

**THE EFFECTS OF MOBILE AUGMENTED
REALITY ON COLLEGE STUDENTS'
PERFORMANCE, MOTIVATION AND
TECHNOLOGY ACCEPTANCE OF LEARNING
INTANGIBLE CULTURAL HERITAGE**

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PERFORMANCE, MOTIVATION AND
TECHNOLOGY ACCEPTANCE OF LEARNING
INTANGIBLE CULTURAL HERITAGE**

by

DU SHAOXU

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TABLE OF CONTENTS

ACKNOWLEDGEMENT	ii
TABLE OF CONTENTS	iv
LIST OF TABLES	xiii
LIST OF FIGURES	xvi
LIST OF ABBREVIATIONS	xix
ABSTRAK	xx
ABSTRACT	xxii
CHAPTER 1 INTRODUCTION	1
1.1 Introduction	1
1.2 Background of Study.....	4
1.3 Problem Statement	11
1.4 Research Objectives	15
1.5 Research Questions	16
1.6 Research Hypotheses.....	19
1.7 Theoretical Framework	21
1.7.1 Cognitive Theory of Multimedia Learning.....	23
1.7.2 Multimedia Learning Principles.....	24
1.7.3 Usability Design Principles.....	25
1.8 Conceptual Framework	26

1.8.1	ARCS Motivation Model	28
1.8.2	Technology Acceptance Model (TAM).....	29
1.9	Research Framework.....	30
1.10	Limitations of the Study	31
1.11	Significance of the Study	33
1.12	Operational Definitions	34
1.13	Summary	38
CHAPTER 2 LITERATURE REVIEW.....		39
2.1	Introduction	39
2.2	Augmented Reality (AR)	39
2.2.1	Mobile Augmented Reality (MAR).....	42
2.2.2	The Use of MAR in Learning	43
2.3	Intangible Cultural Heritage (ICH)	52
2.3.1	Safeguard in ICH	52
2.3.2	Learning in ICH	54
2.3.3	Digital Technology in ICH	55
2.3.4	Chinese Traditional Mortise Tenon Joints (TMTJ)	57
2.3.5	Learning TMTJ by using MAR-MTJs.....	61
2.4	Models and Theories of Research	63
2.4.1	Cognitive Theory of Multimedia Learning (CTML)	64
2.4.1(a)	Three Basic Assumptions of CTML.....	66

2.4.1(b)	Multimedia Learning Principles	69
2.4.2	Keller’s Motivation Model.....	72
2.4.3	Technology Acceptance Model (TAM).....	77
2.4.4	Usability Principles for AR.....	82
2.5	Previous Research with Variables in AR	85
2.5.1	Performance Scores in using AR	85
2.5.2	Motivation in using AR.....	89
2.5.3	Technology Acceptance in using AR.....	93
2.5.4	The Effect of Student’s Stream of Studies in Using AR.....	99
2.6	The Research Gap and Present Study	101
2.7	Summary	103
CHAPTER 3 RESEARCH METHODOLOGY		104
3.1	Introduction	104
3.2	Research Design	104
3.3	Population and Sampling	107
3.3.1	Population	107
3.3.2	Sampling	108
3.4	Research Variable	111
3.4.1	Independent Variable	111
3.4.2	Dependent Variable.....	111
3.4.3	Moderator Variable	112

3.5	Research Instrument.....	113
3.5.1	Traditional Mortise Tenon Joints (TMTJ) Knowledge Test.....	113
3.5.1(a)	The Validity of the TMTJ Knowledge Test	114
3.5.1(b)	The Reliability of the TMTJ Knowledge Test.....	116
3.5.2	Instructional Materials Motivational Survey (IMMS).....	117
3.5.3	Technology Acceptance Model (TAM) Scale	118
3.6	Research Procedures	119
3.7	Threats to Validity.....	122
3.7.1	Internal Validity Threats	123
3.7.2	External Validity Threats	126
3.8	Pilot Test	127
3.8.1	Data Analysis for the Pilot Test.....	129
3.9	Data Analysis Technique	130
3.9.1	Descriptive Statistics.....	130
3.9.2	Inferential Statistics.....	131
3.10	Summary	132
CHAPTER 4 DESIGN AND DEVELOPMENT		133
4.1	Introduction	133
4.2	Instructional Design Model.....	133
4.3	Planning Stage.....	137
4.3.1	Defining the Scope.....	137

4.3.2	Identifying the Learner Characteristics	140
4.3.3	Establishing the Constrains	140
4.3.4	Collecting Resource Materials	141
4.4	Design Phase	143
4.4.1	Develop Initial Content Ideas	144
4.4.1(a)	Macro Strategy: CTML	145
4.4.1(b)	Micro Strategy: Multimedia Design Principles	147
4.4.1(c)	Micro Strategy: Usability Design Principles	149
4.4.2	Create Flowchart and Storyboard	151
4.5	Development Phase	153
4.5.1	Prepare the Text	155
4.5.2	Write Program Code	156
4.5.3	Assemble the Pieces	157
4.5.4	Prepare Support Materials	157
4.5.5	Alpha Test	158
4.5.6	Beta Test	160
4.6	Summary	163
CHAPTER 5 ANALYSIS AND RESULTS		164
5.1	Introduction	164
5.2	Characteristics of the Sample	165
5.2.1	Sample Distribution Based on Moderator Variable	165

5.3	Inferential Statistics Analysis.....	166
5.3.1	Analysis of Covariance (ANCOVA).....	167
5.3.2	Assumptions of ANCOVA.....	167
5.3.2(a)	Selection of Covariate.....	168
5.3.2(b)	Linear Relationship between Covariates and Dependent Variable.....	168
5.3.2(c)	Homogeneity of Variance for Performance Scores.....	169
5.3.2(d)	Homogeneity of Regression Slopes.....	170
5.3.3	Analysis of Variance (ANOVA).....	171
5.3.4	Assumptions of ANOVA.....	172
5.3.4(a)	Independence of Observations.....	172
5.3.4(b)	Normal Distribution.....	172
5.3.4(c)	Homogeneity of Variance for Perceived Motivation...	178
5.3.4(d)	Homogeneity of Variance for Technology Acceptance.....	178
5.4	Testing of Null Hypotheses for Performance Scores.....	179
5.4.1	Hypothesis Testing $H_{0.A.1}$	179
5.4.2	Hypothesis Testing $H_{0.A.2}$, $H_{0.A.3}$, $H_{0.A.4}$, $H_{0.A.5}$, $H_{0.A.6}$	183
5.4.2(a)	Hypothesis Testing ($H_{0.A.2}$).....	185
5.4.2(b)	Hypothesis Testing ($H_{0.A.3}$).....	187
5.4.2(c)	Hypothesis Testing ($H_{0.A.4}$).....	188
5.4.2(d)	Hypothesis Testing ($H_{0.A.5}$).....	189

