ENGLISH READING-LISTENING MATERIALS AND LEARNERS' INFORMATION RETENTION: AN ANALYSIS OF COGNITIVE LOAD THEORY

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Abstract

Cognitive Load Theory (CLT) derives from educational psychology and explains how to design instructional materials for cognitive load learning and problem solving. It examines how supportive cognitive load, e.g. integrated and modality tasks, results in better learning than hindering cognitive load, e.g. split-attention and redundancy tasks. However, very few studies have investigated cognitive load and working memory capacity, especially in EFL cognitive load learning. This research, therefore, aims to bridge the gap in examining the application of CLT in the design of EFL reading-listening materials and its effects on EFL learners' information retention and learning.

Integrating CLT with Baddeley's Working Memory (WM) model, this research employed a mixed-methods approach, consisting of three experiments (WM tests, subjective rating scales and semi-structured interviews) on two experimental groups of seventy-nine Thai EFL undergraduate participants. CLT was employed as intervention effects of supportive and hindering cognitive load, while the WM model acted as a platform for cognitive processing, retention and recognition in EFL reading-listening learning. This supplied both product and process understandings of EFL cognitive load learning and processing.

Findings of the study demonstrated that, from three experiments on reading, listening and listening-reading, supportive cognitive load, i.e. integrated reading and integrated listening, resulted in positive learning when compared with split-attention effects of reading and listening, respectively. Positive retention effects were found on integrated reading and modality listening-reading, compared with split-attention reading and redundancy listening-reading, respectively. These findings confirmed that CLT was applicable in the design of EFL integrated reading and integrated listening for cognitive load learning, and integrated reading and modality listening-reading for EFL information retention.

In terms of information retention, the best supportive cognitive load was found on integrated reading, in that participants reported positive processing in subjective ratings and in the semi-structured interviews that they processed reading information little by little, allowing them to think, understand and remember information efficiently. Modality listening-reading was also found to support retention, in that a graphic summary was registered in the visual channel of WM, which was explained by Dual Coding Theory in the interview analysis and further confirmed in the recognition tests. However, the research found no statistically significant differences in recognition between all supportive and hindering cognitive load, suggesting that learners recognised learnt EFL information in their recognition memory.

The present research contributes to the application of CLT in the design of EFL instructional materials for learning and testing. Also, in addition to experimental results, the use of subjective ratings and semi-structured interviews as research tools contributes to the practicality of research methods in accessing cognitive processing, especially in EFL classroom research contexts. This confirms that a mixed-methods approach is applicable in CLT and language education research.

Further research is suggested to verify if the design of CLT instructional materials for EFL speaking and writing could be carried out in a mixed-methods approach. Research could also include other types of supportive and hindering cognitive loads in EFL learning. This is to extend our understanding on how language skill materials are learnt and engaged cognitively through the lens of mixed-methods approach.

Declaration

I declare that this thesis is my own work. I have correctly acknowledged the work of others and no parts of the material offered has been previously submitted by me for any other award or qualification in this or any other university, at any time.

Monthon Kanokpermpoon

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Dedication

To my endless and upmost respect - the late King Bhumibol Adulyadej

and

To my beloved family – father, mother and aunt

(Kitti and Tanapa Kanokpermpoon, and Supratra Apiwattanachart)

To my beloved siblings – sister and brother

(Monta and Noppakhul Kanokpermpoon)

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Chapter 1. Introduction

1.1 Introduction and background to the study

In the present day of knowledge society, information is available in all forms of printed and online platforms, such as visual, auditory and multimedia. As a second language learner, obtaining information for problem-solving, creativity and learning is a prerequisite in participating in the 21st century knowledge society (Trilling and Fadel, 2009). In 2015, the Association of Southeast Asian Nations (ASEAN) economic community was created and English has become an official working language among ASEAN countries where English is a lingua franca (Kirpatrick, 2010). When it comes to the English language, most Southeast Asian students, especially Thai learners, find it challenging. This seems to derive from the fact that students need to learn so many subjects in a day, and this might impede the capacity of working memory required to obtain and retain new knowledge (Kanokpermpoon, 2013). In Klingberg's (2009) words, the large amount of information entering an individual brain could be overflowing because of one's limited working memory capacity.

