convenient and smart (Kozc et al., 2021).

As a key device for augmented reality, mobile phones are favored by users for their widespread availability, and most people now own devices capable of supporting necessary graphic rendering systems (Challenor & Ma, 2019). According to the theme "Our new Digital 2023 Global Overview Report" on the website "We Are Social", there are over two-thirds (68%) of the global population now owns a mobile phone, and even prevalent even among college students (Chen et al., 2015; Yu et al., 2022). Presently, the number of pupils who own mobile devices has risen considerably, and it has become a customary practice for higher education students to utilize smartphones, many students use their phones as a means of expanding their knowledge and learning purposes (Dahlstrom & Bichsel, 2014; Klimova, 2019). Research shows that students increasingly rely on their mobile phones for academic purposes, utilizing various applications such as messaging for coursework, accessing reference materials, and reviewing lecture slides (Ng et al., 2017; Campus Computing Project, 2015). In developing countries, like those studied by Hossain and Ahmed (2016), mobile phone usage for academic activities has become equally prevalent.

Not only in the world but also in China, based on the article named “The 51st Statistical Report on China's Internet Development (2023)” published by the China Internet Network Information Center (CNNIC), a leading authority in the field of China's Internet industry, by December 2022, 99.8% of Chinese netizens used mobile phones to access the Internet. Also as of 2021, the mobile phone ownership rate among Chinese university students has exceeded 95%. This means that almost all Chinese university students have their mobile phones. At the same time, the website of China Central Television (CCTV) news named The Results of the 19th National Reading Survey in April 2022 also shows that young people now make up the majority of digital readers. In 2021, 77.4% of young individuals read on their mobile phones. It can be seen that digital technology has centered on mobile devices in our lives and work. College students, in particular, prefer to use mobile phones as a means of fragmented learning activities, which could help students supplement their traditional classroom education with easily accessible on-the-go resources. This emergence of the trend has brought about substantial changes in the manner in which students acquire and assimilate knowledge (Hwang & Wu, 2014), and more students are using smartphones for study (Taha & Dahabiyeh, 2021).

Despite the widespread adoption of mobile devices, challenges persist in fully leveraging their potential for educational purposes (Şad et al., 20222). One of the main issues in learning design history, in particular, is that students often find it difficult to visualize complex historical concepts, architectural designs, and spatial relationships from static images and texts (Challenor & Ma, 2019; Haydn, & Stephen, 2021). AR offers a solution by providing immersive, interactive environments that bring these elements to life (Kaur et al., 2020). However, the transition to AR learning presents both opportunities and challenges for educators and students alike (Upadhyay et al., 2024). By integrating AR into design history courses, this study aims to enhance students' learning performance and motivation through hands-on, immersive experiences that support deeper cognitive processing of historical concepts. Students can access this MAR system on their own devices, which has the potential to afford students access to a diverse array of educational resources and learning experiences to enhance design history courses, from interactive 3D models and simulations to gamified learning activities.

From the educator's perspective, the complexity of AR-based learning systems requires careful consideration of how to align interactive 3D models and simulations with course objectives (Palamar et al., 2021). Many educators express concerns about the learning associated with developing AR content, as well as the technical challenges of ensuring that students can access the material on their devices without technical disruptions (Billinghurst & Dünser, 2012; Sahin & Yilmaz, 2020).

For students, AR can lessen the cognitive load required by combining and incorporating various sources of information during the learning process (Buchner et al., 2022; Zhao et al., 2023). There is also evidence to suggest that while AR enhances motivation, it can sometimes lead to surface-level learning if not carefully integrated into broader learning strategies (İbili, 2019). Several studies have demonstrated that AR has a positive impact on students' academic performance (eg. Billinghurst &

Dünser, 2012; Cabero-Almenara et al., 2019; Altmeyer et al., 2020). The primary focus of AR provide a unique and engaging learning experience by creating an immersive and interactive environment. Without being restricted to a location with specialized equipment, students can learn almost anywhere, giving a tangible layer of knowledge to any environment whenever they want (Alem & Huang, 2011), and this holds the potential to revolutionize how information is presented to students (De Sá & Churchill, 2012; Barroso, 2018). Additionally, the immersion, engagement, and exploration aspects of AR enhance the student's motivation for acquiring knowledge, aid in understanding information, and have the potential to be valuable in educational activities that involve hands-on experiences, spatial awareness, and working together with others (Dunleavy et al., 2009; Dalgarno & Lee, 2010; Di Serio et al., 2013; Barroso, 2018).