	5.4.2(e) Hypothesis Testing ($H_{0.A.6}$).....	190
5.5	Testing of Null Hypotheses for Perceived Motivation.....	191
	5.5.1 Hypothesis Testing $H_{0.B.1}$	191
	5.5.2 Hypothesis Testing $H_{0.B.2}$, $H_{0.B.3}$, $H_{0.B.4}$, $H_{0.B.5}$, $H_{0.B.6}$	193
	5.5.2(a) Hypothesis Testing ($H_{0.B.2}$)	195
	5.5.2(b) Hypothesis Testing ($H_{0.B.3}$)	197
	5.5.2(c) Hypothesis Testing ($H_{0.B.4}$)	198
	5.5.2(d) Hypothesis Testing ($H_{0.B.5}$)	199
	5.5.2(e) Hypothesis Testing ($H_{0.B.6}$)	200
5.6	Testing of Null Hypotheses for Technology Acceptance	200
	5.6.1 Hypothesis Testing $H_{0.C.1}$	201
	5.6.2 Hypothesis Testing $H_{0.C.2}$, $H_{0.C.3}$, $H_{0.C.4}$, $H_{0.C.5}$, $H_{0.C.6}$	203
	5.6.2(a) Hypothesis Testing ($H_{0.C.2}$)	205
	5.6.2(b) Hypothesis Testing ($H_{0.C.3}$)	207
	5.6.2(c) Hypothesis Testing ($H_{0.C.4}$)	208
	5.6.2(d) Hypothesis Testing ($H_{0.C.5}$)	209
	5.6.2(e) Hypothesis Testing ($H_{0.C.6}$)	210
5.7	Summary of Findings	210
5.8	Summary	214
	CHAPTER 6 DISCUSSION AND CONCLUSION.....	215
6.1	Introduction	215

6.2	Discussion of Research Findings	216
6.2.1	Research Finding of the TMTJ Learning Applications on Students' Performance Scores.....	216
6.2.1(a)	Effects of MAR-MTJs and Web-MTJs on Students' Performance Scores	217
6.2.1(b)	Effects of MAR-TMJs and Web-MTJs on Students' Performance Scores with Different Streams of Study	219
6.2.2	Research Finding of the TMTJ Learning Applications on Students' Perceived Motivation	222
6.2.2(a)	Effects of MAR-MTJs and Web-MTJs on Students' Perceived Motivation.....	222
6.2.2(b)	Effects of MAR-TMJs and Web-MTJs on Students' Perceived Motivation with Different Streams of Studies.....	225
6.2.3	Research Finding of the TMTJ Learning Applications on Students' Technology Acceptance	228
6.2.3(a)	Effects of MAR-MTJs and Web-MTJs on Students' Technology Acceptance.....	228
6.2.3(b)	Effects of MAR-TMJs and Web-MTJs on Students' Technology Acceptance with Different Streams of Studies.....	231
6.2.4	Research Finding of Interaction Effect	234
6.2.4(a)	Interaction Effects of MAR-MTJs and Web-MTJs on Students' Performance Scores with Different Streams of Studies	235
6.2.4(b)	Interaction Effects of MAR-MTJs and Web-MTJs on Students' Perceived Motivation with Different Streams of Studies	236

6.2.4(c)	Interaction Effects of MAR-MTJs and Web-MTJs on Students' Technology Acceptance with Different Streams of Studies.....	237
6.3	Implications of the Study	238
6.3.1	Contributions to the Body of Knowledge	239
6.3.2	Contributions to Field of Knowledge.....	241
6.4	Recommendations for Future Research	243
6.5	Conclusion.....	246
	REFERENCES.....	248
	APPENDICES	
	LIST OF PUBLICATIONS	

LIST OF TABLES

		Page
Table 2.1	Previous Studies on MAR in Education	46
Table 2.2	Study on MAR in Culture-Related.....	51
Table 2.3	Relevant Literature Sources	67
Table 2.4	Definition of ARCS Model of Motivation (Keller, 1983)	75
Table 2.5	Detail of the AR Design Principles	84
Table 2.6	Relevant Research on Learning Motivation in Using AR	92
Table 2.7	Clustering of Academic Area (Stream of Studies) (Biglan, 1973)	99
Table 3.1	Different Features between the Two TMTJ Learning Applications	111
Table 3.2	Result of Content Validity of Individual Items (I-CVI)	116
Table 3.3	Threats to Internal Validity (Creswell, 2019)	123
Table 3.4	Threats to External Validity (Creswell, 2019)	126
Table 3.5	Performance Results in Pilot Testing	129
Table 3.6	Instrument Reliability	130
Table 3.7	Details of Data Analyses	132
Table 4.1	Comparison of Instructional Design Model.....	134
Table 4.2	Kinds of Constraints and Resources	141
Table 4.3	Usability Design Principles Applied in this Study (Al-Obaidi and Prince, 2022)	150
Table 4.4	Softwares were Used to Create the TMTJ Learning Applications ..	154
Table 4.5	Summary of the Experts' Comments and Suggestions from the Alpha Test.....	160
Table 4.6	Summary of the Students' Comments and Suggestions from the Beta Test.....	162
Table 4.7	Summary of Descriptive Statistics for Evaluation Checklist of TMTJ Learning Applications.....	163

Table 5.1	Sample Distribution for Intervention Modes	165
Table 5.2	Distribution of Sample Based on Moderator Variable.....	166
Table 5.3	Levene’s Test of Equality of Error Variances (Performance Scores).....	170
Table 5.4	Homogeneity of Slope between Type of Treatment and Pre-test	171
Table 5.5	Skewness and Kurtosis Values for Post-test Score	173
Table 5.6	Skewness and Kurtosis Values for Perceived Motivation Score	175
Table 5.7	Skewness and Kurtosis Values for Technology Acceptance Score .	176
Table 5.8	Homogeneity of Variance for Perceived Motivation	178
Table 5.9	Homogeneity of Variance for Technology Acceptance.....	179
Table 5.10	Descriptive Statistics for Performance Scores (Pre-test and Post-test).....	180
Table 5.11	Estimated Marginal Means	181
Table 5.12	ANCOVA Analysis for Students’ Performance Scores across MAR-MTJs and Web-MTJs.....	182
Table 5.13	Effect Size Guidelines (Cohen, 1988; Pallant, 2016)	182
Table 5.14	Descriptive Statistic for the Performance Scores between Different Streams of Study Students on MAR-MTJs and Web-MTJs	184
Table 5.15	Estimated Marginal Means for Performance Scores.....	184
Table 5.16	ANCOVA Analysis of Performance Scores by both TMTJ Learning Applications and Stream of Studies	185
Table 5.17	Results of Pairwise Comparisons of Performance Scores by both TMTJ Learning Applications and Stream of Studies.....	187
Table 5.18	Descriptive Statistics for MAR-MTJs and Web-MTJs on Perceived Motivation	192
Table 5.19	Tests of Homogeneity of Variances	192
Table 5.20	ANOVA Analysis for Students’ Perceived Motivation across MAR-MTJs and Web-MTJs.....	192

