

**EFFECTS OF SIGNALLING, SEGMENTATION,
AND VOICE PRINCIPLES IN INSTRUCTIONAL
MULTIMEDIA VIDEO ON MOTIVATION,
ACHIEVEMENT, AND COGNITIVE LOAD OF
COLLEGE STUDENTS**

ALI SIDDIG ALI AHMED

UNIVERSITI SAINS MALAYSIA

2025

**EFFECTS OF SIGNALLING, SEGMENTATION,
AND VOICE PRINCIPLES IN INSTRUCTIONAL
MULTIMEDIA VIDEO ON MOTIVATION,
ACHIEVEMENT, AND COGNITIVE LOAD OF
COLLEGE STUDENTS**

by

ALI SIDDIG ALI AHMED

**Thesis submitted in fulfilment of the requirements
for the degree of
Doctor of Philosophy**

September 2025

ACKNOWLEDGEMENT

This thesis is dedicated to those who have assisted me directly or indirectly in completing my research. Without their help, I would not have been able to complete my thesis. Firstly, I would like to thank my supervisor Prof. Dr. Irfan Naufal Umar and my former supervisor Prof. Dr. Mona Masood for their expert guidance in my writing of this report and directing my thesis. I would also like to extend my gratitude to Prof. Dr. Wan Ahmad Jaafar Wan Yahaya, Dr. Chau Kien Tsong, and Ts. Dr. Jeya Amantha Kumar as my panel of examiners during the proposal defense for their continued support and guidance throughout my PhD journey, and for providing great insights and feedback on my dissertation. I also want to thank the staff of CITM for assisting me along the way. From the first day I started my PhD journey in USM until today, everyone has been very helpful in helping me in so many ways. I believe I will not be able to complete this journey without everyone's assistance, and I thank everyone for that. I am so grateful for my wife, Khadiga Elfatih, and my children, Mohammed, Alma, Eva, and Asmar for their help and encouragement, which gave me the ability to complete my doctorate and successfully reach my goals.

Ali Siddiq Ali

TABLE OF CONTENTS

ACKNOWLEDGEMENT	ii
TABLE OF CONTENTS	iii
LIST OF TABLES	viii
LIST OF FIGURES	x
LIST OF APPENDICES	xii
ABSTRAK	xiii
ABSTRACT	xv
CHAPTER 1 INTRODUCTION	1
1.1 Introduction	1
1.2 Background of study	1
1.3 Problem statement	5
1.4 Research Objectives	7
1.5 Research questions	8
1.6 Research hypotheses	9
1.7 Theoretical framework	11
1.8 Conceptual framework	16
1.9 Significance of the study	19
1.10 Operational definitions	23
1.11 Limitations	26
1.12 Delimitations	28
1.13 Summary	28
CHAPTER 2 LITERATURE REVIEW	29
2.1 Background	29
2.2 Defining Multimedia	30
2.3 Instructional multimedia video (IMV)	32

2.4	Cognitive Theory of Multimedia Learning (CTML)	35
2.4.1	Dual-channel assumption	41
2.4.2	Limited capacity assumption.....	42
2.4.3	Active Processing Assumption.....	43
2.5	Cognitive Load Theory (CLT)	45
2.5.1	Reducing Extraneous Processing	51
2.5.2	Managing Essential Processing.....	53
2.5.3	Fostering Generative Processing.....	54
2.6	The Theoretical Considerations	56
2.7	Gender and IMV.....	58
2.7.1	Segmentation.....	62
2.7.2	Signalling	64
2.7.3	Voice principle	67
2.7.4	Motivation	69
2.7.5	Achievement.....	74
2.7.6	Previous Research on IMV	76
2.7.7	Learning an Introductory Computer Course	86
2.7.8	Advantages of Instructional Multimedia Videos	88
2.8	Disadvantages of Instructional Multimedia Videos	90
2.9	Research Gaps	91
2.10	Summary	92
	CHAPTER 3 RESEARCH METHODOLOGY	94
3.1	Introduction	94
3.2	Research Design.....	95
3.3	Population & Sampling	99
3.4	Research Variables	101
3.5	Research Instruments	103

3.5.1	Demographics items.....	105
3.5.2	Motivation Instrument.....	106
3.5.3	Achievement Instrument.....	106
3.5.4	Cognitive Load of Mental Effort Questionnaire (CLMEQ)	108
3.6	Reliability And Validity.....	108
3.6.1	Reliability.....	109
3.6.2	Validity.....	110
3.6.3	Threats to internal and external validity.....	111
3.7	Pilot Study.....	114
3.8	Research Procedure of the Actual Study.....	119
3.9	Instructional Treatment.....	123
3.9.1	Signalling with Voice Treatment (SiV).....	124
3.9.2	Segmentation with Voice Treatment.....	125
3.9.3	Signalling, Segmentation and Voice Treatment.....	128
3.9.4	Instructional Treatment Procedures.....	129
3.10	Data Analysis.....	130
3.10.1	Descriptive Statistics.....	131
3.10.2	Inferential Statistics.....	132
3.11	Summary.....	135
CHAPTER 4 DESIGN AND DEVELOPMENT		136
4.1	Introduction.....	136
4.2	ADDIE model.....	138
4.2.1	Phase 1: Analysis.....	142
4.3	Preliminary Study.....	144
4.3.1	Phase 2: Design.....	145
4.4	Instructional Multimedia Video (IMV) Material.....	147
4.4.1	Phase 3: Development.....	155