To alleviate this potential problem, several researchers (such as Sweller, 1994, Cooper, 1998) proposed an idea of redesigning learning to be suitable for learners' limited working memory capacity. According to Sweller (1994, 2011, 2015, 2016, 2017) and his colleagues (Sweller *et al.*, 1998, Sweller, *et al.*, 2011), an applied educational psychology theory which is suitable for the design of efficient information intake is Cognitive Load Theory.

Cognitive Load Theory was first developed during 1980s, and it has gained popularity in applied educational research over the past 30 years (Sweller, 1994, Cooper, 1998, Artino, 2008, Hung, 2009). The theoretical framework is that people's working memory is very limited, compared with a bombarding amount of information to take in. Sweller *et al.* (2011) postulated that the intrinsic nature of instructional materials is hardly controllable, but instructors could manipulate the manner of how information is presented to learners. This theoretical framework has led to success in designing instructional materials in various academic subjects (see, for example, Cooper, 1998, Sweller *et al.*, 1998, Clark *et al.*, 2006, Mills, 2016), but so far, there has been very limited application of Cognitive Load Theory in language education, especially foreign language education (Kudo, 2013). However, under the scenario where Southeast Asian students need to learn English as foreign language (EFL), along with many other subject areas, it is important to reconsider the construction of instructional materials in teaching and learning

English so as to promote effective language education. This is due to the fact that grammatical structures and vocabulary in a foreign language are numerous, but instructors could choose a way of presenting language information of instructions and instructional materials to learners. This might help learners learn a foreign language efficiently (Kutkut, 2011, Kudo, 2013).

In language education, Cognitive Load Theory has been used to figure out if learning a language is efficient under supportive cognitive load effects (Hung, 2009, Plass *et al.*, 2003, Schroeders *et al.*, 2010, Moussa-Inaty *et al.*, 2012, Sombatteera and Kalyuga, 2012, Lee and Mayer, 2015). For instance, when EFL learners read an English article with questions embedded in it (or *integrated task*), they scored significantly better than those reading an article with questions attached at the end (or *split-attention task*) (Hung, 2009). In EFL listening, for example, Sombatteera and Kalyuga (2012) found that learners could learn more efficiently when they were exposed to images and audio (or *modality* task) compared with less productive results in learning from a text and its audio (or *redundancy task*). This means that cognitive load effects are contributing factors in promoting language learning.

Given the fact that Cognitive Load Theory is applicable in language education, an underlying understanding of how learners' working memory works during learning is not yet studied. Although there has been studies trying to investigate learners' cognitive load during learning (such as Pass *et al.*, 2003, Brünken *et al.*, 2010), actual studies on learners' cognitive load and working memory capacity during language learning is still in question.

With regards to working memory (WM) in language education, several researchers (such as Wright, 2009, 2010, 2013, Wen *et al.*, 2015) investigated linguistic phenomena in second language acquisition (SLA) in conjunction with working memory. Some contributing frameworks from WM and SLA are Baddeley's multilevel WM (Baddeley and Hitch, 1974, Baddeley, 1992, 2006, 2007) and Cowan's unitary WM (Cowan, 1988, 2005, 2014). The distinction between the two WM models lead to different understandings of SLA phenomena, but both models were found to contribute to second language (L2) processing, L2 interaction and performance, and L2 instruction and development (Wen *et al.*, 2015). A question regarding this remains, 'How does WM inform learners' cognitive load, especially in the design of instructional materials for language learning?'

Regarding the application of Cognitive Load Theory in foreign language instructional design and language acquisition through the lens of Working Memory, the present research combines the design framework of Cognitive Load Theory in conjunction with Baddeley's WM model to understand if instructional materials in foreign language education lead to learning. It takes an account that reading, listening and listening+reading in a foreign language could be understood if Baddeley's WM model was considered, in that two sensory channels of information storage, i.e. visual and language information, have been found to relate to language processing (Baddeley, 2015). Factors which determine if the reading, listening and listening-reading information lead to efficient learning is cognitive load, i.e. supportive or hindering effects (Sweller, 2017). This means that this research establishes Cognitive Load Theory as a framework in instructional design of language education and employs Baddeley's WM model as the research design of language skills in question.