Table 5.21	Descriptive Statistic for the Perceived Motivation between Students from Different Streams of Study on MAR-MTJs and Web-MTJs ..	194
Table 5.22	Tests of Homogeneity of Variances	194
Table 5.23	Two-way ANOVA for Perceived Motivation between Hard and Soft Science Students on MAR-MTJs and Web-MTJs	195
Table 5.24	Results of Pairwise Comparisons of Perceived Motivation by both TMTJ Learning Applications and Stream of Studies.....	197
Table 5.25	Descriptive Statistics for MAR-MTJs and Web-MTJs on Technology Acceptance	201
Table 5.26	Tests of Homogeneity of Variances	202
Table 5.27	ANOVA Analysis for Students' Technology Acceptance across MAR-MTJs and Web-MTJs	202
Table 5.28	Descriptive Statistic for the Technology Acceptance between Different Streams of Study Students on MAR-MTJs and Web-MTJs.....	204
Table 5.29	Tests of Homogeneity of Variance	204
Table 5.30	Two-way ANOVA for Technology Acceptance between Hard and Soft Science Students on MAR-MTJs and Web-MTJs	205
Table 5.31	The Results of Pairwise Comparison of Technology Acceptance by TMTJ Learning Applications and Stream of Studies.....	207
Table 5.32	Summary of the Research Findings	211

LIST OF FIGURES

	Page
Figure 1.1	Theoretical Framework 23
Figure 1.2	Cognitive Theory of Multimedia Learning (Mayer, 2001)..... 24
Figure 1.3	Conceptual Framework 26
Figure 1.4	Research Framework of this Study 31
Figure 2.1	Virtuality Continuum 40
Figure 2.2	Construct AR Spaces Using 3D Perspective (Choi et al., 2018) 41
Figure 2.3	Hotspot of Industrial 4.0 Technology in Cultural Heritage (Alviz- Meza et al., 2022)..... 48
Figure 2.4	Screenshot of the Interface of the MAR Application Used in Rock Paintings 49
Figure 2.5	PoeticAR Interface for Learning Poetry (Tian et al., 2023)..... 50
Figure 2.6	Three Different Tangible AR Interfaces 50
Figure 2.7	Seven-Story Wooden Tower Scale Model Shaking Table Test (left) Construction Process (right) (Crayssac et al., 2018)..... 59
Figure 2.8	Pre-Ming Dynasty Wooden Structures (Meng et al., 2018)..... 59
Figure 2.9	The Example of the TMTJ 60
Figure 2.10	Application of TMTJ in Chinese Ancient Furniture 60
Figure 2.11	The Structure of Dual Code Theory (Curran & Hollett, 2023)..... 65
Figure 2.12	Keller’s ARCS Model of Motivational Design (Keller, 1983)..... 74
Figure 2.13	Technology Acceptance Model (Davis, 1989)..... 80
Figure 2.14	AR Design Principles (Al-Obaidi & Prince, 2022)..... 83
Figure 3.1	Research Design of the Study 106
Figure 3.2	Factorial Design of the Study..... 106
Figure 3.3	Sample Size Considered in this Study 109
Figure 3.4	The Distribution of Students in the Course..... 109

Figure 3.5	The Process of the Sampling Techniques	110
Figure 3.6	Detailed Experimental Schedule for Three Weeks	120
Figure 4.1	Alessi and Trollip’s Model of Multimedia Learning Design and Development (2001)	136
Figure 4.2	Modified Alessi and Trollip’s Model of Multimedia Learning Design and Development	136
Figure 4.3	The Planning Phase	137
Figure 4.4	The Design Phase	143
Figure 4.5	Screenshot of Multimedia Principle on the MAR-MTJs and Web- MTJs.....	147
Figure 4.6	Screenshot of Spatial Contiguity on the MAR-MTJs and Web- MTJs.....	148
Figure 4.7	Screenshot of Signalling Principle on the MAR-MTJs and Web- MTJs.....	148
Figure 4.8	Screenshot of Coherence Principle on the MAR-MTJs and Web- MTJs.....	149
Figure 4.9	Flowchart of the TMTJ Learning Application	152
Figure 4.10	Storyboard Sample of the TMTJ Learning Application	153
Figure 4.11	The Development Phase.....	154
Figure 4.12	Example of Code for the Interactive Part.....	156
Figure 4.13	Sample GUIs of the TMTJ Application	157
Figure 4.14	Illustration of TMTJ Structures (Zhang et al., 2020)	158
Figure 5.1	Linear Relationship Showing in the Scatter Plot	169
Figure 5.2	Histogram for Normality of Post-test Score	174
Figure 5.3	Normal Q-Q Plot of Post-test Score.....	174
Figure 5.4	Histogram for Normality of Perceived Motivation Score.....	175
Figure 5.5	Normal Q-Q Plot of Perceived Motivation Score	176
Figure 5.6	Histogram for Normality of Technology Acceptance Score.....	177

Figure 5.7	Normal Q-Q Plot of Technology Acceptance Score.....	177
Figure 5.8	Graph Plot of Performance Scores	186
Figure 5.9	Graph Plot of Perceived Motivation	196
Figure 5.10	Graph Plot of Technology Acceptance	206

LIST OF ABBREVIATIONS

ICH	Intangible Cultural Heritage
UNESCO	United Nations Educational, Scientific and Cultural Organization
TMTJ	Chinese Traditional Mortise–Tenon Joints
AR	Augmented Reality
MAR	Mobile Augmented Reality
TAM	Technology Acceptance Model
IMMS	Instructional Materials Motivation Scale
CTML	Cognitive Theory of Multimedia Learning
ATID	Alessi and Trollip Instructional Design Model
VC	Virtuality Continuum
HMDs	Head-Mounted Displays
PU	Perceived Usefulness
PEOU	Perceived Ease of Use
ARCS	Attention, Relevance, Confidence and Satisfaction
MAR-MTJs	Mobile AR-based Mortise Tenon Joints learning applications
Web-MTJs	Web-based Mortise Tenon Joints learning applications

**KESAN REALITI TERIMBUH MUDAH ALIH TERHADAP PRESTASI,
MOTIVASI DAN PENERIMAAN TEKNOLOGI PELAJAR KOLEJ DALAM
PEMBELAJARAN WARISAN BUDAYA TIDAK KETARA**