In the last decade, Bohlin (2016) found no disparities between Swedish men and women in their utilization of mobile apps, except for men being more active in online ticket purchasing, while women used social media apps more frequently. Goswami and Dutta (2016) performed a review of the research on gender variances in the implementation of technological advances across different sectors including education, finance, healthcare, etc. Their results indicate that gender plays a substantial role in the willingness to embrace new technology. This factor could shape how students engage with educational tools in specific fields, such as design history.

Building upon these insights, recently, Cabero-Almenara et al. (2019) offer a more nuanced perspective, showing that female participants displayed greater enthusiasm for adopting new technologies, particularly AR, VR, and traditional videos, compared to their male counterparts. This shift is particularly relevant to the field of design history, where multimedia tools like AR could play a crucial role in mitigating traditional challenges such as low academic performance, high cognitive load, and reduced motivation. The study further suggests that gender could be a moderating variable for student engagement in online learning environments. While these findings point to the potential for technologies to improve educational outcomes, the research by Erbas and Demirer (2019) assert that the learning performance aspect of AR does not influence engagement differently between genders, implying that gender-specific interventions might need to focus on factors beyond engagement alone.

Li et al. (2021) expanded this discourse by highlighting how gender differences in cognitive load could be linked to perceptions of AR system usability. For males, perceived ease of use correlated strongly with extraneous load, while for females, perceived usefulness was more closely tied to intrinsic load. These insights suggest that AR-based design history courses may need to be tailored to address gender-specific cognitive demands, potentially improving academic performance and reducing cognitive load across both groups. Therefore, this study develops and investigates a MAR system in a design history context, seeking to explore how AR can enhance student outcomes in terms of performance, cognitive load, and motivation, while accounting for gender as a critical variable.

1.3 Problem Statement

The first problem faced by the design history is its inherent complexity, which significantly burdens students' cognitive load (Rourke, 2007; Chu et al., 2019). Most students cannot independently establish a relatively complete theoretical framework because they feel difficult to understand the complex history. The mindless memorization of past events resulted in a deficiency of creative and critical thinking abilities among students. They might not fully comprehend the causes, origins, and consequences of historical events until after they have already happened. It can be challenging for instructors to make students empathize and take into account various historical perspectives (Huijgen et al., 2014). Gender may also play a moderating role in these cognitive challenges. Studies have indicated that male and female learners may engage differently with educational content, particularly in technology-enhanced environments (Cabero-Almenara et al., 2019). For example, users of MagicBook hold an AR display to explore digital media superimposed on actual book pages. Users also can press a button on the device to fly into a completely immersive virtual environment while witnessing AR sceneries (Billinghurst et al, 2001). An innovative technology-enhanced instructional approach called REENACT was put forth by Blanco-Fernández et al. (2014) to address the difficulty of augmented reality in the context of history education. Immerses students in historical reenactments, may alleviate cognitive load differently for male and female students. While male students may benefit from the ease of interaction with AR systems, female students might experience a stronger association between the technology's usefulness and their intrinsic cognitive load, enhancing their capacity for understanding complex historical narratives (Li et al., 2021). MAR has the ability to provide an extremely realistic contextual educational environment that fosters sophisticated comprehension and transference (Annansingh, 2019). Therefore, the deployment of MAR in design history classes may offers a dynamic way to explore historical contexts and be pivotal in reducing cognitive load through gender-specific pathways. By addressing these gender-specific cognitive demands, instructors can create more inclusive and effective learning experiences that enhance both the understanding and critical analysis of design history.