4.4.2	Phase 4: Implementation	161
4.4.3	Phase 5: Evaluation	162
4.5	Summary	164
CHAPTER 5 FINDINGS		165
5.1	Introduction	165
5.2	Descriptive Statistics	166
5.3	MANCOVA Assumptions	169
5.4	Inferential Analysis	176
5.4.1	Test of Hypothesis 1	177
5.4.1(a)	Motivation.....	177
5.4.1(b)	Achievement	179
5.4.1(c)	Cognitive load.....	180
5.4.2	Test of Hypothesis 2.....	182
5.4.2(a)	Gender in terms of Motivation	183
5.4.2(b)	Gender in terms of Achievement.....	184
5.4.3	Test of Hypothesis 3.....	184
5.4.3(a)	Interaction effects in terms of motivation.....	184
5.4.3(b)	Interaction effects in terms of achievement.....	186
5.4.3(c)	Interaction effects in terms of cognitive load	188
5.5	Summary of findings	190
CHAPTER 6 DISCUSSION AND CONCLUSIONS		192
6.1	Introduction	192
6.1.1	The Findings in Relation to the Research Objectives	197
6.1.2	The Effects of three IMV modes on Motivation, Achievement and Cognitive Load.	201
6.1.2(a)	Motivation.....	201
6.1.2(b)	Achievement	204
6.1.2(c)	Cognitive Load	205

6.1.3	The differences between male and female students in motivation, achievement and cognitive load.....	207
6.1.3(a)	Gender in terms of Motivation	207
6.1.3(b)	Gender in terms of Achievement.....	209
6.1.3(c)	Gender in term of Cognitive Load.....	210
6.1.4	Interaction Effect between IMV modes and Gender.....	212
6.1.4(a)	Interaction Effect between IMV modes and Gender on Motivation.....	212
6.1.4(b)	Interaction Effect between IMV modes and Gender on Achievement	214
6.1.4(c)	Interaction Effect between IMV modes and Gender on Cognitive Load	215
6.2	Research Implications	217
6.3	Theoretical contributions.....	220
6.4	Practical contributions.....	221
6.5	Research Limitations.....	221
6.6	Recommendations and Future Study.....	223
6.7	Conclusion.....	226
	REFERENCES.....	228
	APPENDICES	

LIST OF TABLES

	Page
Table 2.1	Three different ways of information processing.....39
Table 2.2	Multimedia Instructional Development Principles50
Table 3.1	The Research Design.....98
Table 3.2	Summary of Research Variables 102
Table 3.3	Research Instrument..... 104
Table 3.4	Cognitive Load of Mental Effort Questionnaire 108
Table 3.5	Reliability values for the research instrument..... 117
Table 3.6	Treatment/Lesson Plan..... 123
Table 3.7	SSV/Method..... 126
Table 3.6	Data Analysis 133
Table 4.1	The steps of research and development of the ADDIE model..... 141
Table 4.2	IMV segmentation..... 148
Table 4.3	Gagne’s Nine Events of Instruction and Internal Mental Process ... 157
Table 4.4	Pre-Instructional Activity..... 159
Table 4.5	Instructional Activity 160
Table 4.6	Post Instructional activity..... 161
Table 5.1	Descriptive Statistics for Participant Demographics 166
Table 5.2	The descriptive statistics of the three dependent variables 167
Table 5.3	Tests of Normality..... 172
Table 5.4	Distribution of groups based on gender. 173
Table 5.5	Correlations among dependent variables 174
Table 5.6	Box's Test of Equality of Covariance Matrices. 175
Table 5.7	Levene's Test of Equality of Error Variances. 175

Table 5.8	MANCOVA results for the effects of the three IMVs and motivation	177
Table 5.9	Post hoc test for IMV modes on motivation	178
Table 5.10	MANCOVA result for the effects of the three IMVs and achievement.....	179
Table 5.11	Post hoc test for IMV modes on achievement	179
Table 5.12	MANOVA result for effects of the three IMVs and cognitive load	181
Table 5.13	Post hoc test for IMV modes on cognitive load.....	181
Table 5.14	Levene's Test of Equality of Error Variances.	183
Table 5.15	Descriptive statistics of the three dependent variables among.....	183
Table 5.16	Interaction effect between IMV and gender on Motivation.....	185
Table 5.17	Descriptive Statistics for Motivation	185
Table 5.18	Interaction effect between IMV and gender on Achievement	186
Table 5.19	Descriptive Statistics for Achievement.....	187
Table 5.20	Interaction effect between IMV and gender on Cognitive Load.....	188
Table 5.21	Descriptive Statistics for Cognitive Load	189
Table 5.22	Summary of Findings.....	190

LIST OF FIGURES

	Page
Figure 1.1	CTML and the working memory model 15
Figure 1.2	The Conceptual framework..... 19
Figure 2.1	Cognitive Theory of Multimedia Learning (Mayer, 2010).....36
Figure 2.2	Design Solution Layout.58
Figure 3.1	Research Framework for IMVs Study95
Figure 3.2	The 3 x 2 factorial design applied in this study98
Figure 3.3	Pilot Test 115
Figure 3.4	Data Collection Procedure 120
Figure 3.5	Research Procedure..... 122
Figure 4. 1	Developed version of ADDIE Model 140
Figure 4.2	Segment Introduction 149
Figure 4.3	Signalled Clip..... 150
Figure 4. 4	IMV Storyboard Production Sketch..... 152
Figure 4. 5	IMV Story layout 153
Figure 4. 6	SiV screen shots 155
Figure 4. 7	SeV screen shots 156
Figure 4. 8	SSV screenshots 156
Figure 5. 1	Normal Boxplots of Motivation. 170
Figure 5. 2	Normal Boxplots of Achievement. 170
Figure 5. 3	Normal Boxplots of Cognitive Load..... 171
Figure 5.4	Interaction plot between IMV modes and gender in terms of motivation. 186

Figure 5.5	Interaction plot between IMV modes and gender in terms of achievement.....	188
Figure 5.6	Interaction plot between IMV modes and gender in terms of cognitive.....	190

LIST OF APPENDICES

APPENDIX A	DEMOGRAPHIC QUESTIONNAIRE
APPENDIX B	MOTIVATION QUESTIONS FROM
APPENDIX C	ACHIEVEMENT – KNOWLEDGE LEVEL QUESTIONS
APPENDIX D	COGNITIVE LOAD MENTAL EFFORT QUESTIONNAIRE
APPENDIX E	SITE APPROVAL REQUEST LETTER
APPENDIX F	REVIEW PANEL FEEDBACK FORM
APPENDIX G	LETTER TO PARTICIPANTS
APPENDIX H	REQUEST FOR PERMISSION TO CONDUCT RESEARCH
APPENDIX J	PREVIOUS STUDIES INVESTIGATIONS