Given the fact that the two theoretical frameworks are applied in the research design of the present study, an underlying understanding of cognitive load learning is still in question. According to Kvale (1996, 1999, 2003), some psychological theories have been tested and developed when researchers take participants' interviews and/or self-reports into consideration in addition to statistical analysis. Since this research aims to investigate instructional material design for efficient language learning, learners' cognitive processing could possibly be accessed through learners' self-report – this has been studied in algebra learning, for example (see, Mills, 2016). This could yield aspects of cognitive load learning from learners' points of view to supply additional answers for cognitive load learning using instructional materials under investigation.

1.2 The context of the study

English is regarded as a foreign language for communication in Thailand, and this has been reformed in education in 2014 (Office of the Basic Education, Ministry of Education, 2014). The aim of reform is to strengthen English language education for learners. One of the aims is to upgrade secondary students' English to B1 based on the Common European Framework of Reference for Languages (CEFR). In tertiary education, Thammasat University, one of the most prestigious universities in Thailand, has responded to the reform of educational policy in Thailand in promoting an Active Learning approach (Lertpaithoon, 2014, Udon, 2015). One of its aims is to promote learners to actively engage in learning activities in and outside classroom, and foundation English courses have also been changed to respond to the reform, especially in the design of new teaching materials. As a lecturer at the university, I always perceive that to learn English as a Foreign Language (EFL) well, learners need to engage with instructional materials actively in addition to social interactions. EFL instructional materials, especially in terms of reading and listening, should also be designed as supportive resources so that they enhance and support language learning, not impede learning.

In the language classroom, receptive skills, i.e. reading and listening, are prominent language input and serve as available language resources for comprehension (Mishan and Timmis, 2015). This is relevant for the present study as language resources could be considered as available information for EFL learners to interact with when they read, listen and listen-and-read in tertiary language classroom (Swerller, 2017). Cognitive load effects, i.e. integrated, split-attention, modality and redundancy tasks, in receptive-skill instructional materials could be considered as supportive or hindering variables in EFL learning, and this could be used as determining factors in the design of English reading+listening instructional materials at Thammasat University. The efficient learning in language classroom could also be informed by a combination of modified EFL reading+listening instructional materials and learners' cognitive load for instructional materials.

1.3 Research gap

In this present research, the efficient design of instructional materials based on Cognitive Load Theory (CLT) is studied. It is drawn from existing research in CLT that supportive cognitive load effects, i.e. integrated and modality tasks, enhance learning (Hung, 2009, Plass *et al.*, 2003, Schroeders *et al.*, 2010, Moussa-Inaty *et al.*, 2012, Sombatteera and Kalyuga, 2012, Lee and Mayer, 2015). However, in a language classroom, determining learners' cognitive load and working memory capacity when they are interacting with instructional materials is rarely found in existing literature. The present study aims to fill the research gap as follows.

Firstly, literature in Cognitive Load Theory has mainly focused on whether cognitive load effects result in efficient learning, but actual measurement of learners' cognitive load and working memory during learning has been minimally explored. Although other objective methods of cognitive load measurement have been proposed for Cognitive Load Theory research, such as secondary tasks and task difficulty measurements (DeLeeuw and Mayer, 2008, Haji *et al.*, 2015), dual tasks (de Neys and Schaeken, 2007, Park and Brüken, 2015), subjective ratings (Schmeck *et al.*, 2015), only few studies have combined elements of objective and subjective measurements into accessing cognitive load studies (Wernaart, 2012, Joseph, 2013, Mills, 2016). For example, Joseph (2013) investigated participants' intrinsic cognitive load when they were participating in a puzzle task of car moves. He employed subjective ratings, eye-tracking and EGG technology in accessing participants' cognitive load. Mills (2016) used a mixed-methods approach in accessing cognitive load (objective test) and cognitive presence (subjective measurement) in algebra learning. He analysed moves of online discussion as a qualitative approach to understand learners' cognitive presence in algebra learning. Given the two examples, it could be claimed that, in language education, an approach in assessing cognitive load has not yet been used to study Cognitive Load Theory. So, the present study could bridge a gap of cognitive load measurement through using both quantitative and qualitative methods.