The second problem is that most students have little motivation to learn design history as general design courses itself is hard to stimulate students' willingness to study independently (Davey et al., 2007; Challenor & Ma, 2019). In China, a large number of college students are currently getting ready for a variety of exams, like the College English Test Band 4 (CET-4), College English Test Band 6 (CET-6), and the National Computer Rank Examination (NCRE), as well as numerous final exams for each semester (Zhou, 2004; Peng, 2010). This puts them under significant stress and pressure. However, it is worth noting that many teachers still rely heavily on traditional lecturing as their primary teaching method. Unfortunately, this approach has resulted in a lack of interest among students in these courses (Balakrishnan, 2022). As a result, a growing number of universities in China are anticipating the implementation of innovative technologies to enhance the engagement of students in design courses and provide them with additional motivation (Wei et al., 2015). Motivation levels may also differ by gender in the context of emerging technologies. Studies suggest that females are more positively motivated by their VR or AR experiences than males (Dirin et al., 2019). For instance, in a storytelling workshop using AR, instructors presented an AR book of Giant Jimmy Jones by Gavin Bishop to students aged 10 to 14. It offers a multidimensional learning method that integrates written content, visual content, music, and movement and is a wonderfully motivating interaction style, and the report declares that there is unequivocal evidence suggesting that AR will emerge as a profoundly impactful medium for both entertainment and educational purposes (McKenzie & Darnell, 2004). Moreover, the deployment of approaches to active learning in AR learning settings has been demonstrated to be efficient, redefining individuals' roles from mere recipients of information to active contributors who facilitate the acquisition of knowledge (Alzahrani, 2020). This shift is particularly important for female students, who may respond more positively to active learning experiences, further enhancing their motivation to study design history. Wojciechowski and Cellary's (2013) study in chemistry classrooms demonstrated that AR can successfully transform passive learning environments into active ones, thereby boosting student engagement and motivation. Likewise, Ibáñez et al. (2020) found that the use of AR tools in geometry classes led to higher levels of enjoyment and engagement among students, suggesting that similar technologies could increase motivation in design history courses as well. Thus, incorporating AR into design history education may address gender-related motivational differences by providing immersive, interactive experiences that particularly resonate with female students while enhancing engagement for all learners. This approach may ultimately boost motivation, making design history more appealing and accessible to a broader student base.

Thirdly, traditional printed textbooks are unable to provide interactive information, which makes it difficult for students to fully experience the rich design history and perform well in their learning (Xu & Gu, 2019). Research has consistently highlighted notable gender differences in academic achievement. It has become a widely recognized trend that girls tend to excel academically compared to boys (Voyer and Voyer, 2014) because females generally excel in reflective and visual learning environments (Prajapati et al., 2011). This is particularly relevant in design history, a subject that requires visual comprehension and reflection on historical contexts and aesthetics. Studies have shown that girls typically outperform boys in reading and language comprehension (Eriksson et al., 2020), such skills crucial for understanding design history's theoretical aspects. A strong advantage of MAR books over traditional print textbooks is the additional interactivity, and the interactive capabilities are becoming increasingly significant for engaging students and supporting them retain information. Afify (2020) shown that the utilization of interactive information can greatly enhance students' ability to retain and recall information. By engaging with interactive materials, students can strengthen their memory and subsequently improve their academic performance (Fatih et al., 2018). Furthermore, MAR books have virtual graphics superimposed on the pages which can be moved around by rotating, tilting, or flipping to experience simulated content from various perspectives. Users can interact with the book by simply looking at the page and using gesture input to activate animations, move virtual items, or mark information (Grasset et al., 2007). A 3D cardboard creation emerges from the page when a reader opens a pop-up book, providing an animated scene to complement printed content, and augmented books are sort of like digital counterparts, allowing rudimentary interactivity (Billinghurst & Dünser, 2012). Additionally, digital materials may easily customized to meet the needs of individual students, providing an adaptive learning environment that could further bridge gender-based differences in academic outcomes. For design history, the ability to visually manipulate and interact with historical content can help all students, particularly females, strengthen their comprehension and academic performance. By addressing the limitations of traditional print textbooks, MAR may assist students in boosting their academic performance, creating a more engaging and gender-responsive learning environment.

1.4 Research Objectives

The primary propose of this research is to develop a MAR learning system to address the issue of design history classes in traditional college courses. To fulfill this objective, this study aims to take advantage of 3D Realism, the Cognitive Theory of

Multimedia Learning (CTML), the Cognitive Load Theory (CLT), Hick's Law, and Fitts's Law to design a MAR learning system that reduces students' cognitive load, increases academic performance, and motivation of the design history.

The objectives of the research are as follows:

i. To design and develop a printed textbook-based MAR learning system featuring 3D models: student learning design history through utilizing the CTML as instructional strategies, which uses Hick's and Fitts's laws to construct the interface.

ii. To investigate the effect of using the MAR learning system with printed textbook in class (MART) and the multimedia electronic textbook in class (MuET) in design history classes on academic performance among students of different genders.

iii. To investigate the effect of MART and MuET in design history classes on cognitive load among students of different genders.

iv. To investigate the effect of MART and MuET in design history classes on motivation among students of different genders.

