THE EFFECTS OF GRAPHICS AND ANIMATION WITH WORKED EXAMPLES IN THE TEACHING OF ELECTROLYSIS ON LEARNERS WITH DIFFERENT COGNITIVE STYLES

by

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LIST OF ABBREVIATIONS

ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
ESG	Example with Static Graphic
FD/FI	Field-Dependence/Field-Independence
FD	Field-Dependence
FD-ESG	Field-Dependence learners who used the Example with Static Graphic
FD-WEAG	Field-Dependence learners who used the Worked Example with Animated Graphic
FD-WESG	Field-Dependence learners who used the Worked Example with Static Graphic
FI	Field-Independence
FI-ESG	Field-Independence learners who used the Example with Static Graphic
FI-WEAG	Field-Independence learners who used the Worked Example with Animated Graphic
FI-WESG	Field-Inependence learners who used the Worked Example with Static Graphic
GEFT	Group Embedded Figures Test
ICT	Information and Communication Technology
IQ	Intelligence Quotient
SD	Standard Deviation
SPSS	Statistical Packages for Social Sciences
WEAG	Worked Example with Animated Graphic
WESG	Worked Example with Static Graphic
USM	Universiti Sains Malaysia

KESAN GRAFIK DAN ANIMASI DENGAN CONTOH BERPANDU DALAM PENGAJARAN ELEKTROLISIS TERHADAP PELAJAR DENGAN GAYA KOGNITIF BERBEZA

ABSTRAK

Kajian ini mengkaji kesan contoh berpandu dan kesan grafik animasi dalam contoh berpandu dalam koswer multimedia pembelajaran terhadap pencapaian pelajar yang pelbagai gaya kognitif. Tiga mod persembahan koswer multimedia pembelajaran yang berbeza, iaitu (i) mod *Example with Static Graphic* (ESG), (ii) mod *Worked Example with Static Graphic* (WESG) dan (iii) mod *Worked Example with Animated Gpahic* (WEAG), telah direka bentuk dan dibangunkan secara sistematik untuk memenuhi tujuan kajian ini. Kajian eksperimen kuasi menggunakan rekabentuk faktorial 3 x 2 dengan mengambil tiga mod persembahan koswer multimedia pembelajaran yang berbeza (ESG, WESG dan WEAG) sebagai pembolehubah tidak bersandar dan gaya kognitif *field-dependence/field-independent* (FD/FI) pelajar sebagai pembolehubah moderator. Skor pencapaian pelajar merupakan pembolehubah. Statistik deskriptif dan inferens telah dijalankan untuk menganalisis data yang dikumpul. Dari segi pencapaian, dapatan analisis menunjukkan bahawa pelajar yang menggunakan mod WESG menunjukkan prestasi yang lebih baik secara signifikan berbanding dengan pelajar yang menggunakan mod ESG. Apabila gaya kognitif pelajar diambilkira, pelajar-pelajar FD yang menggunakan mod WESG menunjukkan prestasi pencapaian yang lebih baik secara signifikan berbanding dengan pelajar-pelajar FD yang menggunakan mod ESG. Antara pelajar FI, mereka yang menggunakan mod WESG menunjukkan prestasi pencapaian yang lebih baik secara signifikan berbanding dengan mereka yang menggunakan mod ESG. Mengambil pelajar-pelajar secara keseluruhan, dapatan analisis menunjukkan bahawa pelajar-pelajar yang menggunakan mod WEAG tidak

menunjukkan prestasi pencapain yang lebih baik secara signifikan berbanding dengan pelajar-pelajar yang menggunakan mod WESG. Apabila gaya kognitif pelajar diambilkira, pelajar-pelajar FD yang menggunakan mod WEAG tidak menunjukkan prestasi pencapaian yang lebih baik secara signifikan berbanding dengan pelajar-pelajar FD yang menggunakan mod WESG. Antara pelajar-pelajar FI, mereka yang menggunakan mod WEAG menunjukkan prestasi pencapaian yang lebih baik secara signifikan berbanding dengan mereka yang menggunakan mod WESG.

THE EFFECTS OF GRAPHICS AND ANIMATION WITH WORKED EXAMPLES IN THE TEACHING OF ELECTROLYSIS ON LEARNERS WITH DIFFERENT COGNITIVE STYLES