Another gap in research which the present study can fill in is that of classroom cognitive load measurement. As can be seen in both Joseph (2013) and Mills (2016), it is challenging for a language teacher to apply laboratory scientific measurements, such as eye-tracking, EGG technology, laboratory WM tests, etc., in understanding learners' cognitive load learning in a classroom. As a language teacher, only practical methods on cognitive load measurement could be used in language classroom research (such as Lee and Mayer, 2015 on task difficulty measurement). So, the present study aims to offer alternative measurements, i.e. subjective ratings, WM measurement (Reading Span Task) and psychological interviews, for classroom teachers to employ in accessing learners' cognitive capacity.

The gap is Cognitive Load Theory and Working Memory (WM) as a combined construct. Several studies on Cognitive Load Theory contributed to the effects of cognitive load on learning from reading (e.g. Diao and Sweller, 2007, Hung, 2009, Luchini *et al.*, 2015, González, 2017), listening (Chang and Tseng, 2011, Moussa-Inaty *et al.*, 2012, Jiang *et al.*, 2017), and listening+reading (e.g., Schroeders *et al.*, 2010, Lee and Mayer, 2015). In WM studies, linguistic elements, such as syntax (Wright, 2009, 2010, 2013), have also been studied. Although there has been a conceptual framework for how Cognitive Load Theory contributes to second language acquisition (Sweller, 2017), a combination of Cognitive Load Theory and WM still needs further study. The present thesis follows the traditional research of CLT to explore information retention when EFL learners are interacting with instructional materials and offers a possible bridge between Cognitive Load Theory and WM.

Results from the present study could be used to guide language instructors to redesign EFL instructional materials, especially in reading and listening, based on Cognitive Laod Theory, to understand cognitive load learning through working memory studies, and to offer an alternative way of studying Cognitive Load Theory through a mixed-methods approach.

1.4 Research questions

The aim of the present study is to investigate if EFL reading+listening instructional materials designed based on Cognitive Load Theory help EFL learners to learn and retain EFL reading-listening information. The study also explores EFL learners' cognitive load and working memory capacity when learners are interacting with instructional materials from both learning and learners' points of view. It is hoped that the results of the present study could yield more understanding of how Cognitive Load Theory could be used to design EFL reading+listening materials, which are then used to support cognitive load learning in tertiary EFL classroom. The following are research questions:

***RQ**: Can learners process information in their working memory better from modified listening and reading materials?"*

***Sub-RQ1**. Is there an association between learners' information retention and English listening, reading and reading+listening materials?*

***Sub-RQ2**. What kind of modified materials best supports learners' language learning?*

***Sub-RQ3**. How much mental effort do learners perceive to use in working with instructional materials?*

This is a mixed-methods research aiming to answer the main research question on EFL instructional materials and learners' learning and information retention. The platform of research employs three experiments for each language skill instructional material, i.e. reading, listening and listening+reading. The first research question aims to test whether EFL materials with supportive or hindering cognitive load (CL) support or hinder learners' learning and information retention. It uses cognitive load effects, i.e. integrated and redundancy (supportive CL) and split-attention and redundancy (hindering CL), as independent variables in the design of EFL instructional materials and learners' learning and information retention as dependent variables. Working memory measurements are also employed to answer this research question so as to understand not only cognitive load effects on learning, but to also offer an understanding of how working memory is exercised in cognitive load learning with EFL instructional materials. Answers from the research question 1 can be used to answer research question 2. The second research question aims to find the best candidate of cognitive load effects in helping support EFL learners' cognitive load learning. It employs a mixed methods of experimental tests and semi-structured interviews to yield answers from two different perspectives, i.e. quantitative and qualitative measurements. The last question focuses on the measurement of cognitive load which is perceived by Thai EFL learners during learning from instructional materials. It uses an additional method of subjective ratings and semi-structured interviews to bridge Cognitive Load Theory and WM in understanding cognitive capacity and cognitive load learning. Statistical analysis of pre-tests, learning, testing, recognition, and WM tests is used to examine the effects of cognitive load variables in EFL reading+listening learning and information-retention in research question 1, and to find the best candidate of cognitive load effect in supporting learning in research question 2. Descriptive statistics from the measurement of learners' cognitive load subjective ratings are used to answer research question 3. Qualitative analysis of semi-structured interviews is used to reveal the amount of perceived load in research question 3 and what happens in cognitive load learning to supply more information for the best cognitive load candidate in research question 2.