**KESAN PRINSIP ISYARAT, SEGMENTASI DAN SUARA
DALAM VIDEO MULTIMEDIA INSTRUKSI TERHADAP MOTIVASI,
PENCAPAIAN DAN BEBAN KOGNITIF PELAJAR KOLEJ**

ABSTRAK

Video Multimedia Instruksi (IMV) adalah antara aplikasi teknologi pendidikan yang terhasil akibat perkembangan konsep multimedia. Walaupun IMV telah digunakan dalam pelbagai bidang dan disiplin ilmu serta dalam semua peringkat pendidikan, beberapa prinsip multimedia seperti prinsip isyarat, prinsip segmentasi dan suara boleh dipertimbangkan dalam mereka bentuk IMV bagi memberi kesan terhadap pembelajaran pelajar. Kajian ini bertujuan mengkaji kesan isyarat, segmentasi, dan suara dalam IMV terhadap motivasi, pencapaian dan beban kognitif pelajar. Seramai 159 orang pelajar dari Kolej Kejuruteraan Universiti Bisha, Arab Saudi telah didedahkan kepada tiga kumpulan rawatan IMV iaitu (a) IMV dengan gabungan prinsip isyarat, segmentasi dan suara, SSV, (b) IMV dengan gabungan prinsip isyarat dan suara, SiV, dan (c) IMV dengan gabungan prinsip segmentasi dan suara, SeV. Selepas rawatan, perbezaan tahap motivasi, pencapaian dan beban kognitif mereka telah diukur. Kajian ini mendapati bahawa tiada perbezaan signifikan antara kumpulan SSV, SiV dan SeV dari aspek motivasi, pencapaian, dan beban kognitif para peserta kajian. Ini menunjukkan bahawa ketiga-tiga kumpulan adalah setara dalam kesemua pemboleh ubah bersandar walaupun mereka menerima mod rawatan berbeza. Seterusnya, kajian turut mendapati tiada perbezaan signifikan antara pelajar lelaki dan pelajar perempuan bagi ketiga-tiga pemboleh ubah bersandar tersebut. Dapatan turut menunjukkan tiada kesan interaksi antara kaedah IMV (SSV, SeV dan SiV) dengan jantina pelajar bagi pemboleh ubah motivasi, pencapaian dan beban kognitif. Kajian

ini mencadangkan penggunaan IMV sebagai strategi pembelajaran untuk meningkatkan motivasi, pencapaian, dan mengurangi beban kognitif pelajar. Gabungan prinsip-prinsip reka bentuk pembelajaran multimedia (Isyarat, Segmentasi dan Suara) juga penting untuk mencapai hasil pembelajaran yang positif.

**EFFECTS OF SIGNALLING, SEGMENTATION, AND VOICE PRINCIPLES
IN INSTRUCTIONAL MULTIMEDIA VIDEO ON MOTIVATION,
ACHIEVEMENT, AND COGNITIVE LOAD OF COLLEGE STUDENTS**

ABSTRACT

Instructional Multimedia Video (IMV) is one of the educational technology applications due to the expansion of multimedia design concept. Although IMV has been applied in various sectors and knowledge disciplines as well as in several levels of education, some multimedia principles including signalling, segmentation and voice principles can be considered in designing IMV to affect students' learning. This study attempts to investigate the impact of signalling, segmentation, and voice principles in IMV on college students' motivation, achievement, and cognitive load. A sample of 159 students from the University of Bisha College of Engineering, Saudi Arabia were treated with three IMV interventions: (a) IMV with signalling, segmentation, and voice principles, SSV, (b) IMV with signalling and voice principles, SiV, and (c) IMV with segmentation and voice principles, SeV. After the interventions, the differences on the participants' motivation levels, achievement, and cognitive load were measured. The findings indicate no significant differences in motivation, achievement, and cognitive load between the SSV, SeV and SiV groups. These findings show that all treatment groups are equal in all three dependent variables although they were treated differently. In addition, the study found no significant differences in all three dependent variables between the male and female students. The analyses also indicate no significant interaction effects between the three IMV methods (SSV, SeV and SiV) and the students' gender for motivation, achievement, and cognitive load. The study recommends using IMV as a learning strategy to enhance students' motivation,

achievement, and cognitive load. A combination of the design principles of multimedia learning (Signalling, Segmentation and Voice) is also essential in order to achieve positive learning outcome.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Videos are used for passive or active learning in a variety of asynchronous, synchronous and face to face educational settings and learning conditions. Various types of videos can be utilized to improve teaching and learning based on the course learning outcomes, students' learning needs, and instructional strategies (Galatsopoulou et al., 2022). Videos can enhance students' understanding of course content while providing an engaging and dynamic learning environment. Furthermore, visuals support and enhance the effectiveness of teaching methodologies because the way the message is presented may work in accordance with the student's capacity to decode the semantic of the learning message (Nicolaou, 2021).

This chapter will provide an overview of the study's background and address the problem statement related to the implementation of instructional videos. It will outline the research questions aimed at exploring these issues, along with the study's objectives and hypotheses. Additionally, the chapter will discuss the study's significance, the theoretical framework, and the operational definitions of key concepts and variables.

1.2 Background of study

The rise of multimedia education tools has brought about new challenges in ensuring these tools are effective and accessible for students. The integration of multimedia instructional videos in education has grown significantly in recent years due to advancements in technology and the increasing demand for flexible, engaging learning methods. However, to ensure these instructional videos are effective, they must

be designed with cognitive and motivational considerations in mind. Instructional multimedia video (IMV) is an educational technology tool that integrates video with additional modalities, including audio, text, and animation. Its purpose is to enhance student motivation, achievement and overall learning outcomes. Incorporating media (abstract illustrations, images, audio, video, animations, or a combination of all) into teaching increases learners' interest, comprehension, and interaction (Sasan & Rabillas, 2022). Based on the previous studies on the use of dynamic audio-visual learning materials in education, students prefer instructional video as compared to text and they are also more likely to understand the material conceptually deeper when watching a video than when reading only (Mayer, 2002, 2003; Mayer & Moreno, 2002).