ABSTRACT

This study investigated the impact of worked example effect and animated graphic effect in worked example in multimedia learning courseware towards learners' achievement for learners with different cognitive styles.Three different presentation modes of multimedia learning courseware, namely (i) Example with Static Graphic mode (ESG), (ii) Worked Example with Static Graphic mode (WESG) and (iii) Worked Example with Animated Graphic mode (WEAG), were systematically designed and developed to serve the purpose of this study. This quasi-experimental study employed a 3 x 2 factorial design by taking the three different presentation modes of multimedia learning courseware (ESG, WESG and WEAG) as the independent variable and the learners' cognitive styles of field-dependence/field-independence (FD/FI) as the moderator variable. The dependent variable was the learners' achievement score. Descriptive and inferential statistics were performed to analyse the data. The analyses revealed that learners who learned with WESG mode performed significantly better compared to those who learned with ESG mode. When the learners' cognitive styles were taken into consideration, the FD learners who learned with WESG mode performed significantly better compared to FD learners who learned with ESG mode. Among FI learners, the FI learners who learned with WESG mode performed significantly better compared to FI learners who learned with ESG mode. When taking the learners as whole, the analyses also revealed that learners who learned with WEAG mode does not performed significantly better compared to those who learned with WESG mode. When the learners' cognitive styles were taken into consideration, the FD learners who learned with WEAG mode

does not performed significantly better compared to FD learners who learned with WESG mode. However, the FI learners who learned with WEAG mode outperformed significantly those FI learners who learned with WESG mode.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter explains the general structure, concept and framework of this study. The research background of this study is discussed followed by the problem statement. The significance of this study is then highlighted to show the contributions of this study from practical standpoint. Both theoretical framework and research framework are described to capture the overall structure of the research. This chapter also includes the limitations of this study as well as the definitions of variables and key terms used in this dissertation.

1.2 BACKGROUND

Malaysia is moving towards realising its vision to be a progressive and fully developed country by the year 2020. One of the aims of Vision 2020 is to establish a scientific and progressive society. Hence, the challenge is to establish a society that is innovative, forward-looking and one that is a consumer of technology and side by side a contributor to scientific and technological civilisation of the future (Krishnasamy, 2007). Thus, the emphasis on science and technology in schools has introduced Information Communication Technology (ICT) and multimedia technology as one of the delivery systems.

1.2.1 Role of Information Communication Technology (ICT) in Malaysia Education System

In order to fulfil the Vision 2020, the multimedia technology has been brought into the education system (Krishnasamy, 2007). One of the projects that

have been launched is the Smart School project. In this project, the schools have been systematically reinvented in terms of its teaching and learning practices as well as the school management via the use of ICT. By doing so, it enables students to practice self-assessed and self-directed learning by focusing on individual achievements and development (Ministry of Education, Malaysia, 1997). The Ministry of Education is also attempting to reduce the barrier that exists in different parts of the country particularly the schools in rural areas and the schools in cities, by providing computer laboratories to thousands of schools to enable teachers toutilise the computers and ICT into the teaching and learning process.

The Ministry of Education is fully aware that ICT plays a vital role in education. In order to make this resilient, efforts are geared towards developing new media as tools in the service of richer curricula as well as enhanced pedagogies. The Ministry of Education further believes that properly designed and implemented ICT and multimedia learning tools have the potential to inspire education and enhance learning (Chan, 2002).

1.2.2 The Use of ICT and Multimedia Technologies in Teaching and Learning of Science Subjects

ICT along with multimedia technologies in learning environment provide students with speedy access to new information. Some salient examples of its practical application is that it can make teaching and learning more diversified, flexible, and effective (Dawson, Forster, & Reid, 2006).

Kumar and Helgeson (2000) noted that science education reform emphasised the need for integrating computer technology such as computer-based laboratories, interactive videos, simulations, intelligent tutors, the internet and the World Wide Web (WWW) into teaching and learning of science. They strongly supported that a better education in science is possible by enhancing the method of teaching and learning, with special emphasis on the use of computer technology. Dawes (2001) also supported that new multimedia technologies have the potential to support science education and improve communications in teaching science between teachers and students in ways that have not been possible before.

The ICT and multimedia technology in teaching and learning science has enable information to be presented in various modes such as text, sound, static graphic and animated graphics (Daniels, 1996). Numerous cases have confirmed the effectiveness of such learning tools to boost students' thinking level (Lim, 2007), facilitate problem-solving (Hennessy, Ruthven, & Brindley, 2005; Markauskaite, 2007), and offer learning tools which can develop related scientific abilities (McFarlane & Sakellariou, 2002). Emphasis in ICT and multimedia technology in learning environment will help students in developing a better visual and graphics understanding of scientific concepts (Ainsworth, 1999).

Several measures have been successfully explored such as integrating computer-based learning environments aiming at promoting learning and attaining goals in teaching science (Bodemer, Ploetzner, Bruchmuller, & Hacker, 2005; Lowe, 2003). These innovations improved their ability to master scientific concepts and developed positive student attitudes toward science (King-Dow Su, 2008).

1.2.3 Teaching and Learning of Chemistry

For the past few years, chemistry courses have undergone several changes in terms of what is taught and how it is taught. The latest change took place in 2000. The chemistry syllabus was reorganised and several teaching and learning approaches of science were introduced. The latest chemistry curriculum for secondary school in Malaysia aims (Ministry of Education, 2005) to provide students the knowledge and skills in chemistry and technology. Besides, it also aims to enable students to solve problems as well as to make decisions in daily life based on scientific attitudes and noble values.