1.5 Outline of the chapters

The present study covers six chapters. Chapter 1 provides introduction and background of the present study. It also highlights significance and contributions of this research along with research questions. Chapter 2 accounts for detailed discussions of related literature on human cognitive architecture in learning, Cognitive Load Theory in detail, the application of Cognitive Load Theory in language learning and retention. It also focuses on how results from experimental studies of Cognitive Load Theory seem not to be consistent in language learning, which leaves a gap for the present study. Chapter 3 outlines research methodology. It consists of how research is designed as/in a mixed-methods approach. Details of participants, research instrument and procedure, reports of a pilot study, research validity and reliability, and ethical considerations are covered. Chapter 4 provides detailed analysis of data into five major sections – experiment results, cognitive load effects on information retention, comparisons of cognitive load effects, subjective ratings, and semi-structured interviews. Chapter 5 answers research questions, discusses possible contributions and implications of Cognitive Load Theory on cognitive load learning and instructional material designs. It also highlights the importance of mixed-methods in the design of Cognitive Load Theory for language learning. The thesis is concluded with suggestions for further studies in Chapter 6.

Chapter 2. Literature Review

This present research project aims to investigate whether modified instructional materials help Thai EFL learners learn and retain information from reading-listening instructional materials effectively. In this chapter, literature which is related to instructional materials and how instructional materials, especially materials for language education, help or hinder learners' information retention will be presented.

The chapter is divided into four sections. Firstly, rationale in relation to how the research project was initiated will be presented. Next, literature and research studies related to instructional design and materials will be discussed. The last section deals with how related literature in this chapter helps formulate the present research design and methodology.

2.1 Rationale

In learning in the 21st century, learners are not only exposed to information presented in online and/or printed media, but they are also required to learn from different presentations of text in various ways (Paivio, 1990, Klingberg, 2009, Mayer *et al.* 2014). For example, a learner might read printed information and listen to the same information through audio media. Alternatively, a learner might read information from a printed medium and look at illustrations of the text. A question arises in this scenario, 'How could a learner learn and retain information effectively, where one is exposed to a lot of information presented in various ways?'

The above question was investigated by many scholars in various fields of study. In educational psychology, for example, some scholars (such as Paivio, 1990, Sydorenko, 2010, Ari *et al.*, 2014, Lee and Mayer, 2015) proposed that gathering information through both channels of learning, i.e. visual and audio, could enhance learning and enable obtaining information effectively. However, some (e.g. Diao and Sweller, 2007; Torcasio and Sweller, 2010; Luchini *et al.*, 2015) speculated that altering the presentation into a combined form could support learning in education and trainings.

Given the fact that there is no conclusive consensus in the presentation of various forms of information, a further question arises in what would happen if a learner needs to learn information presented in a foreign language. Would the intake of information be too overwhelming for a foreign language learner? What would happen in one's cognitive processing if one is exposed to an overloaded form of presentation?

In this chapter, literature in relation to what happens in one's cognitive architecture in interacting with instructional materials and how instructional materials could be designed to suit one's cognitive architecture will be discussed. First, what cognitive architecture is will be presented.

2.2 Human cognitive architecture

Human cognitive architecture originated in experimental psychology and conceptualised into a well-known word '*memory'*. According to *Oxford English Dictionary*, memory is defined as '*senses relating to the action or process of commemorating, recollecting, or remembering*' (Simpson and Weiner, 2001). In cognitive psychology, *memory* is defined as '*the process of maintaining information overtime*' (Maltin, 2005, p. 23).