ABSTRAK

Integrasi teknologi digital dalam pendidikan Warisan Budaya Tidak Ketara (WBTK) telah berkembang pesat. Oleh itu, kajian ini bertujuan untuk membangunkan dan mengkaji kesan aplikasi berasaskan AR mudah alih (MAR-MTJs) dan aplikasi berasaskan Web mudah alih (Web-MTJs) dalam pembelajaran Penyambungan Mortise dan Tenon Tradisional (TMTJ) terhadap skor prestasi, motivasi, dan penerimaan teknologi di kalangan pelajar kolej. Aplikasi ini direka berdasarkan Teori Kognitif Pembelajaran Multimedia (CTML) dan prinsip reka bentuk kebolehgunaan. Suatu reka bentuk eksperimen kuasi dengan faktorial 2x2 telah diaplikasikan dalam penyelidikan ini. Pemboleh ubah bebas dalam kajian ini melibatkan dua aplikasi rawatan iaitu MAR-MTJs dan Web-MTJs. Manakala pemboleh ubah bersandar adalah (i) skor prestasi, (ii) motivasi, dan (iii) penerimaan teknologi. Pemboleh ubah moderator dalam kajian ini adalah aliran pengajian pelajar. Sampel kajian ini terdiri daripada 140 pelajar kolej dan pelajar dibahagikan kepada dua kumpulan iaitu kumpulan eksperimen menggunakan MAR-MTJs dan kumpulan kawalan menggunakan Web-MTJs. Data kajian eksperimen dianalisis dengan menggunakan ANCOVA dan ANOVA. Hasil dapatan menunjukkan bahawa pelajar yang

menggunakan MAR-MTJs mencapai skor prestasi yang lebih tinggi, lebih bermotivasi, dan penerimaan teknologi juga lebih tinggi berbanding pelajar yang menggunakan Web-MTJs. Selain itu, tidak terdapat kesan pengaruh yang signifikan bagi aliran pengajian pelajar ke atas hubungan antara aplikasi pembelajaran dengan skor prestasi pelajar dan motivasi. Walau bagaimanapun, kesan pengaruh yang signifikan ditemui bagi penerimaan teknologi. Kajian ini mencadangkan bahawa teknologi AR mudah alih dapat meningkatkan pengalaman pembelajaran pelajar dengan TMTJ, tanpa mengira aliran pengajian pelajar, sama ada mereka dalam aliran sains atau seni. Hasil kajian ini akan memberikan pandangan yang bernilai bagi memperkembangkan pendidikan Warisan Budaya Tidak Ketara (WBTK) di institusi pengajian tinggi serta menawarkan implikasi praktikal kepada pereka bentuk Realiti Terimbuh.

**THE EFFECTS OF MOBILE AUGMENTED REALITY ON COLLEGE
STUDENTS' PERFORMANCE, MOTIVATION AND TECHNOLOGY
ACCEPTANCE OF LEARNING INTANGIBLE CULTURAL HERITAGE**

ABSTRACT

The integration of digital technologies into Intangible Cultural Heritage (ICH) education has been increasing rapidly. However, effective strategies for learning and preserving ICH remain insufficiently explored. This study aims to develop and examine the effects of mobile Augmented Reality-based applications (MAR-MTJs) and mobile Web-based applications (Web-MTJs) on college students' performance, motivation, and technology acceptance in learning Traditional Mortise Tenon Joints (TMTJ). The applications were designed following the Cognitive Theory of Multimedia Learning (CTML) and usability design principles. A 2x2 quasi experimental factorial design was adopted in this research. The independent variable comprised the two types of learning applications (MAR-MTJs and Web-MTJs), while the dependent variables included (i) performance scores, (ii) perceived motivation, and (iii) technology acceptance. Additionally, students' streams of study served as a moderating variable. The study sample consisted of 140 college students, who were assigned to either the experimental group (using MAR-MTJs) or the control group (using Web-MTJs). All the collected data were analysed using ANCOVA and ANOVA. The findings indicate that students using MAR-MTJs achieved significantly

higher performance scores, greater perceived motivation, and increased technology acceptance compared to those using Web-MTJs. Besides that, no significant moderating effects of students' streams of study were observed on the relationships between the learning applications and both students' performance scores and perceived motivation, although a significant moderating effect was found for technology acceptance. These findings suggest that mobile AR technology can enhance students' learning experiences with TMTJ, regardless of students' streams of study, whether they belong to the hard science or soft science streams. These results will provide valuable insights for advancing ICH education in higher education institutions and offer practical implications for AR designers.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Traditional culture is the cultural capital of a country, and it is an essential driving force for the revitalisation of the economy. Many traditional cultures are being impacted or are on the verge of disappearing (Guo, 2020). Cultural preservation is an essential component in maintaining the unity of a country or a specific group of people (Jung et al., 2020). Promoting traditional culture will not only create jobs but also boost the regional economy. Measures and actions to improve the protection of Intangible Cultural Heritage will help nations improve their sense of identity with their national culture and enhance their self-confidence.

In 2003, when the United Nations Educational, Scientific and Cultural Organization (UNESCO) officially promulgated the Convention for the Safeguarding of the Intangible Cultural Heritage, the term "Intangible Cultural Heritage (ICH)" was formally defined, and all countries actively participated in the safeguarding of ICH (UNESCO, 2003). ICH is the historical crystallisation of a nation's thoughts, emotions and wisdom, and it is also a cultural treasure for all mankind. The preservation of ICH is of great strategic importance to the cultural development of a nation and a country, and it will contribute to the preservation of traditional national culture and cultural diversity (Lin, 2023). ICH ultimately needs the protection and inheritance of the younger generation, but factors such as changes in the living environment, the impact

of modern technology, the lack of school-related education, and the entry and dissemination of Western culture have created a distance between them and ICH. Researchers and political organisations highly endorse the promotion of ICH among college students (Yan & Li, 2023; Zhou et al., 2022). This is not only due to their higher level of education and innovation ability but also because they are in the formation period of their values and cultural identity (Li & Xie, 2023).

There are many forms of ICH transmission, such as education, social events, digital transmission and international exchange. All these forms are inseparable from the transmission of knowledge, and education plays a vital role in the transmission and inheritance of culture (Ji et al., 2020). Education in traditional culture can be learned through formal and informal learning. Formal learning is mainly through systematic training and learning about traditional culture in educational institutions. Informal learning refers to learning activities that take place in an informal setting. This type of learning does not rely on formal curricula and educational institutions but rather takes place through social events, museums, exhibitions, cultural and creative products, etc.

With the advancement of digital technology in recent years, ICH education is gradually integrating digital technology to provide a more convenient, interesting, and novel way for the inheritance and learning of traditional culture. The application of new technologies provides more possibilities for the dissemination and learning of traditional culture. For example, the use of augmented reality/virtual reality technology in museums can enable visitors to have a more comprehensive

understanding of cultural relics, and compared with traditional guided tours, digital technology is richer and more interesting for the presentation of cultural relics. Xu et al. (2023) used augmented reality (AR) technology to present the interactive experience of the cultural relics in the museum and introduced the background and basic information of the cultural relics. The results show that the use of augmented reality by users has an obvious effect on learners' motivation to learn cultural relics. Digital technology is not only applied to tangible cultural heritage but also to some invisible and intangible cultural heritage. For example, Tian et al. (2023) studied the integration of ancient poetry and heritage scenery in heritage sites where traditional Chinese ancient poems were created, combining augmented reality technology to interactively present the integration of ancient poems and heritage landscapes so that visitors can learn and understand intangible cultural heritage while enjoying the scenery. Digital technology contributes significantly to the preservation and repair of cultural artefacts in addition to being vital in the transmission and education of traditional culture. For example, Fu et al. (2020) used virtual reality (VR) technology to show the complete details of the murals in the Dunhuang murals and present the restoration techniques and processes of the murals in an interactive way, thereby conveying the restoration techniques and the awareness of the protection of the murals.