An Introductory Computer course, which is required as part of the first-year studies curriculum, is the main course for most first-year students of University of Bisha in Saudi Arabia. Therefore, providing students with appropriate computer skills for their studies and the job market is becoming increasingly important. The main stumbling block for most students, especially in the first year of study is introductory computer course, which is an essential part of the computer studies curriculum. Aside from hardware devices, one of the three primary pedagogical goals of computer learning is to cover basic concepts of the number system and conversions. Mastering the number system concept is critical because it prepares students for their computer course on first year of study.

The human brain is more adept at remembering information when it is presented visually (Ilesanmi, 2023). Therefore, instructional video is shown to be an effective teaching tool that produces better results than traditional learning techniques.

Instructional videos could aid to represent in the learner's mind like the progress of a phenomenon, and the value representation of the interaction designated in a text could benefit selected related information (Cheng, Lu, & Yang, 2015). Furthermore, visual medium emphasizes concepts, improves comprehension, and broadens learners' perception by providing an abstract representation of information (Nicolaou, 2021).

Nevertheless, the current study systematically reviews the limited body of research on the use of multimedia instruction in engineering education, assessing its effectiveness in enhancing the current learning landscape. Multimedia applications are shown to play a critical role in highlighting key concepts, deepening comprehension, and broadening students' understanding, as they transform abstract or complex information into accessible and structured representations (Nicolaou, 2021). Building on these findings, research by Stalbovs et al., (2015) emphasizes the importance of both content design and the learner's ability to effectively process multimedia materials. By focusing on instructional design principles, Stalbovs and colleagues aimed to improve educational outcomes, demonstrating that multimedia tools offer significant benefits when appropriately designed and aligned with learners' cognitive processing capabilities.

The signalling principle (adding cues to highlight essential information), the segmentation principle (breaking content into smaller, manageable chunks), and the voice principle (using human voices instead of machine-generated ones) are critical multimedia design principles grounded in Cognitive Load Theory (CLT) and Mayer's Multimedia Learning Theory. These principles aim to optimize the way learners process information by reducing extraneous cognitive load and enhancing engagement. Selected

Cognitive Theory of Multimedia Learning (CTML) design principles proposed by Richard Mayer (2020) were used in various ways during the design of the instructional multimedia videos, with varying degrees of integration into each video. In addition, Mayer (2014b) proposed three multimedia design principles based on three learning states - extraneous processing, generative process, and germane. These three learning states are important concepts to be considered in designing effective learning experiences. By understanding how multimedia principles affect learning outcomes, instructors can design IMVs that improve academic success while minimizing cognitive strain.

Despite these theoretical advancements, there remains a gap in understanding how these design principles influence student motivation, achievement, and cognitive load specifically in higher education settings. College students often face challenges with motivation and information overload when engaging with instructional videos, which can impact their learning outcomes. These foundational CTML principles offer the basis for particular strategies to design an instructional video. This contributes a framework in which IMV includes signalling, segmentation, and voice over, which could be tested as a variable influencing students' motivation, achievement, and cognitive load. Research claimed that instructional videos (particularly with infographics/visuals illustrations) contribute substantial differences in students' learning performance, motivation, achievement, and reduce their cognitive load (Ismaeel & Mulhim, 2021). The findings of this study are expected to offer valuable insights into the effects of various IMV methods, providing guidance for enhancing the design and implementation of instructional multimedia videos.

This study aims to explore the effects of signalling, segmentation, and voice principles on the motivation, achievement, and cognitive load of college students using instructional multimedia videos. Understanding these relationships will guide the development of optimized instructional videos, which will be discussed further in the methodology section. The findings are expected to provide insights into designing effective multimedia learning tools that align with the cognitive and motivational needs of learners in higher education.

1.3 Problem statement

Despite the growing use of IMVs as an educational tool, their design often fails to optimize learning outcomes, particularly in addressing student motivation, achievement, and cognitive load. Key design elements, such as signalling, segmentation, and modality integration, are frequently underutilized or misapplied, limiting the potential of instructional videos to create meaningful and engaging learning experiences. This gap highlights the need for research into effective video design strategies that balance cognitive load while fostering motivation and achievement in diverse educational contexts. Furthermore, numerous studies have found that academic motivation tends to decrease during first year program, thus, we need to understand the factors that may influence students' motivation (Elfeky & Elbyaly, 2023). In other words, there is a need for an effective instructional video that can address these challenges by presenting information in motivating, concise, and visually stimulating manner, fostering and managing better understanding, knowledge retention, and real-world application among students. Moreover, many instructional videos may not be

developed according to the CTML design principles (Mayer, 2003; 2014a; Moreno, 2002).

As highlighted by Homer, Plass, and Blake (2008), the cognitive demands associated with processing multimedia information emphasize the critical role of efficient memory utilization in managing cognitive load and achieving effective learning outcomes. In particular, cognitive researchers have recognized three main important categories in using graphics, audio, and visual elements in instruction: (a) the challenges for students to focus their attention on important elements in the audio-visual material, (b) the transitory form of dynamic visualizations materials, and (c) the implication of irrelevant content that contrasts with essential materials for limited cognitive resources (Alonso & de Koning, 2020).