1.5 Research Questions

The following research questions, depending on the main effect and interaction effect, are dealt with in this study:

A. What are the effects of two study modes of design history (MART and MuET) in terms of student's academic performance? And the subsequent inquiries to research question A are:

i. Is there any significant difference in terms of students' academic performance between the two study modes of design history (MART and MuET)?

ii. Is there any significant difference in terms of students' academic performance among students of different genders in MART?

iii. Is there any significant difference in terms of students' academic performance among students of different genders in MuET?

iv. Is there any significant difference in terms of students' academic performance among students with males in MART and those in MuET?

v. Is there any significant difference in terms of students' academic performance among students with females in MART and those in MUET?

B. What are the effects of two study modes of design history (MART and MuET) in terms of students' cognitive load? And the subsequent inquiries to research question B are:

i. Is there any significant difference in terms of students' cognitive load between the two study modes of design history (MART and MuET)?

ii. Is there any significant difference in terms of students' cognitive load among students of different genders in MART?

iii. Is there any significant difference in terms of students' cognitive load among students of different genders in MuET?

iv. Is there any significant difference in terms of students' cognitive load among students with males in MART and those in MuET?

v. Is there any significant difference in terms of students' cognitive load among students with females in MART and those in MuET?

C. What are the effects of two study modes of design history (MART and MuET) in terms of students' motivation? And the subsequent inquiries to research question C are:

i. Is there any significant difference in terms of students' motivation between the two study modes of design history (MART and MuET)?

ii. Is there any significant difference in terms of students' motivation among students of different genders in MART?

iii. Is there any significant difference in terms of students' motivation among students of different genders in MuET?

iv. Is there any significant difference in terms of students' motivation among students with males in MART and those in MuET?

v. Is there any significant difference in terms of students' motivation among students with females in MART and those in MuET?

1.6 Research Hypotheses

The following null hypotheses are based on research questions:

A. The effects of two study modes of design history (MART and MuET) in terms of students' academic performance. The subsequent inquiries to research hypothesis A are:

$H_{O.A.1}$: There is an insignificant difference in academic performance between students who learned from MART and MuET.

$H_{O.A.2}$: There is an insignificant difference in academic performance among students of different genders in MART.

$H_{O.A.3}$: There is an insignificant difference in academic performance among students of different genders in MuET.

$H_{O.A.4}$: There is an insignificant difference in academic performance among students with males in MART and those in MuET.

$H_{O.A.5}$: There is an insignificant difference in academic performance among students with females in MART and those in MuET.

B. The effects of two study modes of design history (MART and MuET) in terms of student's cognitive load. The inquiries of main effects and interaction effects to research hypothesis B are:

$H_{O.B.1}$ (class mode): There is no significant difference in cognitive load between MART and MuET.

$H_{O.B.2}$ (gender): There is no significant difference in cognitive load between male and female students.

$H_{O.B.3}$ (interaction): There is no interaction effect between class mode (MART and MuET) and gender (male and female) on cognitive load.

C. The effects of two study modes of design history (MART and MuET) in terms of student motivation. The inquiries of main effects and interaction effects to research hypothesis C are:

$H_{O.C.1}$ (class mode): There is no significant difference in motivation between MART and MuET.

$H_{O.C.2}$ (gender): There is no significant difference in motivation between male and female students.

$H_{O.C.3}$ (interaction): There is no interaction effect between class mode (MART and MuET) and gender (male and female) on motivation.

1.7 Theoretical Framework

The basic idea of the theoretical framework discussed in this section is to combine all the theories from design, psychology, and instructional technology that are related to one another to create a framework that experimentally supports the methodology used in this study. The five key theories that served as the foundation for the investigation are as follows:

i. Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2001)

ii. Cognitive Load Theory (CLT) (Sweller, 1994)

iii. Hick's Law (Hick, 1952)

iv. Fitts's Law (Fitts, 1954)

v. 3D Realism (Abu Bakar et al., 2014)

Theoretical frameworks such as the Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2001) and Cognitive Load Theory (CLT) (Sweller, 1994) are utilized to provide guidance to students in the field of education. Multimedia information in the MAR learning system can be guided by CTML. It might, for instance, have an impact on the way educational resources are organized, making sure that auditory and visual components work in concert to improve comprehension. The approach promotes the use of text, narrative, and pertinent images to accommodate various learning styles. Furthermore, it may have an impact on CLT's approach to imparting knowledge to students. The design should make sure that the cognitive load is maximized for successful learning by avoiding providing pupils with too much information at once. This could entail dividing up the content into manageable chunks, offering intuitive navigation, and removing pointless distractions.