This research integrated the learning and transmission of ICH in the fields of multimedia, art, culture, and education. The purpose of this study is to emphasise the significance of augmented reality in designing ICH learning material. The effects of these factors on college students' performance scores, perceived motivation, and

technology acceptance were also evaluated. To explore and understand the nature of the problem in more depth, this study combined the theories of multidisciplinary fields. The issues related to research variables were proposed in the following subsections of this chapter.

1.2 Background of Study

As science and technology advance, the application of AR/VR technologies has become increasingly prevalent across numerous domains, particularly within education and cultural experiences. AR is a visualisation technology that visually represents ICH by seamlessly superimposing the corresponding physical places, objects, or patterns (Bekele et al., 2018). The development of AR technology has allowed us to see more possibilities, which has the potential to become a new memory technology tool (Chattopadhyay & White, 2019). Moreover, mobile augmented reality (MAR) technology circumvents the need for specialised and costly hardware (Challenor & Ma, 2019). This technology operates seamlessly on ubiquitous smartphone devices, which are widely possessed by the majority today. Such accessibility significantly enhances the prospects for widespread dissemination and educational engagement with ICH, offering a substantial advantage in its preservation and appreciation efforts.

As stated by the UNESCO Intangible Cultural Heritage List, 708 elements of ICH were recognised globally as of March 2023 (UNESCO, 2023). These elements include traditions, music, dance, festivals, crafts, and other forms of cultural

expression. China has the largest number of elements inscribed on the UNESCO Intangible Cultural Heritage List, with 43 elements as of March 2023 (UNESCO, 2023). These elements include traditions such as the Dragon Boat Festival, Chinese craftsmanship for timber-framed structures, and Chinese Calligraphy. In addition to the UNESCO list, China also maintains its national list of ICH, which includes over 1,557 elements as of 2021 (Ihchina, 2021). This list includes both cultural practices and natural phenomena, such as the traditional new year pictures, the pottery craft, and the traditional fishing methods of the Tanka people.

The safeguarding of ICH is rapidly evolving into a global social and cultural initiative with widespread impacts (Yan & Chiou, 2021). With the rapid changes in contemporary society, there is a growing concern that many traditional cultural practices and knowledge systems are at risk of being lost forever. This has prompted increased attention from researchers, policymakers, and practitioners in the field of heritage conservation.

It is reassuring that there has been an increase in interest in ICH integration in the fields of tourism and education in recent years. Many countries have developed educational programs that include ICH as a subject, and there has been an increasing emphasis on the role of ICH in sustainable tourism development (Mahfoodh & Alhashmi, 2020). By integrating ICH into these sectors, it is hoped that awareness and appreciation of intangible heritage will be increased, and its preservation will be further supported.

In China, the government has gradually realised the value of heritage protection and education, so they have formulated relevant education policies for college students to promote the development of heritage culture (Ye et al., 2021). The younger generation lacks an understanding of the importance of ICH, which usually makes them feel bored (Cao & Guo, 2020). College students, especially representatives of the younger generation, demonstrate a unique blend of inclusivity and learning ability (Tănase et al., 2023). Their ability to think outside the box and their willingness to experiment with new methods make them particularly well-suited to revitalise and sustain ICH in ways that resonate with modern audiences. On the contrary, in the current development of digital technology, young people are increasingly interested in games and short videos or the other lure of the Internet (Tang et al., 2023). This makes it common for the current inheritors of ICH to be mostly passed on by families. This will not be conducive to the spread of ICH.

Cultural heritage conservation through education and training has consistently been a topic of considerable interest (Achille & Fiorillo, 2022). As the traditional culture is suffering a serious impact (S. Kim et al., 2019), the ecological equilibrium of cultural diversity is threatened. Education can efficiently safeguard, preserve, and propagate ICH as defined by UNESCO (2003) through both structured learning within educational institutions and informal learning experiences outside of the traditional classroom setting, such as visits to museums, exhibitions, and participation in cultural tourism. Chen et al. (2023) assert that media and education play crucial roles in disseminating ICH. In the hope that our traditional culture can be passed on, education

is an inevitable method to protect ICH. Research has shown that educational engagement positively impacts the sustainability of ICH, including the preservation of cultural vibrancy and the empowerment of individuals with the knowledge necessary to safeguard the longevity of ICH (Yan & Chiou, 2021).

However, conventional methods of instruction and learning ICH mainly include guided tours, public videos and presentations on the website, or classroom learning. These methods provide learners with a passive learning experience, and these methods lack interaction and communication between learners and ICH (Tian et al., 2023). Although there are currently a large number of multimedia learning materials for learning ICH, these conventional multimedia technologies mainly include e-books, videos, audio, and pictures in mobile web applications (B. Liu et al., 2024). Mobile web applications can enhance learning effects through the combination of pictures, texts, audio and video, but the interactivity of conventional multimedia applications is still limited, and they cannot fully simulate the real operating experience and three-dimensional display effects. ICH is relatively abstract or difficult to display with text or static images, and conventional learning models often make it difficult for students to clearly identify its internal structure or pattern information. This makes students lose motivation when exposed to ICH. The conventional ways of safeguarding and inheriting ICH can no longer meet the growing needs of people, and there is an urgent need to seek new forms of inheritance and education. With the accelerated development of the information age, to realise the protection, inheritance and innovative development of ICH, people have to keep up with the wave of digitalisation

and use new digital technology to fully tap brilliant cultural values so as to realise the inheritance, protection and development of ICH.

Tzima et al. (2020) posited that new digital technology holds appeal for the younger demographic, a trend that has prompted museums to significantly enhance their exhibits with interactive digital media, as observed by Cheng and Huang (2022). Nevertheless, how do people spread and inherit these kinds of immaterial things that are invisible, intangible, and inexperienced? In addition to collecting, sorting, and preserving those cultures or making them material through records and other means, it is more important to make them continue to develop in people, groups, regions, or societies through inheritance, education, and other means. Therefore, protection is not just a material form of preservation. Under the principle of authenticity protection, a new medium is needed to build a bridge for us to understand the ICH.

In the domain of education, AR finds its application not solely in structured classroom settings but also extends to informal learning spaces such as museums, parks, and archaeological sites, among others (Vargas et al., 2020; Tian et al., 2023; Juan et al., 2017). AR applications can serve as a substitute for conventional guided tours, allowing visitors to gain a deeper comprehension of the artwork through an interactive tour that has an impact that is stimulating, immersive, and engaging (De Paolis et al., 2023). According to Vargas et al. (2020), AR systems can also be used to create, distribute, and grant access to educational materials. This will improve student motivation and the skills required for the learning process by enhancing interactivity

and immersion in the virtual content (Kaur et al., 2020). The widespread adoption of AR technology in educational contexts has significantly enhanced learners' knowledge acquisition. However, this advancement is not without its challenges, including problems regarding the efficacy of knowledge transfer, user acceptance, the intention to utilise the technology, and the sophistication of AR itself. Therefore, it makes sense to understand user acceptance of AR technology.