The problem in the current study was the lack of applying instructional strategy design of IMV. The study attempts to integrate instructional technology and design principles to increase motivation, achievement and decrease cognitive load among first year engineering college students who are enrolled in an introductory computer course. Numerous researchers have asked for enhancements to the instructional technology setting, in an attempt to reduce the lack of this psychological characteristic, for instance, instructional content design (Arabai & Ratcliffe, 2013). Merely watching IMVs will not help for deep learning to occur, the students need to actively interact with the materials (Mayer, 2018). Based on the above-mentioned statement, the problem can be formulated to investigate the effectiveness of instructional multimedia video in developing academic motivation, achievement, and cognitive load across groups of male and female students. Furthermore, gender inequalities may emerge due to

differences in teaching strategies used and their relationship to level of motivation, achievement, and cognitive load. Therefore, from this study, some insights highlight the critical role of well-designed, interactive instructional technologies in fostering successful learning outcomes.

1.4 Research Objectives

This research aims to develop an instructional multimedia video (IMV) for undergraduate students based on Cognitive Theory of Multimedia Learning (CTML). This study focused on applying CTML's signalling, segmentation, and voice principles. It also aims to determine the degree to which method of IMV is beneficial in affecting students' motivation, achievement, as well as reducing their cognitive load. Thus, the three research objectives are:

1. to investigate the differences in motivation, achievement, and cognitive overload between the students who received three different IMV methods [signalling and segmenting with voice (SSV), signalling with voice (SiV), and segmenting with voice (SeV)],
2. to investigate the differences in motivation, achievement, and cognitive overload between male and female students who received IMV methods, and,
3. to examine the interaction effect of IMV methods [signalling and segmenting with voice (SSV), signalling with voice (SiV), and segmenting with voice (SeV)] and gender on students' motivation, achievement, and cognitive load.

1.5 Research questions

The following three research questions guided this study:

Based on Research Objective 1

- RQ1** Are there significant differences in terms of motivation, achievement, and cognitive overload between the students who received: (a) signaling and segmentation with voice (SSV), (b) signaling with voice (SiV), and (c) segmentation with voice (SeV) interventions?
- RQ1a** Is there any significant difference in motivation between the SSV, SiV, and SeV groups?
- RQ1b** Is there any significant difference in achievement between the SSV, SiV and SeV groups?
- RQ1c** Is there any significant difference in cognitive load between the SSV, SiV and SeV groups?

Based on Research Objective 2

- RQ2** Are there any significant differences between male and female students in terms of motivation, satisfaction, achievement, and cognitive load after IMV interventions?
- RQ2a** Is there any significant difference between male and female students in terms of motivation after learning from IMV?
- RQ2b** Is there any significant difference between male and female students in terms of achievement after learning from IMV?
- RQ2c** Is there any significant difference between male and female students in terms of cognitive load after learning from IMV?

Based on Research Objective 3

- RQ3** Are there any significant interaction effects between IMV method and gender in terms of motivation, satisfaction, achievement, and cognitive load?
- RQ3a** Is there any significant interaction effect between IMV method and gender in terms of students' motivation?
- RQ3b** Is there any significant interaction effect between IMV method and gender in terms of students' achievement?
- RQ3c** Is there any significant interaction effect between IMV method and gender in terms of students' cognitive load?

1.6 Research hypotheses

The current study attempts to examine the differences in learning outcomes between the groups of students who received SSV, SiV, and SeV interventions enrolled in Introductory Computer course (specifically on the topic of Data representation). Nine hypotheses were designed in this study:

Hypothesis statement

- H₀₁** There are no significant differences in motivation, achievement, and cognitive overload between the students who received the Signalling and Segmentation with Voice (SSV), Signalling with Voice (SiV) and Segmentation with Voice (SeV) video methods.

- H_{01a}** There is no significant difference in motivation between SSV, SiV and SeV groups.
- H_{01b}** There is no significant difference in achievement between SSV, SiV and SeV groups.
- H_{01c}** There is no significant difference in cognitive overload between SSV, SiV and SeV.
- H₀₂** There are no significant differences in terms of motivation, achievement and cognitive load between male and female students who received the instructional multimedia video interventions.
- H_{02a}** There is no significant difference in terms of motivation between male and female students who received the IMV methods.
- H_{02b}** There is no significant difference in terms of achievement between male and female students who received the IMV methods.
- H_{02c}** There is no significant difference in terms of cognitive load between male and female students who received the IMV interventions
- H₀₃** There are no significant interaction effects between IMV modes and gender in terms of students' motivation, achievement and cognitive load.
- H_{03a}** There is no significant interaction effect in terms of motivation between the IMV modes and gender.

H_{03b} There is no significant interaction effect in terms of achievement between the IMV modes and gender.

H_{03c} There is no significant interaction effect in terms of cognitive load between the IMV modes and gender.

1.7 Theoretical framework

The current study draws on numerous theoretical perspectives to investigate the relationship between instructional design principles (Signalling, Segmentation, and Voice) and the learning outcomes of motivation, achievement, and cognitive load. These theories provide a robust foundation for understanding how the study's variables interact within the specific educational context of Saudi engineering students in a computer science course.

To analyze learner motivation, the study employs Self-Determination Theory (SDT) and Keller's ARCS Model of Motivation. SDT posits that motivation is driven by the fulfillment of three basic psychological needs: independence, competence, and relatedness (Deci & Ryan, 1985). Instructional design elements such as signaling, segmentation, and voice can foster these needs by providing clear, organized, and engaging content that aligns with learners' intrinsic and extrinsic goals. Keller's ARCS model (1987), on the other hand, focuses on attention, relevance, confidence, and satisfaction as the four pillars of motivation in learning. By applying signaling to direct attention, segmentation to make content relevant and manageable, and voice to enhance learner confidence and satisfaction, the study aligns its instructional design strategies with well-established motivational theories.

To understand how instructional design impacts academic performance, the study considers Bloom's Taxonomy of Learning Domains and Achievement Goal Theory. Bloom's Taxonomy categorizes learning objectives into cognitive, affective, and psychomotor domains, providing a framework to evaluate how signaling, segmentation, and voice influence comprehension, application, and retention of course content (Bloom, 1956). Meanwhile, Achievement Goal Theory explores how learners' orientation toward mastery (intrinsic) or performance (extrinsic) goals impacts their academic success (Elliot & McGregor, 2001). By structuring content to meet both mastery-oriented and performance-oriented needs, the instructional design principles aim to enhance learners' achievement levels.