Thoughtful learning is emphasised in the teaching and learning strategies in chemistry curriculum. It is a process that guides students to acquire knowledge and to master skills. Some of the teaching and learning approaches that are introduced in the new curriculum are:

i) inquiry-discovery which emphasises learning through experiences. Inquiry means to question, to search information and to investigate a phenomenon that is happening in the surroundings.

ii) constructivism; it suggests that students learn when they construct their own understanding.

iii) contextual learning which is an approach that learning associates with students' daily experiences.

iv) mastery learning which is an approach that ensures all students are able to acquire and master the intended learning objectives. It is based on the principle that if students are given adequate opportunities, they are able to acquire and master the intended knowledge or skill.

Besides the teaching and learning approaches, the use of technology is important in the teaching and learning of chemistry. This is because technology has great potentials in enhancing the learning of chemistry. For example, television, radio, video, computer, and internet can make the teaching and learning of chemistry more interesting. In addition, animation and computer simulation are effective tools that can be presented through courseware or web page for the teaching and learning of abstract or difficult chemistry concepts.

1.2.4 Effectiveness of Worked Example

Worked example is a step-by-step approach of demonstrating procedural learning material and methods to perform a task or to solve a problem (Clark & Mayer, 2008c). Worked example can effectively reduce cognitive load by freeing working memory capacity during the construction of new knowledge. New knowledge forms as learning progresses. Hence, worked example is useful in helping learners automate new knowledge (Clark & Mayer, 2008c). Embedding worked example into a lesson and continue to use it in practice does make learning efficient. Moreover, worked example has been found to be useful in many domains such as physics, mathematics, and computer programming (Atkinson & Renkl, 2007); concept mapping (Hilbert & Renkl, 2007); and geometry (Tarmizi & Sweller, 1988). Learners who learn with worked example usually need less time for learning and the probability of making mistakes decreases (Sweller & Cooper 1985; Paas & van Merriënboer 1994).

1.2.5 Graphic and Animation as Visualisation Aid

Graphics used in teaching and learning can be perceived as a representation of an object, a concept, or a process that can be detected by the eye, independent of the use of text or numbers (Fong, 2000). In this study, the researcher defines drawing, charts, graphs, maps, or photos as static graphics while animated graphic and video as dynamic graphic.

According to Clark (2007) there are five different kinds of content that can be taught using graphics, which are: (1) fact, (2) concept, (3) process, (4) procedure, and (5) principle. These kinds of content can effectively use graphics as a visual aid in teaching and learning process.

Animation is a popular technique that is usually incorporated into multimedia courseware to enhance the learning experience and learning outcomes. The reason behind this is that animation consists of dynamic graphics that changes and moves continuously in demonstrating some phenomena that are difficult to visualise (Clark & Mayer, 2008; Şimşek, 2009).

1.2.6 Learners' Differences and Pedagogical Design

In designing a learning material, learners' differences have to be considered so that learners with different learning style can learn well using the same learning material. In this study, learners' cognitive styles (FD/FI) were taken into consideration. This is due to the nature of field-dependent (FD) learners and field-independent (FI) learners that requires different pedagogical approach to learn. Based on literature review, worked examples approach and graphical approach seem to

show a potential to serve as effective strategies for both FD and FI learners. In addition, the field-dependence-independence dimension has been the most extensively studied and has had the widest application to educational problems (Witkin et al., 1997). Besides, Fong (2000) compiled several research studies (Toh, 1995; Sabrina, 1997; Fong & Ng, 2000) conducted in Malaysia that reported the effective use of Computer Aided Instruction in learning to reduce the gap of achievement between FD learners and FI learners.

1.3 PROBLEM STATEMENT

Many students report that chemistry is one of the most difficult subjects to learn and understand (Nordin & Lee, 2010; Sirhan, 2007). In addition, chemistry courses are generally taught at a level of abstraction. Teachers often use chemical symbols, mathematical formulas and scientific measurements to illustrate the non-visible phenomena in chemistry classes. Thus, the abstract knowledge of chemistry has a direct negative effect on learning for students (Stieff & Wilensky, 2002). Gabel (1999) also claimed that chemistry is a very complex and difficult subject to learn. Many researchers (Chan, 1998; Gabel, 1999; Muth & Guzman, 2000; Yalcinalp et al., 1995) also reported that chemistry is an abstract and a formal subject that often resulting in students facing learning difficulties.

1.3.1 Challenges in Teaching and Learning of Electrochemistry

Based on past research studies, many teachers and students have ranked electrochemistry as being one of the most difficult topics to teach and to learn (Ceyhun & Karagölge, 2005; Doymus, Karacop, & Simsek, 2010; Jong & Treagust, 2002; Yang, Andre, Greenbowe, & Tibell, 2003). The researchers identified that the

learning difficulty is due to the fact that most processes which occur in electrochemistry cannot be observed with the naked eye. Thus, students find it hard to visualise and understand the dynamic chemical processes (Doymus et al., 2010).