As a world ICH, the value contained in Chinese craftsmanship for timber-framed structures cannot be ignored. Traditional Mortise and tenon joints (TMTJ), the core elements of traditional Chinese craftsmanship for timber-framed structures, represent an ancient woodworking technique that has been developed and employed for six to seven millennia (Zhu et al., 2023). It is renowned for its exquisite craftsmanship, eco-friendly nature, and the characteristic of securely connecting wood without the need for nails or glue. However, with the advancement of modern manufacturing techniques and the pursuit of production efficiency, traditional craftsmanship faces various challenges, including the inheritance and learning of TMTJ (Lee, 2020).

Due to the complexity and hidden nature of TMTJ, learners often find it difficult to intuitively observe its three-dimensional structure and assembly method. When learners understand the mortise and tenon structure, it is usually only presented in a 2D manner in books or videos. Li (2021) emphasised that two-dimensional (2D) images lack intricate details and can lead to visitor disinterest when overloaded with

information. Research indicates that employing three-dimensional (3D) visualisation enhances students' engagement, participation, and motivation for learning (Taştı & Avcı, 2020). Moreover, it improves learner's cognitive abilities and memory retention compared to two-dimensional (2D) information (Triviño-Tarradas et al., 2022).

AR is a technology that can effortlessly combine virtual 3D data with the real world by superimposing relevant real-world locations, objects, or patterns (Bekele et al., 2018). AR technology can provide interactive teaching and guidance functions (Vargas et al., 2020). Mobile Augmented Reality (MAR) is especially advantageous because it offers accessibility and convenience, allowing learners to engage with content anytime and anywhere. Therefore, this research employed MAR technology to simulate the 2D mortise and tenon graphics on the booklet to present a 3D effect and allow learners to interact with the three-dimensional model in real time. Meanwhile, in order to evaluate the effectiveness of mobile AR-based learning, this study also developed a mobile Web-based learning application for the control group. In this study, the Web-based learning application represents the conventional media technology, which aims to learn the TMTJ structure through text and pictures only.

In China, before enrolling in college, students will be required to select the academic disciplines they want to study. It depends on the subjects they studied in high school. In the study by Biglan (1973), the academic areas (stream of studies) are categorised into two main groups: hard sciences and soft sciences. Due to the different professional background knowledge encountered by students majoring in different

disciplines, their perspectives on issues and their acceptance of new things may differ (Diao & Shih, 2019). Numerous studies underscore the notion that student's stream of studies exerts a significant influence on their emotional attributes and behavioural patterns (Gamage et al., 2021; Litten et al., 2018; Kuo et al., 2014).

Based on the aforementioned discussion, it is pertinent to delve into the domain of students' stream of studies (major) as a factor that could impact the implementation of diverse learning modules on perceived motivation and technology acceptance. Moreover, the research was carried out within a college setting, wherein the students were classified based on their academic disciplines. Hence, the stream of studies of the respondents was taken into account as the moderating variable to comprehend the impacts of the various learning modules on their perceived motivation and technology acceptance. Moreover, college students possess substantial familiarity with the Internet and demonstrate a high level of openness to novel ideas, regardless of their field of study (Tănase et al., 2023; Zaib Abbasi et al., 2022). The research outcomes have the potential to significantly contribute to comprehending the performance scores, perceived motivation and technology acceptance of higher education students towards ICH learning and can aid in the development of ICH curricula for students from various specialised fields in the future.

1.3 Problem Statement

The preservation of ICH is an urgent matter in the face of globalisation, urbanisation, and technological advancement (Tian et al., 2020). With the rapid

changes in contemporary society, there is a growing concern that many traditional cultural practices and knowledge systems are at risk of being lost forever (Chen et al., 2023). As a UNESCO World ICH, the Chinese traditional mortise and tenon structure (TMTJ) not only represents important historical and cultural information but also has educational value that should not be underestimated (Han et al., 2022). Due to the wide variety of TMTJ structures, certain joints exhibit highly complex structures, posing a challenge for learners to visually grasp the internal structure of the joints using conventional learning methods (Lee, 2020). Consequently, this has led to a decline in learners' interest and motivation towards the learning process.

In general, ICH is more familiar to most elderly people, especially concerning heritage in craftsmanship (Martins et al., 2020; Li et al., 2022). The young generation and college students are not sufficiently interested or motivated in learning ICH, and they rely more on entertainment, thereby posing a challenge to the inheritance of traditional cultures (Tang et al., 2023; Shi and Li, 2022; Tsvetkova et al., 2020; Wang, 2019). The government and schools in China are increasingly focusing on the protection and learning of ICH, and the Ministry of Education and schools have launched relevant training and research programs (Underhill and Salazar, 2016; Liu and Li, 2020). Li and Xie (2023) claimed that encouraging higher education institutions to carry out ICH learning for college students should become a sustainable approach to protecting ICH. However, efficient strategies to learn and protect ICH remain limited (Dang et al., 2021). Consequently, it is imperative to identify more

interesting and efficacious ways to promote ICH learning and protection among college students.

Numerous studies have emphasised cultural protection in digital technology (Li et al., 2022; Hou et al., 2022; Ji et al., 2020) and inheritance education (Yan & Chiou, 2021). The safeguarding and learning of ICH requires widespread public engagement and backing, especially through digital media and education (Cao & Guo, 2020), which is very important. To improve the participation of college students in ICH, it is imperative to identify a suitable way to enhance their performance scores and experience of ICH from their perspective.

While college students are currently exposed to ICH in class, they mainly use some traditional multimedia technologies to learn ICH, such as audio, video, e-books, mobile web applications in the current practice. However, these traditional multimedia materials lack interactive experience, and some intangible or hidden structural elements are difficult to present. Students who are motivated tend to engage more deeply with the material, focusing on understanding rather than merely skimming through it. Their motivation drives them to pay closer attention and make a genuine effort to comprehend the information rather than just completing tasks superficially (Lin et al., 2021a). Therefore, investigating students' perceived motivation towards the instructional material is important for researchers.

Some research findings indicated that AR has the potential to enhance students' perceived motivation (Li et al., 2023; Liu et al., 2023; Vargas et al., 2020) and boost

students' performance scores (Amores-Valencia et al., 2023; Buchner et al., 2022). Nevertheless, the motivation for learning activities facilitated by AR has not always consistently resulted in enhancements in students' performance (Elford et al., 2022; Erbas and Demirer, 2019). Despite the growing adoption of AR in education, its inconsistent impact on student performance raises critical questions about how to effectively integrate this technology into specialized domains like ICH. Current research predominantly examines AR in foundational subjects, yet the unique demands of ICH education such as preserving tacit craftsmanship and contextual cultural knowledge need to be addressed (Li et al., 2022).