The study's focus on cognitive load is grounded in Cognitive Load Theory (CLT) while incorporating insights from Dual Coding Theory (DCT) and Schema Theory. CLT (Sweller, 1988) explains how the intrinsic, extraneous, and germane cognitive load impacts learning efficiency. Signaling reduces extraneous cognitive load by clarifying complex content, while segmentation manages intrinsic load by presenting information in smaller, more digestible chunks. Voice enhances germane load by fostering better cognitive engagement with the material.

Dual Coding Theory (Paivio, 1986) highlights the role of visual and auditory processing in multimedia learning, supporting the use of signaling and voice to integrate these modalities effectively. Schema Theory (Bartlett, 1932; Anderson, 1984) emphasizes the importance of prior knowledge structures in learning. Segmentation aligns with this theory by presenting information in a structured manner that supports the gradual development of learners' schemas.

These theories inform the design and analysis of IMVs tailored to Saudi engineering students. By aligning the instructional design principles with motivational, achievement related, and cognitive load focused theories, the study ensures a comprehensive approach to address the challenges of teaching computer science to a diverse student population. This theoretical framework underscores the potential of evidence-based strategies to enhance learning outcomes while providing practical insights for educators and instructional designers in similar educational settings.

In the domain of multimedia learning, several competing theories provide frameworks for understanding how learners process and preserve information. The Cognitive Theory of Multimedia Learning, CTML (Mayer, 2014) offers a holistic framework specifically designed to multimedia learning, making it the most applicable choice for this study. CTML integrates principles from CLT, DCT, and motivational theories, providing a comprehensive explanation of how learners process multimedia content.

The CTML builds upon three foundational assumptions to explain the processes underlying effective multimedia learning. First, it assumes that individuals process information through dual channels one for auditory/verbal input and another for visual/pictorial input. Second, it emphasizes the limited capacity of each channel, meaning only a finite amount of information can be processed at a time. Third, it highlights the active nature of learning, where learners filter and select relevant information, organize it into coherent mental structures, and integrate it with existing knowledge (Lo & Tsai, 2022). Additionally, CTML outlines principles for designing

effective instructional multimedia materials, grounded in these core assumptions (Wang, Mayer, Han & Zhang, 2023).

Furthermore, CTML's empirical foundation includes design principles such as signalling, segmentation, and voice, directly addressing the independent variables of this study. These principles are particularly relevant for Saudi engineering students in a computer science course, where cognitive demands are high, and motivation plays a critical role in academic success. While competing theories contribute valuable perspectives to understanding multimedia learning, CTML's integration of cognitive, motivational, and instructional design principles makes it the most suitable framework for this study. Its ability to explain the interactions between signalling, segmentation, and voice with motivation, achievement, and cognitive load ensures that the study is both theoretically grounded and practically applicable.

The three sorts of multimedia design principles offered by Mayer (2014b) were based on three learning contexts. With active learning, students engage in three forms of cognitive processing when they use learning communications (Mayer, 2002a; 2014b). Because of this, the design should be tailored to engage students' cognitive processes (Chiu & Churchill, 2015; Mayer, Lee, & Peebles, 2014). These activities were meant to provoke meaningful responses and encourage students to focus on comprehending rather than memorising (Chiu & Churchill, 2015; Krammer et al., 2006). There were three aspects of the human brain, according to CTML, which together dictate learning efficiency:

1. The audio and visual channels in our brains allow us to process information in two different ways.

2. There is a decline in processing new information via working memory due to the limited capacity of the human brain
3. The learner's dynamic involvement must process additional information to develop new knowledge or enhance old schematics (Greer, Crutchfield, & Woods, 2005; Kirschner & Paul, 2002; Sorden, 2005).

The following CTML model (Figure 1.1) visually represents this study's theoretical framework. During instruction, work memory overload happens by reducing, managing, and fostering to accept and organise the incoming information.

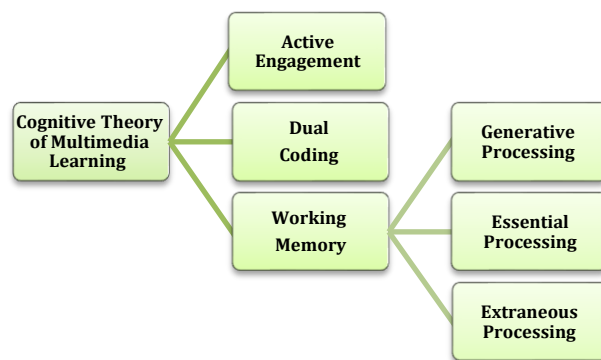


Figure 1.1 CTML and the working memory model (Mayer, 2014b; Sorden, 2005a)

The integration of multiple theories supplements the conceptual framework of this study, providing a nuanced understanding of how signalling, segmentation, and voice effect motivation, achievement, and cognitive load. This multi theoretical approach not only strengthens the study's validity but also increases its applicability to diverse educational contexts.

1.8 Conceptual framework

A conceptual framework acts as the guiding framework, providing specific elements or concepts that specify the relationships among the research variables in order to achieve a research project's goal and outlining how these relationships come together to produce logical conclusions (Swaen & George, 2022). The conceptual framework for this study is designed to examine the relationship between instructional design principles namely signaling, segmentation, and voice and their impact on the key learning outcomes of motivation, achievement, and cognitive load. This framework is contextualized within the specific educational setting of Saudi engineering students enrolled in a computer science course, addressing both theoretical underpinnings and practical applications. The study aims to achieve the following objectives: (i) to enhance motivation by creating engaging and learner friendly instructional materials, (ii) to improve academic achievement through better comprehension and retention of course content, and (iii) to reduce cognitive load to ensure students focus on meaningful learning rather than unnecessary mental effort. Since this study is quantitative in nature, the theories used are intended to be used to frame this study by defining concepts, organizing ideas, and identifying relationships.