As for this study, a preliminary survey on the learning difficulties in chemistry faced by secondary school students was conducted in Kedah and Penang. A total number of 184 Form Five students were requested to respond to a survey which consists of eighteen likert scale items (Appendix A). During the survey, it was found that 74% students ranked electrochemistry as one of the top three difficult topics to learn. They claimed that most processes that occur in electrochemistry cannot be observed with naked eyes and caused them difficult to visualise and to understand the dynamic chemical processes in electrochemistry. The concept of electrolysis is the main foundation for the learning of Electrochemistry. The researcher identified that electrolysis is a form of procedural knowledge topic that depicts the decomposition of an electrolyte through electric current. The explanation of the procedural knowledge involves a series of steps that may be too complex for the students.

Learning electrolysis concept requires a lot of efforts in terms of visualisation, especially when students attempt to understand the non-visualised processes in the movement of ions and the transferred of electrons. Hence, graphic either static or animated could be used to facilitate the learning of electrolysis concept and to enhance the students' understanding towards the concept. Animations may be more efficient in enhancing learning, but, several past research studies (Arguel & Jamet, 2009; Ayres, Marcus, Chan & Qian, 2009; Boucheix & Schneider, 2009; Lin &

Atkinson, 2011; Tunuguntla et al., 2008) that explored the effect of animated graphic compared to static graphic on learning yielded mixed results in certain conditions.

1.3.2 Embedding Graphic into Worked Example

Electrolysis involves a lot of procedural steps and visualisation. Researcher believes that a combination of worked example and graphics will help learners to learn electrolysis better. This is because segmented graphics when embedded into worked example help the learners to visualise the process in a stepwise manner. However, the concern here is whether the animated graphics will enhance the worked example effect in learning. Therefore, this study attempt to examine the effect of worked example alone and the effect of worked example with embedded animations that could create a better learning experience for learners in learning electrolysis resulting in enhanced learning outcomes.

1.4 RESEARCH OBJECTIVES

The main objective of this study is to examine the effect of: (1) worked example and (2) animated graphic in worked example, in multimedia learning courseware towards learners' achievement.

The specific objectives of this study are:

1. To design and develop three different presentation modes of multimedia courseware, namely the (i) Example with Static Graphic mode (ESG), (ii) Worked Example with Static Graphic mode (WESG) and (iii) Worked Example with Animated Graphic mode (WEAG).

2. To examine the effects of WESG courseware in multimedia learning courseware towards learners' achievement for learners with different cognitive styles (FD/FI) in relation to ESG courseware.

3. To examine the effects of animated graphic in WEAG courseware in multimedia learning courseware towards learners' achievement for learners with different cognitive styles (FD/FI) in relation to WESG courseware.

1.5 RESEARCH QUESTIONS

Based on the research objectives, six research questions were formulated to be addressed. The research questions were:

Research Question 1 (Q1):

By taking the learners as a whole, would the learners who used WESG courseware will perform significantly better than the learners who used ESG courseware in terms of achievement?

Research Question 2 (Q2):

Among the FD learners, would the learners who used WESG courseware will perform significantly better than the learners who used ESG courseware in terms of achievement?

Research Question 3 (Q3):

Among the FI learners, would the learners who used WESG courseware will perform significantly better than the learners who used ESG courseware in terms of achievement?

Research Question 4 (Q4):

By taking the learners as a whole, would the learners who used WEAG courseware will perform significantly better than the learners who used WESG courseware in terms of achievement?

Research Question 5 (Q5):

Among the FD learners, would the learners who used WEAG courseware will perform significantly better than the learners who used WESG courseware in terms of achievement?

Research Question 6 (Q6):

Among the FI learners, would the learners who used WEAG courseware will perform significantly better than the learners who used WESG courseware in terms of achievement?

1.6 RESEARCH HYPOTHESES

Based on the research questions, six directional hypotheses were formulated to test the effect of independent variable towards dependent variable.

Hypothesis 1:

H_1: By taking the learners as a whole, the learners who used WESG courseware will perform significantly better than the learners who used ESG courseware in the mean of achievement scores, μ_A, that is:-

$$\mu_{A\ (WESG)} > \mu_{A\ (ESG)}$$

Hypothesis 2:

H_2: Among the FD learners, the FD learners who used WESG courseware (FD-WESG) will perform significantly better than the FD learners who used ESG courseware (FD-ESG) in the mean of achievement scores, μ_A, that is:-

$$\mu_{A\ (FD\text{-}WESG)} > \mu_{A\ (FD\text{-}ESG)}$$

Hypothesis 3:

H_3: Among the FI learners, the FI learners who used WESG courseware (FI-WESG) will perform significantly better than the FI learners who used ESG courseware (FI-ESG) in the mean of achievement scores, μ_A, that is:-

$$\mu_{A\ (FI\text{-}WESG)} > \mu_{A\ (FI\text{-}ESG)}$$

Hypothesis 4:

H_4: By taking the learners as a whole, the learners who used WEAG courseware will perform significantly better than the learners who used WESG courseware in the mean of achievement scores, μ_A, that is:-

$$\mu_{A\ (WEAG)} > \mu_{A\ (WESG)}$$

Hypothesis 5:

H_5: Among the FD learners, the FD learners who used WEAG courseware (FD-WEAG) will perform significantly better than the FD learners who used WESG courseware (FD-WESG) in the mean of achievement scores, μ_A, that is:-

$$\mu_{A\ (FD\text{-}WEAG)} > \mu_{A\ (FD\text{-}WESG)}$$

Hypothesis 6:

H_6: Among the FI learners, the FI learners who used WEAG courseware (FI-WEAG) will perform significantly better than the FI learners who used WESG courseware (FI-WESG) in the mean of achievement scores, μ_A, that is:-

$$\mu_{A\ (FI\text{-}WEAG)} > \mu_{A\ (FI\text{-}WESG)}$$

1.7 SIGNIFICANCE OF THE STUDY

The major goal of this study was to investigate the effects of worked example and graphic presentation in multimedia learning courseware on learners with different cognitive styles in the learning of electrolysis. Findings of this study will give us information on how to design effective multimedia learning courseware to facilitate and enhance the learning of electrolysis from theoretical and practical standpoints. This study would provide alternative choice for multimedia instructional

designers in designing and developing multimedia courseware in teaching electrolysis. Furthermore, this study would also provide guidelines based on research findings for multimedia instructional designers in designing and developing worked example embedded with graphics to teach certain topics that involve a lot of procedural steps and visualisation.

1.8 THEORETICAL FRAMEWORK

The following theories, principles and models were the theoretical foundation of this study:-

- Theory for Worked Example
  - ACT-R Model (Anderson, 1993)
  - Cognitive Load Theory (Sweller, 1988)
  - Segmenting Principle (Clark & Mayer, 2008a)
- Theory for Animated Graphic
  - Gagné's Information Processing Theory (Gagné, 1985)
  - Cognitive Theory of Multimedia Learning (Mayer, 2002)
  - Congruence Principle (Tverksky, Morrison & Betrancourt, 2002)
- Theory for Learners with Different Cognitive Styles
  - Witkin's Theory of Field Dependence-Independence (Witkin, 1965)
- Theory for Designing Multimedia Learning Courseware
  - Gagné's Events of Instruction (Gagné, 1985)
  - Multimedia Design Principles (Mayer, 2002)

The ACT-R Model (Anderson, 1993), Cognitive Load Theory (Sweller, 1988) and Segmenting Principle (Clark & Mayer, 2008a) served as the theoretical

support for the implementation of worked example in multimedia learning environment to improve learning. The Gagné's Information Processing Theory (Gagné, 1985), Cognitive Theory of Multimedia Learning (Mayer, 2002) and Congruence Principle (Tverksky, Morrison & Betrancourt, 2002) provided the theoretical support for the integration of graphic into worked example in multimedia learning environments to enhance knowledge construction and cognitive processing. Witkin's Theory of Field Dependence-Independence (Witkin, 1965) served as theoretical support for the learners with different cognitive styles. Gagné's Events of Instruction (Gagné, 1985) was reffered to as the guideline in designing the sequence of learning material of the courseware. The events of instruction are structured based on the way humans process information to construct long-term memory. Multimedia Design Principles (Mayer, 2002) are referred to as the guideline in designing the interface of the multimedia learning courseware. Figure 1.1 illustrates the conceptual framework of this study.