According to the general definition and psychological definitions of *memory*, it could be argued that *memory* is related to the process of information intake and how human mind manipulates the information so that the processed information can be retained and then retrieved for later use. In educational context, the process of encoding information into human mind is as important as the information retrieval process (Maltin, 2005, Sweller *et al.*, 2011). According to Sweller *et al.* (2011), learning is a process where interacting elements of information are encoded into a single configuration in memory. To manipulate the end-product learning, memory storage should be considered so that the memory storage is suitable for learning, and the result of learning with appropriate memory storage means efficient learning (Clark *et al.*, 2006). According to Clark *et al.* (2006) and Sweller *et al.* (2011), efficient learning is a result of reducing irrelevant load, increasing relevant load and managing intrinsic load in memory storage. In terms of learning outcomes, Mayer (2009) categories learning outcomes into retention and transfer. Retention is a cognitive process where information and experience are collected in human memory for a further recall (Joiner and Smith, 2008). However, transfer is a cognitive process where information stored in human memory is applied in another memory formation (Mayer, 2009). When irrelevant load increases in human memory storage, it could be argued that human memory is overwhelmed with information overload, resulting in an overflowing brain (Klingberg, 2009).

In terms of cognitive processes, there are two areas of knowledge for a person to process in the mind/brain: domain-general and domain-specific knowledge (Chomsky, 2006, Shaffran and Thiessa, 2007). The domain-general concept refers to the innate ability of a person to process and store all learning in a general sense as problem-solving. The domain-specific concept refers to the idea that there are specific areas of knowledge. In generative-linguistics-based child language acquisition, the idea of domain-general knowledge resonates with innateness where the child is assumed to possess and use only the domain specific to language for acquisition of their L1, i.e. to use the Language Acquisition Device/LAD (Chomsky, 2006).

In cognitive studies, domain-general and domain-specific knowledge represents the nature and nurture systems of cognitive processes (Geary, 2002, 2012, Shaffran and Thiessa, 2007). According to Li *et al.* (2014), domain-general knowledge involves developmental skill learning in cognitive processes, whereas specific areas of the brain are activated to process domain-specific knowledge, such as second language learning (Sweller, 2017). The ideas of nature/nurture are in close connection with LAD and language principles and parameters in Chomsky's terms, in that domain-general (nature) is an innate ability for the acquisition of language, whereas in instructed second language learning, the mechanisms of language module for interlanguage are domain specific for central processing systems (Schwartz, 1993). What Sweller says seems to contradict the generative position which can be found in Krashen's (1982) acquisition-learning distinction but expressed very clearly in Schwartz (1993).

The question of whether language is domain general or domain specific continues to be debated and more recently Campbell and Tyler (2018) claim in their study that domain-general systems are used as mechanism for syntactic knowledge, but not for language processing. In their study on L1 natural listening from four conditions of sequencing tasks, i.e. acoustic baseline, subordinate, dominant and unambiguous (p. 134), the domain-specific systems of young adult learners' brain in the left-lateralised frontotemporal were found to process syntax and phonology, i.e. syntactic knowledge, in context-free condition. The researchers argue that, for natural syntactic processing, domain-general input is not involved in neurological processes, rather the domain-specific input is. This resonates with Schwartz (1993) hypothesis on learned linguistic data for learned linguistic knowledge in L2 learners' interlanguage.

In the present study, domain-general knowledge is perceived as learners' general knowledge of L1 in terms of both language and visual abilities, whereas learning L2 is domain-specific knowledge to process in their cognitive capacity. Now, we turn to memory storage for cognitive processes.

As for memory storage, there are two kinds of memory: long-term memory and working memory (Maltin, 2005; Cowan, 2005, 2014; Baddeley, 2007; Sweller *et al.,* 2011). Regarding the long-term memory, a person could hold as much information as possible in their memory capacity since information is processed and formulated in a human brain to construct schema, i.e. background knowledge, from learning and experience (Cowan, 2005, Maltin, 2005, Sweller *et al.*, 2011). Information stored in long-term memory is unlimited because it is processed as a unitary system. In other words, an immense amount of information is organised systematically in human brain. This means that when information from learning and experience is transferred to long-term memory, the ability to use such information in existing and novel situations is efficient (Sweller, 1998, Clark *et al.*, 2006, Artino, 2008).

However, when it comes to working memory, or a short-time, limited storage of information in human mind (Martin, 2005), different views of conceptualisation have been competing as follows.