Hence, the study will be conducted with the following concepts as variables: The design principles of signaling, segmentation and voice as independent variables, while the students' motivation, achievement, and cognitive load will be the dependent variables. Firstly, the signaling principle refers to the use of visual or auditory cues to emphasize key information and guide learners' attention. For example, highlighting, arrows, or verbal emphasis can direct focus to critical content. Secondly, the segmentation principle involves dividing instructional content into smaller, manageable

sections to facilitate understanding. This principle is especially beneficial for engineering students dealing with intricate programming or theoretical concepts in computer science. Segmentation reduces intrinsic cognitive load by breaking down challenging content into digestible parts, fostering sustained engagement and deeper learning. Thirdly, the voice principle pertains to the narration style used in instructional multimedia, such as human or synthetic voices, and its clarity and pacing. For Saudi students, a clear and engaging narration, possibly in their native language or accessible English, enhances relatability and comprehension. This principle ensures alignment between auditory and visual elements, minimizing extraneous cognitive load and fostering motivation.

Instructional multimedia videos incorporating signalling, segmentation, and effective voice narration create an engaging and learner centred experience. This fosters intrinsic motivation by connecting the material to students' goals and providing them with confidence to succeed. Clear instructional design facilitates better comprehension and long-term retention of complex computer science concepts, leading to improved academic performance among the students. Each design principle addresses different types of cognitive load. Signalling reduces extraneous load, segmentation manages intrinsic load, and effective voice delivery ensures germane load is optimized for learning.

This theoretical foundation for this study is grounded in two primary theories: The cognitive theory of multimedia learning CTML by Mayer (2024), explores how learners process information presented in multimedia formats, emphasizing the importance of well-designed instructional materials. The Cognitive Load Theory CLT

by Sweller (2020), highlights the significance of managing mental effort during learning. The design principles aim to optimize cognitive resources, enabling students to focus on understanding and applying knowledge effectively. The practical applications for the framework provide actionable insights for educators and instructional designers to create effective multimedia content tailored to engineering students. Universities can adopt these principles as part of their instructional standards to enhance learning outcomes. The framework's principles are versatile and can be applied to other disciplines and educational contexts.

This conceptual framework underscores the critical role of signaling, segmentation, and voice in improving motivation, achievement, and cognitive load. By addressing the specific needs of Saudi engineering students in a computer science course, the study provides a targeted approach to instructional design. The integration of these principles promises to enhance educational outcomes, offering a robust foundation for further research and practical application in multimedia learning environments. The conceptual framework of this study is depicted in Figure 1.2. The research framework below shows the independent variables (IVs) that represent the design principles from CTML, and the dependent variable (DV) represented by motivation, achievement and cognitive load as a learning outcome. Meanwhile, gender moderates the interaction effects between IMV modes and students' motivation, achievement and cognitive load.

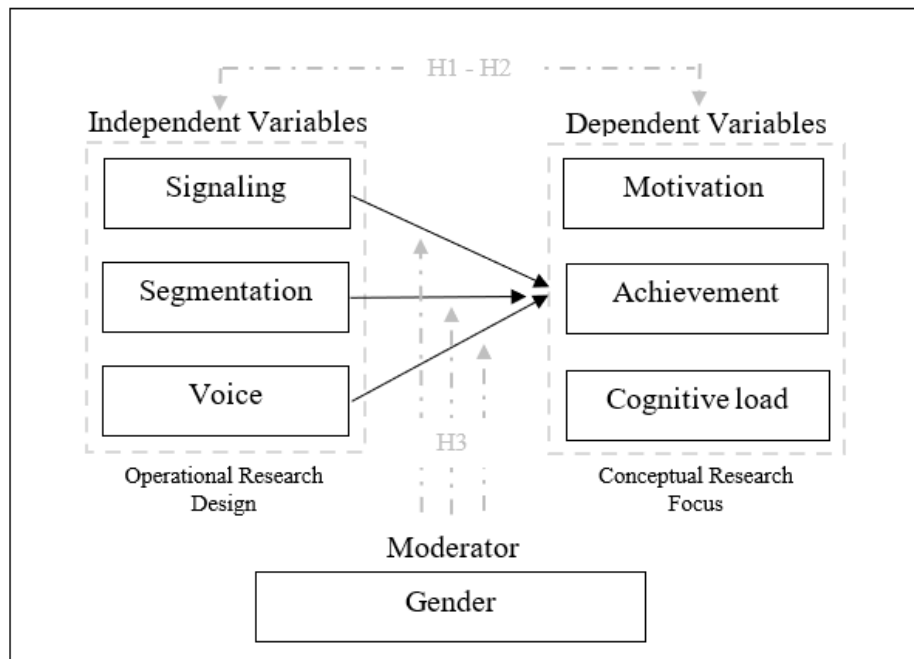


Figure 1.2 The Conceptual framework

1.9 Significance of the study

A diverse learning environment can be accommodated by using instructional multimedia videos, which create an atmosphere in which all students are eager to advance their knowledge (Allison, 2015a). Because instructional videos are becoming more and more common in both online and face-to-face learning, the study of their effectiveness is essential (Shipper, 2013). According to Melendez (2013), well-designed videos help students become more productive in their studies and more motivated.

The contributions of this study would be of interest to scholars in instructional technology and multimedia as well as to teach designers, particularly in designing instructional multimedia videos based on CTML using the relevant design principles.

In addition, Cognitive Load Theory (CLT) identifies an ideal instructional design that efficiently uses an individual's limited cognitive processing capability to obtain and apply skills and knowledge (Sweller, 2020). People learn by actively utilizing cognitive resources, such as picking relevant information and creating a coherent mental representation. Finally, people know by integrating newly obtained information with current knowledge (Mayer, 2024). CLT and CTML share a theory as the foundation for this argument (Mayer, 2014b). As claimed by Shipper (2013), research in this area is also essential: “Studying the effectiveness of instructional videos is important because it is a delivery method that is becoming more and more popular” (p.6).