Although AR has been widely adopted across various fields, the maturity of the technology itself does not guarantee its effective implementation in all educational settings (Rong & Yu, 2022). The adoption of digital technology by learners in learning craftsmanship heritage is still a significant challenge (Martins et al., 2020). The effectiveness of AR within educational contexts is contingent upon the acceptance of the technology by both learners and instructors (Silva et al., 2023). Whether AR can enhance students' perceived usefulness and perceived ease of use in the context of learning ICH remains a significant challenge. In particular, the degree to which educational technologies are accepted could significantly influence performance scores. Zuo et al. (2022) further suggest that a heightened acceptance of educational technologies has the potential to enhance students' motivation towards learning. By identifying the technical barriers to AR application in ICH education, targeted

recommendations can be provided to governments and institutions to address these issues.

Students from different stream of studies exhibit diverse learning characteristics and bring varying levels of background knowledge to their educational experiences (Diao & Shih, 2019). Orji (2010) found significant differences in technology usage behaviour and acceptance across stream of studies, highlighting the crucial role of students' stream of studies as a moderating factor in technology adoption research. Pumptow and Brahm (2023) investigated differences in the use of study-related technology across stream of studies and reported significant variations in how students from different stream of studies engage with learning technologies. Since this study was conducted in higher education institutions, students' stream of studies was considered a moderating variable.

Hence, the researcher aims to create and implement a mobile AR-based learning application (MAR-MTJs) to examine the impact of MAR-MTJs on students' performance scores, perceived motivation, and technology acceptance in this study. Furthermore, to compare the effectiveness of mobile AR-based learning, a mobile web-based learning application (Web-MTJs) with identical learning content was also be developed.

1.4 Research Objectives

The primary objective of this research is to investigate the effect of using MAR-MTJs (Mobile AR-based learning applications) and Web-MTJs (Mobile Web-

based learning applications) on learning TMTJ (Traditional Mortise Tenon Joints) and students from two different streams of studies on students' performance scores, perceived motivation and technology acceptance. The specific research objectives are as follows:

- i. To investigate the effects of using MAR-MTJs and Web-MTJs on performance scores in learning TMTJ among students with different streams of studies.
- ii. To investigate the effects of using MAR-MTJs and Web-MTJs on perceived motivation in learning TMTJ among students with different streams of studies.
- iii. To investigate the effects of using MAR-MTJs and Web-MTJs on technology acceptance in learning TMTJ among students with different streams of studies.

1.5 Research Questions

This study was conducted to investigate several research questions and sub research questions, emphasizing both the main effects and interaction effects, as detailed below:

- i. What are the effects of using MAR-MTJs & Web-MTJs on students' performance scores in learning TMTJ?
 - a. Is there any significant difference in students' performance scores using MAR-MTJs & Web-MTJs?
 - b. Is there a significant interaction effect of the type of TMTJ learning applications (MAR-MTJs & Web-MTJs) and stream of studies (Hard science & Soft science) on students' performance scores?

- c. Is there any significant difference in students' performance scores using MAR-MTJs & Web-MTJs between the students from hard science?
 - d. Is there any significant difference in students' performance scores using MAR-MTJs & Web-MTJs between the students from soft science?
 - e. Is there any significant difference in students' performance scores between the students from two different streams of studies in learning TMTJ with MAR-MTJs?
 - f. Is there any significant difference in students' performance scores between the students from two different streams of studies in learning TMTJ with Web-MTJs?
- ii. What are the effects of using MAR-MTJs & Web-MTJs on students' perceived motivation in learning TMTJ?
- a. Is there any significant difference in students' perceived motivation using MAR-MTJs & Web-MTJs?
 - b. Is there a significant interaction effect of the type of TMTJ learning applications (MAR-MTJs & Web-MTJs) and stream of studies (Hard science & Soft science) on students' perceived motivation?
 - c. Is there any significant difference in students' perceived motivation using MAR-MTJs & Web-MTJs among the students from hard science?
 - d. Is there any significant difference in students' perceived motivation using MAR-MTJs & Web-MTJs among the students from soft science?

- e. Is there any significant difference in students' perceived motivation among the students from two different streams of studies in learning TMTJ with MAR-MTJs?
 - f. Is there any significant difference in students' perceived motivation among the students from two different streams of studies in learning TMTJ with Web-MTJs?
- iii. What are the effects of using MAR-MTJs & Web-MTJs on students' technology acceptance in learning TMTJ?
- a. Is there any significant difference in students' technology acceptance using MAR-MTJs & Web-MTJs?
 - b. Is there a significant interaction effect of the type of TMTJ learning applications (MAR-MTJs & Web-MTJs) and stream of studies (Hard science & Soft science) on students' technology acceptance?
 - c. Is there any significant difference in students' technology acceptance using MAR-MTJs & Web-MTJs between the students from hard science?
 - d. Is there any significant difference in students' technology acceptance using MAR-MTJs & Web-MTJs between the students from soft science?
 - e. Is there any significant difference in students' technology acceptance among the students from two different streams of studies in learning TMTJ with MAR-MTJs?

- f. Is there any significant difference in students' technology acceptance among the students from two different streams of studies in learning TMTJ with Web-MTJs?

1.6 Research Hypotheses

In this study, the hypotheses are structured as null hypotheses. These null hypotheses pertain to the research questions and are stated below:

A. The effects of using MAR-MTJs & Web-MTJs on students' performance scores in learning TMTJ (Mortise–Tenon Joints).

H_{0.A.1}: There is no significant difference in students' performance scores using MAR-MTJs & Web-MTJs

H_{0.A.2}: There is no interaction effect between two different learning modules (MAR-MTJs & Web-MTJs) and students' stream of studies on students' performance scores.

H_{0.A.3}: There is no significant difference in students' performance scores using MAR-MTJs & Web-MTJs between the students from hard science.

H_{0.A.4}: There is no significant difference in students' performance scores using MAR-MTJs & Web-MTJs between the students from soft science.

H_{0.A.5}: There is no significant difference in students' performance scores using MAR-MTJs between the students from two different streams of studies.

H_{0.A.6}: There is no significant difference in students' performance scores using Web-MTJs between the students from two different streams of studies.

B. The effects of using MAR-MTJs & Web-MTJs on students' perceived motivation in learning TMTJ.

H_{0.B.1}: There is no significant difference in students' perceived motivation using MAR-MTJs & Web-MTJs

H_{0.B.2}: There is no interaction effect between two different learning modules (MAR-MTJs & Web-MTJs) and students' stream of studies on students' perceived motivation.

H_{0.B.3}: There is no significant difference in students' perceived motivation using MAR-MTJs & Web-MTJs between the students from hard science.

H_{0.B.4}: There is no significant difference in students' perceived motivation using MAR-MTJs & Web-MTJs between the students from soft science.