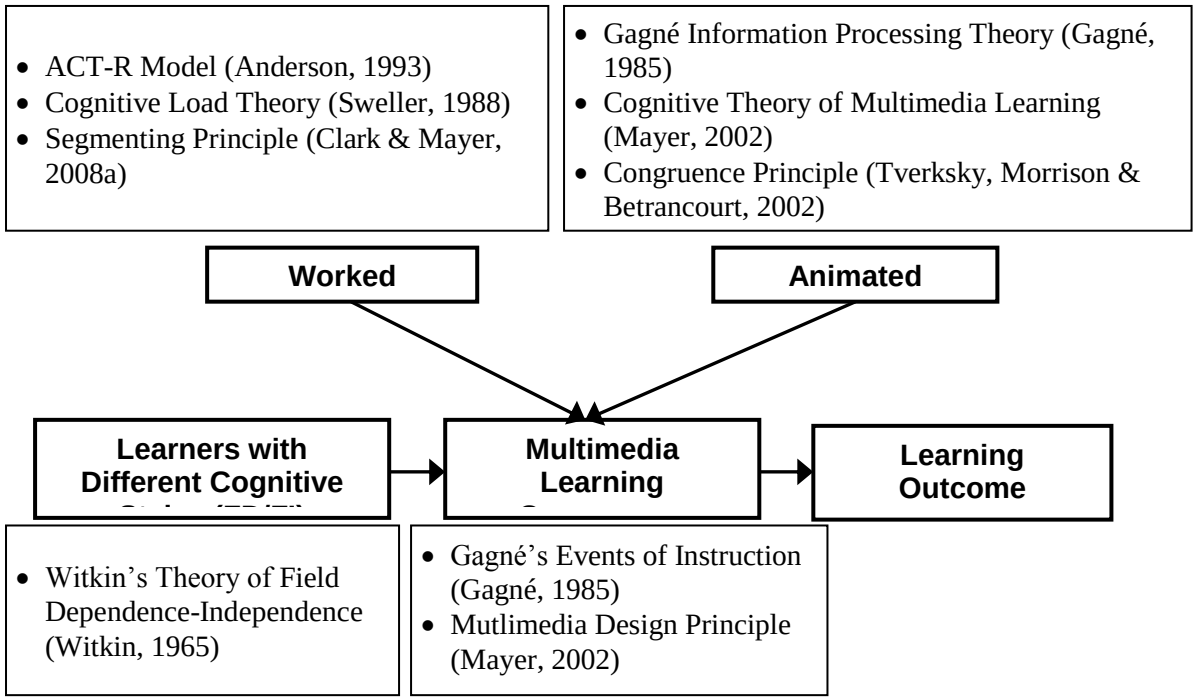

Figure 1.1: The Conceptual Framework

1.8.1 Theory for Worked Example

There are three theories for worked example and there are:

i) ACT-R Model

ii) Cognitive Load Theory

iii) Segmenting Principle

1.8.1.1 ACT-R Model

ACT-R Model (Anderson, 1993) is a model that illustrates human cognition and understanding on how people organise knowledge and produce intelligent behaviour. There are several assumptions made by ACT-R model in the knowledge presentation: (1) knowledge is stored in two long-term memory structures known as declarative memory and procedural memory; (2) the basic unit of knowledge in declarative memory is represented as chunk; (3) the basic unit of knowledge in procedural memory is represented as productions (production rules).

If the declarative memory (chunk) is activated frequently, they can eventually become procedural knowledge. Procedural knowledge is dynamic and involves rules that guide how thinking occurs (Sorden, 2005). Declarative knowledge can be obtained from direct encoding of the environment while procedural learning occurs after a certain amount of practice has taken place.

Anderson & Schunn (2000) believe that procedural skills are gained through practising and making past references as references. Therefore, ACT-R is a theory of learning by doing and by example (Sorden, 2005). In accordance with this model,

this study will employ segmented Worked Example to teach electrolysis for the novice learners.

1.8.1.2 Cognitive Load Theory

Cognitive Load Theory (Sweller, 1988) is an instructional theory that presents the architecture of human mind as having limited working memory with pertains to the amount of information it can hold and unlimited long-term memory.

According to Sweller, schema construction and rule automation are two main principles that guide knowledge acquisition for novice learners. Schemas are organised based on content knowledge found in long term-memory. The schemas handle new information as it enters working memory. The capacity of working memory can increase when the information is organised into schemas. Schemas need to be processed in working memory before they achieve long term memory. Therefore, the schemas serve as storage for learned information in long term memory reducing the cognitive demands on working memory (Kalyuga, Chandler & Sweller, 1998).

By practicing, learners can build up job-relevant skills. However, working memory can become overloaded if the mental aspect requires one to perform too many exercises. Worked examples are more efficient for learning new tasks as they can reduce the load in working memory load by allowing the learner to learn steps to solve a problem.

1.8.1.3 Segmenting Principle

According to Clark and Mayer (2008a), segmenting principle means breaking a lesson into segments or parts to manage its complexity of the lesson. This segmenting principle is supported by the Cognitive Theory of Multimedia Learning (Mayer, 2002). Worked example is an approach that demonstrates procedural learning material step-by-step, where the learning material had been segmented.

1.8.2 Theory for Animated Graphic

There are three theories for animated graphic and there are:

i) Gagné's Information Processing Theory

ii) Cognitive Theory of Multimedia Learning

iii) Congruence Principle

1.8.2.1 The Gagné Information Processing Theory

The Gagné Information Processing Theory (Gagné, 1985) postulates the activities of brain using the computer analogy. It explains the learning process as a series of transformation of information. Figure 1.2 illustrates the Gagné Information Processing Theory.