This study attempts to investigate motivation in learning from IMV. Motivation relates to how a learner is intensively involved, motivates, continues goal-directed performance, and employs an effort-making sense of the instructional messages so that positive achievement can be produced (Estrella & Mayer, 2014). According to Krammer (2006), achieving relevance, confidence, and satisfaction is important for learning and being motivated in a lesson. Ed, Jessica and Perry (2013) stated that learners who learned through instructional videos commonly have an optimistic attitude. IMV is significant in assisting students in developing mental representations during learning. Connecting any combination of visual and verbal information improves and increases student recall. It is assumed that IMV will significantly improve motivation, achievement, and reduce cognitive load in an introductory computer course. In other words, IMV strategies are aimed at assisting students in developing their computer skills, which include theoretical and practical knowledge.

The findings of this study will help researchers to better understand the benefits of IMV and design principles in improving students' computer performance in Introductory Computer course. If this method is proven to be effective in improving learners' performance in learning basic computer skills, educators in government colleges may adopt it. Perhaps the IMV could be used as an alternative delivery method to face-to-face instruction for lecturers in Saudi colleges and universities.

Ideally, this study would influence the introductory computer course program on student learning outcomes at the University of Bisha, Saudi Arabia. Studies show that this procedure for instructional video design is favored by students and leads to effective and profound learning (Allred, Duffy, & Smith, 2016; Mayer, 2014b; Mohamed Ibrahim, 2011).

The findings of this study may be approved by the Ministry of Higher Educations in Saudi Arabia as proper strategy for teaching computer course skills at Saudi colleges and universities to prompt better understanding and performance in computer skills. Furthermore, the study could be used as a foundation for future research into the methodologies used, as well as the effects of educational technologies for improving learning in colleges and universities.

Numerous studies on instructional video have been conducted in several countries; nevertheless, the current study will be conducted in Saudi Arabia's educational context. In associating to the effects of CTML design principles applied to an instructional video that reviewed from research resources, several studies were reported in Saudi Arabia, United Kingdom, United States, Australia, China, Brazil,

Finland, and France (Blayney, Kalyuga, & Sweller, 2015; Mayer & Estrella, 2014; Muhammad, 2018; Shahid & Ali, 2017). Most of these studies have been focusing on the design principles of multimedia learning applied to the instructional video content (Clark, Nguyen, Sweller, & Baddeley, 2006; Mayer & Moreno, 2010). Moreover, some of these studies focused on the content design and measuring the cognitive overload that happens during the instruction within face-to-face lectures at Saudi higher education institutions. Hence, the study has the main outcome of developing the instructional content design used in the Saudi Arabia educational setting. The outcomes of the current study may contribute to several design elements - SSV, SiV and SeV - focusing on the advancement of an instructional video used in educational settings.

An instructional video could be enhanced by the findings of these studies, which could add to the existing body of information on CTML and CLT. Some experimental investigations of instructional multimedia video design had not used this paradigm, particularly in Saudi Arabia. Thus, the findings of this research would aid in implementing instructional multimedia video and a better understanding of the technique used in content creation.

The study contributes to the design and conceptualization of effective instructional methods and face-to-face learning by creating new information on how to improve learner motivation and achievement while reducing cognitive load. It will integrate the instructional design principles, which could help other researchers focus on this topic, especially in the conventional face-to-face education settings commonly used in Saudi Arabia. One important contribution of this study is employing IMV as online and offline instruction. Online education could be defined as digital lessons or

computer-based education brought on a digital style intended to support teaching (Mayer, 2019). This study is the first to be conducted on an introductory computer course in a face-to-face classroom setting to encourage motivation, achievement and reduce cognitive overload with students at the University of Bisha in Saudi Arabia, specifically via an IMV.

This study illustrates that applying multimedia design principles to IMV can increase students' achievement, motivation, and reduce cognitive load. The findings could perhaps support framing recommendations and strategies to improve novel instruction and content design methods in Saudi online education. Therefore, this study presents specific suggestions, recommendations, and IMV design strategies.

1.10 Operational definitions

The following are the operational definitions for the variables and concepts covered in this study:

Cognitive load. Is defined as the mental effort experienced by learners while engaging with IMVs. According to Sweller's Cognitive Load Theory, there are three types of cognitive load, namely, intrinsic, extraneous and germane load. In this study, the students' cognitive load will be assessed through intrinsic, extraneous and germane load instrument, Measurement Extraneous Questionnaire (MEQ) developed by Leppink et al., (2013). As Intrinsic Load: Measured by the complexity of the learning material, controlled through consistent task difficulty across the study. Extraneous Load: Evaluated based on learner feedback about distractions or unclear elements in the video design. Germane Load: Measured through reflective questions assessing the learners'

schema-building and understanding of the material. These measures collectively quantify the learners' cognitive load to examine its relationship with motivation and achievement outcomes.

Instructional multimedia video (IMV). For the purposes of this study, an IMV is defined as a structured, multimedia-based educational tool designed to deliver content to undergraduate students. These videos integrate multiple modalities, including visual content such as diagrams, animations, or live-action demonstrations to visually represent the instructional material. Second, auditory content narration and sound effects synchronized with the visuals to reinforce learning. Third, textual content as on-screen text or captions providing supplementary explanations. The IMVs in this study apply signalling, segmentation and voice principles. The SSV is the main treatment which uses signalling, segmentation and voice principles aimed at fostering generative and reducing extraneous processing. The second mode, i.e., the SiV mode, was designed based on the signalling and voice principles in which the titles of the essential material topics were highlighted with bold font, borders, and colour, and the important elements were cued with arrows and animations. For the third IMV, i.e., the SeV, the main material was divided into small series of clips based on the segmentation and voice principles.

These videos are tailored to the curriculum content of a selected undergraduate course and are evaluated for their impact on students' motivation, achievement, and cognitive load.

Motivation. Motivation, according to Keller (1983), refers to “the choices people make as to what experiences or goals they will approach or avoid, and the degree