H_{0.B.5}: There is no significant difference in students' perceived motivation using MAR-MTJs between the students from two different streams of studies.

H_{0.B.6}: There is no significant difference in students' perceived motivation using Web-MTJs between the students from two different streams of studies.

C. The effects of using MAR-MTJs & Web-MTJs on students' technology acceptance in learning TMTJ.

H_{0.C.1}: There is no significant difference in students' technology acceptance using MAR-MTJs & Web-MTJs

H_{0.C.2}: There is no interaction effect between two different learning modules (MAR-MTJs & Web-MTJs) and students' stream of studies on students' technology acceptance.

H_{0.C.3}: There is no significant difference in students' technology acceptance using MAR-MTJs & Web-MTJs between the students from hard science.

H_{0.C.4}: There is no significant difference in students' technology acceptance using MAR-MTJs & Web-MTJs between the students from soft science.

H_{0.C.5}: There is no significant difference in students' technology acceptance using MAR-MTJs between the students from two different streams of studies.

H_{0.C.6}: There is no significant difference in students' technology acceptance using Web-MTJs between the students from two different streams of studies.

1.7 Theoretical Framework

The theoretical framework is the core of research, which provides the direction and basis for research and ensures that the research is systematic and scientific. These theoretical underpinnings not only inform the research methodology but also provide a comprehensive framework for the analysis and interpretation of the findings. The

selection of these theories and models is predicated on their relevance to the research objectives and their established efficacy in similar scholarly inquiries.

The theories mentioned in this section serve as the foundational theoretical framework for this research to make the learners learn better. In this study, two kinds of strategies are used to describe the theoretical framework of this research: micro strategies and macro strategies. Macro strategies refer to the broad methods used to organise and arrange teaching content as a whole, with the goal of helping students retain knowledge for a long time and be able to apply this knowledge to solve problems. Micro strategies refer to specific teaching methods and principles used to teach individual concepts or facts, ensuring that students can quickly understand and remember this information (Van Patten et al., 1986). Liang and Sedig (2009) asserted that macro-level frameworks focus on the overall structure, features, and components of a design, such as teaching methods and overall strategies, while micro-level frameworks focus on the specific details and elements of a design, such as how information is presented and how users interact with that information. The theoretical framework in Figure 1.1 illustrates the micro and macro strategies.

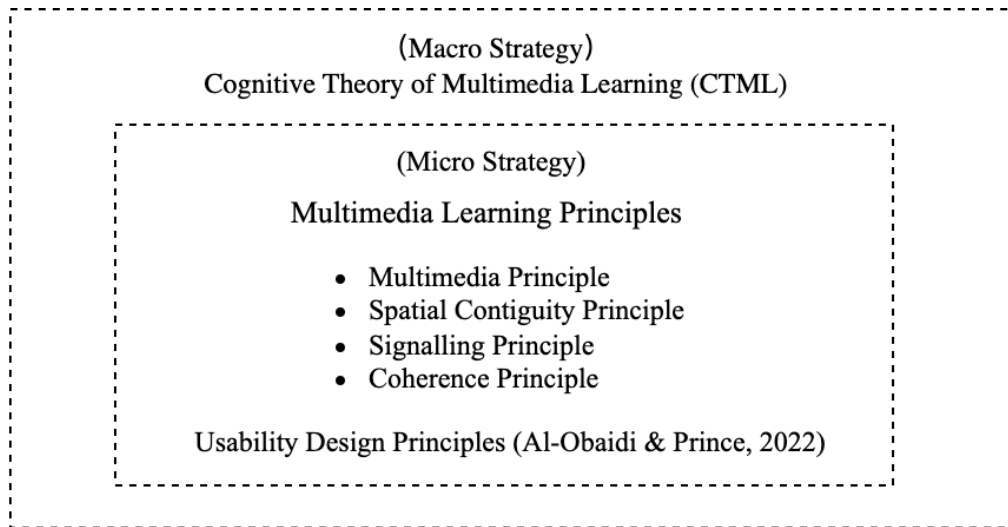


Figure 1.1 Theoretical Framework

For additional insights, Chapter Two detailed the comprehensive explanations of the theories and principles utilised in this study.

1.7.1 Cognitive Theory of Multimedia Learning

Cognitive Theory of Multimedia Learning (CTML) is highly suitable for application in Augmented Reality (AR) design because it emphasises the optimisation of cognitive processing to enhance learning efficiency (Krüger & Bodemer, 2022a). By integrating AR, which inherently involves virtual and physical information, designers can create immersive and interactive learning experiences that align with CTML principles.

Multimedia refers to the combination of various media for presentation, such as text, graphics, images, sound, and animation. Mayer (2001) proposed the CTML based on the dual-channel theory, explaining how the cognitive system allocates and processes multimedia messages during human multimedia learning. Figure 1.2

illustrates the CTML, which suggests that different types of information are processed differently.

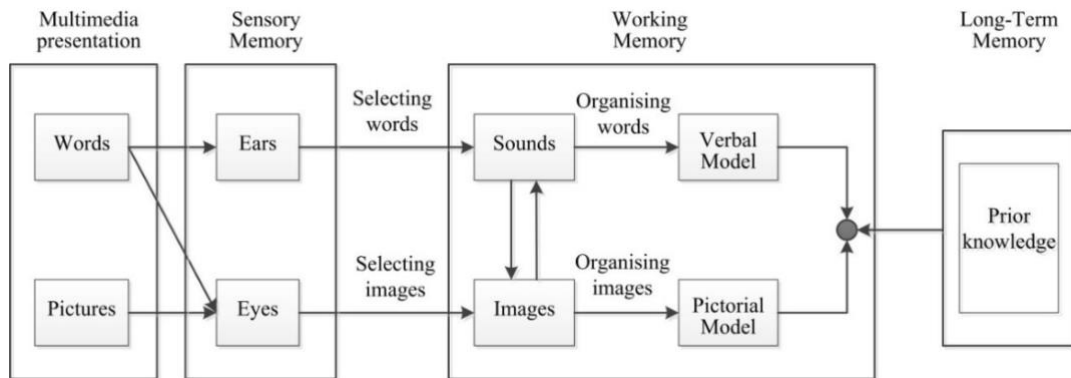


Figure 1.2 Cognitive Theory of Multimedia Learning (Mayer, 2001)

The processing of images and text is done through visual reception by the eyes, entering the visual memory area, organised into image patterns, and eventually combined with relevant prior knowledge.

In this study, multimedia serves as the primary tool for developing the TMTJ learning applications. Thus, it is crucial to use the CTML as a key reference and guideline in formulating the theoretical framework. By applying CTML, this study ensures that the learning content is presented in a way that enhances students' performance scores, perceived motivation, and technology acceptance, aligning closely with the study's objectives.

1.7.2 Multimedia Learning Principles

The principles of multimedia learning within the CTML emphasise the importance of effectively combining text, audio, and visuals to enhance learning by