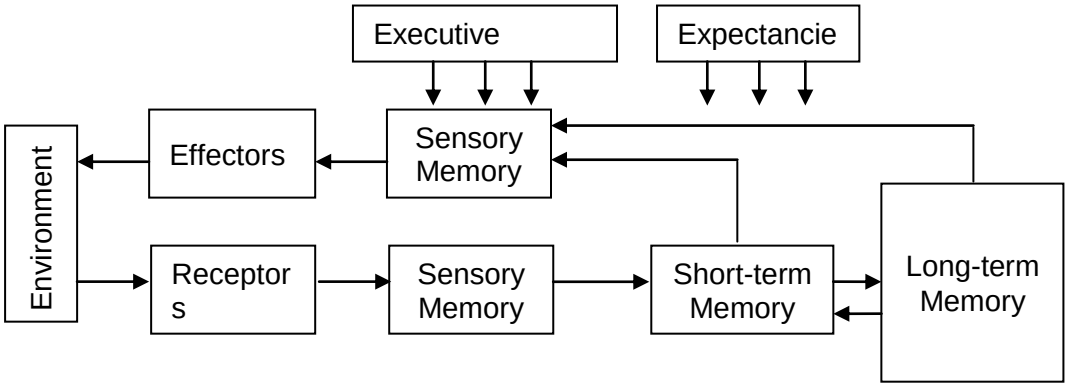

Figure 1.2: Gagné Information Processing Theory (Gagné, 1985)

Based on the information processing theory, each individual has different capacity in terms of processing, storage and retrieval of information. Thus, this study investigates the effects of various graphics presentation modes towards learners' achievement with different cognitive styles (FD/FI).

1.8.2.2 Cognitive Theory of Multimedia Learning

The Cognitive Theory of Multimedia Learning (Mayer, 2002) postulates that the human mind works to acquire and construct new knowledge from multimedia instructions by transforming information received by eyes and ears in visual-pictorial channel and auditory-verbal channel respectively. During the process of selecting words, the learner pays attention to some of the words and constructs the word sounds in working memory. In the process of selecting images, the learner pays attention to some of the pictures and constructs the word sounds in working memory. In organising the words, the learner organises the words into a coherent presentation in working memory named as verbal model. In organising the images, the learner will organise the pictures into a coherent presentation in working memory named as pictorial model. In the integrating process, the learner builds the connection between the verbal and pictorial models, and also appropriate prior knowledge from long-term memory.

According to the limited capacity assumption, there is a challenge for the learner to carry out these processes within the constraints, for example, how much processing can occur in each channel at one time. In order to overcome this challenge, Clark & Mayer (2008b) proposed several design principles as a guideline to develop effective multimedia environment for learning based on several empirical studies

conducted by them. One important principle which supported the utilisation of graphic to promote learning is the multimedia principle (Clark & Mayer, 2008b).

1.8.2.3 Congruence Principle

The Congruence Principle was proposed by Tverksky et al. (2002) stated that the structure and content of a graphic should correspond to the structure and content of the information being conveyed. Animation conveys change in time, which is natural and compatible correspondence. Hence, animations are claimed to have an advantage over text and static graphics.

1.8.3 Theory for Learners with Different Cognitive Styles

The theory for learners with different cognitive styles is Witkin's Theory of Field Dependence-Independence.

1.8.3.1 Witkin's Theory of Field Dependence-Independence

The Witkin's Theory of Field Dependence-Independence (Witkin, 1965) serves as a theoretical support for learners with different cognitive styles. Field Independent (FI) learners could identify simple figure quickly from a complex design, while Field Dependent (FD) learners could not identify the simple figure from a complex figure in limited time. Hence, FD learners need more help than FI learners in the learning task that involves isolating and manipulating a detail from within a complex visual field. Witkin and his colleagues developed an instrument called the Group Embedded Figures Test (Witkin, et al., 1971) to measure the learners' field dependency.

1.8.4 Theory for Designing Multimedia Learning Courseware

There are two theories for designing multimedia learning courseware and there are:

i) Gagné's Events of Instruction

ii) Multimedia Design Principles

1.8.4.1 Gagné's Events of Instruction

The Gagné's Event of Instruction (Gagné, 1985) is used as a guideline in designing the three modes of courseware. According to Gagné (1985), there are nine events that activate processes needed for effective learning. Gagné believes all lessons should include this sequence of instructions. These are (1) gaining attention, (2) informing learners of the objectives, (3) stimulating recall of prior knowledge, (4) presenting the stimulus material, (5) providing learning guidance, (6) eliciting performance and practise, (7) providing feedback, (8) assessing performance, and (9) enhancing retention and transfer.

1.8.4.2 Multimedia Design Principles

Multimedia Design Principles (Mayer, 2002) is used as a guideline in designing the interface of the multimedia learning courseware. These design principles were proposed by Clark and Mayer (2008b) in order to create learning environments that minimise extraneous cognitive processing, manage essential processing, and foster generative processing. These design principles are (1) multimedia principle, (2) contiguity principle, (3) modality principle, (4) redundancy principle, (5) coherence principle, (6) personalisation principle, (7) segmenting

principle, (8) pre-training principle, (9) interactivity principle, and (10) signalling principle.