Hick's Law (Hick, 1952) and Fitts's Law (Fitts, 1954) are employed in the design of the user interface for the MAR learning system. Hick's Law can be used to make user interactions more efficient. This guarantees that students can effectively explore the system and make decisions without being overtaken by possibilities. Additionally, Fitts' Law can direct interactive element design. To make it simple for students to engage with interactive elements, such as buttons, they should be placed and sized suitably. This improves the system's general usability and makes the interface more user-friendly.

Additionally, 3D Realism (Abu Bakar et al., 2014) is incorporated in the creation of 3D models related to renowned buildings used in the MAR learning system. Incorporating 3D Realism into the creation of educational content about famous buildings can be quite important for the MAR learning system. In addition to improving the visual attractiveness of the learning process, realistic 3D models can aid learners in comprehending the structures found in virtual environments. This theory uses realistic 3D representations to improve comprehension and engagement, which adds to the overall efficacy of the MAR learning system.

In summary, each theory plays a specific and critical role in shaping different aspects of the MAR learning system, from content creation to interface design, with the ultimate goal of providing an effective and engaging educational experience for students.

1.7.1 The Cognitive Theory of Multimedia Learning (CTML)

The CTML refers to the use of multimedia content such as films, audio files, or interactive features to aid in the teaching of students, this aligns well with the teaching of design history, where the active role of learners in constructing knowledge by processing visual and verbal content. In particular, CTML suggests that the learner is considered a knowledge constructor, actively selecting and connecting components of visual and spoken knowledge. The core idea of the CTML is that the way learners participate in the cognitive processes necessary for significant learning through their visual and verbal information processing mechanisms is influenced by the design of multimedia education (Mayer, 1997). When an individual forms a mental image of the lightning system based on phrases and visuals in multimedia educational communication, multimedia learning occurs (Mayer, 2002).

Thus, CTML not only enhances multimedia instructional design but also establishes a strong link between the use of multimedia and the subject of design history, allowing students to form richer, more meaningful connections with the material. The theoretical framework of the CTML is shown in the figure1.1. This theory can guide the development of instructional materials, ensuring that they are presented in a way that enhances comprehension and retention. For further elaboration, please refer to Chapter 2.

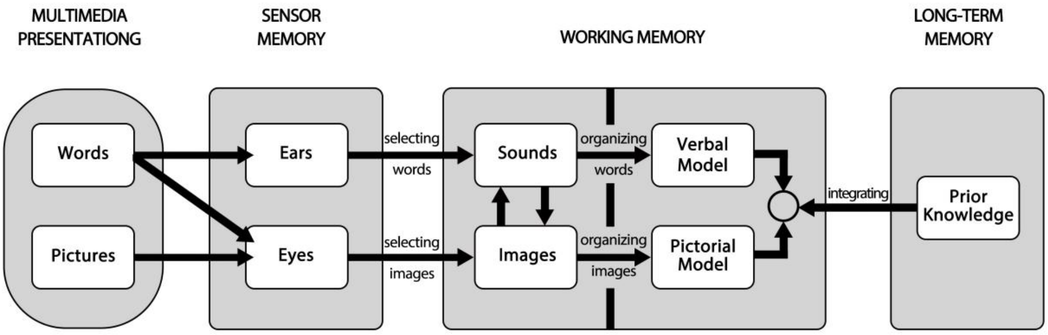

Figure 1.1 CTML Framework

1.7.2 Cognitive Load Theory (CLT)

The CLT is a theory in psychology and education that explores the limits of human working memory and the way it affects the process of learning. It posits that the human brain has a limited amount of working memory capacity and that this capacity is used to process information and solve problems. As stated by Sweller (1988), the majority of current research generally takes into account that there are three different types of cognitive stress: intrinsic load, extraneous load, and germane load. Working memory has a certain amount of space, thus instructional methods should avoid filling it up with extra tasks that don't directly support learning.

CLT is widely utilized in developing instructional materials and educational technology. Its primary objective is to minimize extraneous cognitive load while maximizing germane cognitive load, ultimately improving learning outcomes. By applying CLT, the design of the MAR learning system can be optimized to manage