1.9 RESEARCH FRAMEWORK

Figure 1.3 illustrates the research framework of this study. The framework postulated the independent variables and moderator variable that would show significant variance on the dependent variable. The independent variables were the three different presentation modes of multimedia learning courseware, namely the (i) Static Graphic with Example (ESG) mode, (ii) Worked Example with Static Graphic (WESG) mode and (iii) Worked Example with Animated Graphic (WEAG) mode. The dependent variable was the achievement scores while the moderator variable was the learners' cognitive styles of field-dependence/field-independence (FD/FI).

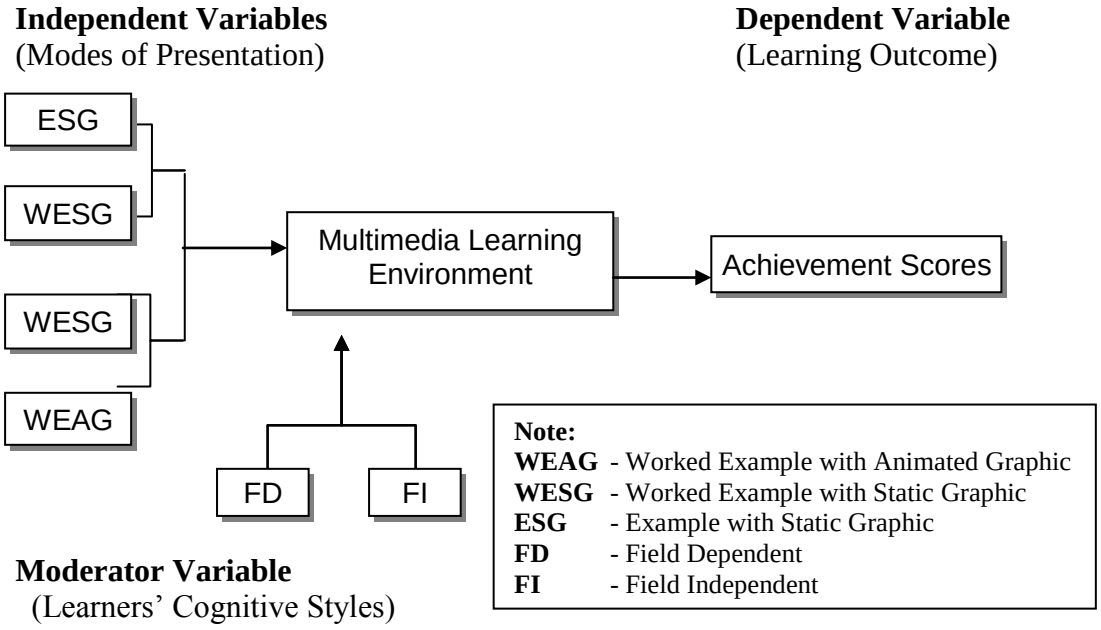

Figure 1.3: The Research Framework

1.10 LIMITATIONS OF THE STUDY

There were several limitations in this study. Firstly, the sample of this study consisted of Form Four Science students of a secondary school in Penang Island. This limited the generalising of this study as it does not include non-science (arts) students and students from other states in Malaysia. Besides, it also limited the generalising of this study to Form Five and Form Six students. As a consequence, the results and outcomes of this study may possibly apply to Form Four science students only.

Secondly, this study investigated only one among the 13 topics in chemistry that made generalisation on chemistry impossible. The coursewares were designed for procedural skills and the non-visible phenomena topics. Thus, the results from this study could not be generalised for all the topics in chemistry.

Thirdly, the learners' differences examined in this study were limited to the cognitive styles of field-dependence/field-independence (FD/FI). Further research can also be conducted to investigate other types of cognitive styles such as impulsive/repulsive, visual/haptic, constricted/flexible control, and levelling/sharpening. Others aspects such as intelligence levels, ethnicity, gender, and psychosocial traits could also be considered for further investigation.

Lastly, the duration allocated for the learning with the courseware was limited to 45 minutes. This could also be considered as a limitation because if the duration for the learning was extended and the learning material covers the whole chapter of

electrochemistry, the outcomes of the study may differ. Thus, in depth research could be conducted by extending the duration of the learning with the courseware.

1.11 OPERATIONAL DEFINITIONS

In this section, several key terms used for the study were defined.

Worked Example (WE)

WE is a step-by-step approach of demonstrating procedural learning material and methods to perform a task or to solve a problem.

Example with Static Graphic (ESG)

ESG is a type of presentation mode that presents examples (in the format on-screen text without step-by-step explanation) along with a static graphic to explain a procedural concept in the courseware.

Worked Example with Static Graphic (WESG)

WESG is a type of presentation mode that presents examples in the form of worked examples (with step-by-step explanation) along with a series of static graphics to explain a procedural concept in the courseware.

Worked Example with Animated Graphic (WEAG)

WEAG is a type of presentation mode that presents examples in the form of worked examples (with step-by-step explanation) along with a series of animated graphics to explain a procedural concept in the courseware.