2.2.1 Cowan's Working Memory

In Cowan's model (1988, 2005, 2014) (see Figure 2.1), an idea of systematising working memory is based on an idea of a unitary working memory system. In other words, both long-term memory and working memory are not separate systems. All information is processed and held in long-term memory, but because of an 'attention filter', or sensory stimuli, information held in long-term memory is activated to assist working memory for information processing. This means that a working memory storage in this view acquires information through sensory stimuli, which activate information in long-term memory in a unitary system. According to Li *et al.* (2014), working memory, which is activated through both audio and visual stimuli in all processes of 'encoding, maintenance, and retrieval' (p. 646), is considered a domain-general working memory storage system[1]. This means that working memory in the Cowan's model is in relation to domain-general knowledge, which is stored and triggered from one's long-term memory.

[1] According to Buehl *et al.* (2002) and Li *et al.* (2014), domain-general knowledge refers to interdependent areas of the brain to function together to learn whole skill knowledge. It is believed that domain-general knowledge can be used to learn any skills in general. In terms of domain-specific knowledge, however, specific areas of the brain are activated to learn particular skill knowledge only (Traxler, 2012). This means that domain-specific knowledge cannot be used to intake other irrelevant skills.

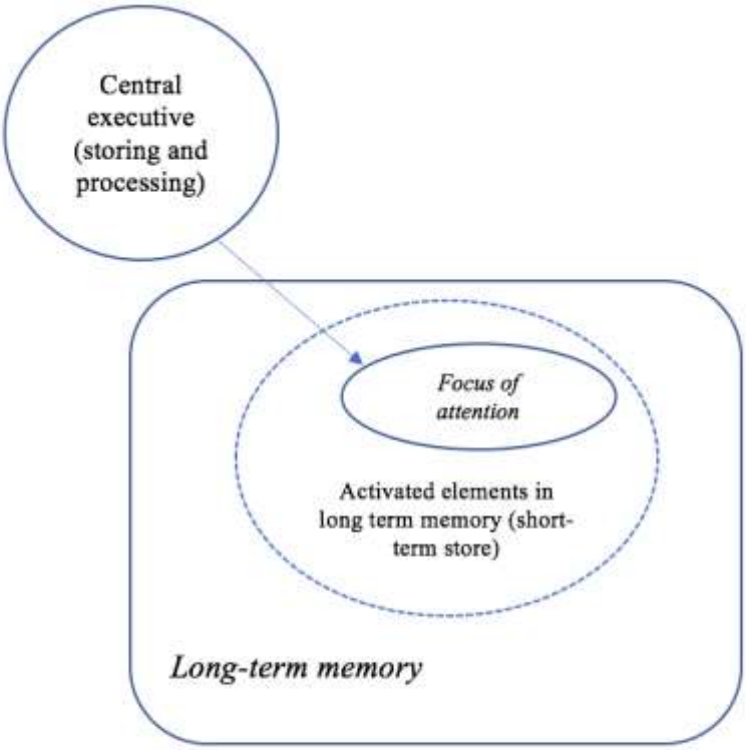


Figure 2.1. Cowan's working memory model (adapted from Cowan, 1988, 2005, 2014)

Given the fact that stored information is triggered in long-term memory from new sensory input to process in working memory, it is questionable if information held in long-term memory constitutes information not for complete beginners, but all other second language learners. As for instructional implications, this view of attention filter in bringing about foreign language learning might not be satisfied since working memory might only bring domain-general knowledge of language learning (cf. Li *et al.*, 2014) from long-term memory in dealing with new foreign language information. However, according to Traxler (2012) and Sweller (2017), languages are domain-specific, and the result of bringing about domain-general knowledge from long-term memory on learning a specific foreign language could be perceived as taking information beyond the focus of attention area (Cowan, 2014). So, this working memory model might be problematic in explaining foreign language learning, and we might need to discover another view of working memory for foreign language education.

2.2.2 Baddeley' Working Memory

With reference to Baddeley (1992, 2006, 2007) and his colleagues (Baddeley and Hitch, 1974), working memory works in relation to long-term memory, but different kinds of information are stored and processed in different channels (see Figure 2.2). According to Baddeley (2006, 2007), visual input, such as pictures or tangible objects, are stored in the *visuospatial sketchpad*, while verbal information, e.g. written or spoken language, is stored in the *phonological loop*. Both channels are perceived to be in working memory. However, to process information in working memory, Baddeley (2006, 2007) offers a central executive as a platform for information processing from both channels, and an episodic buffer to bring about information, which is processed in central executive, to construct schema in long-term memory.

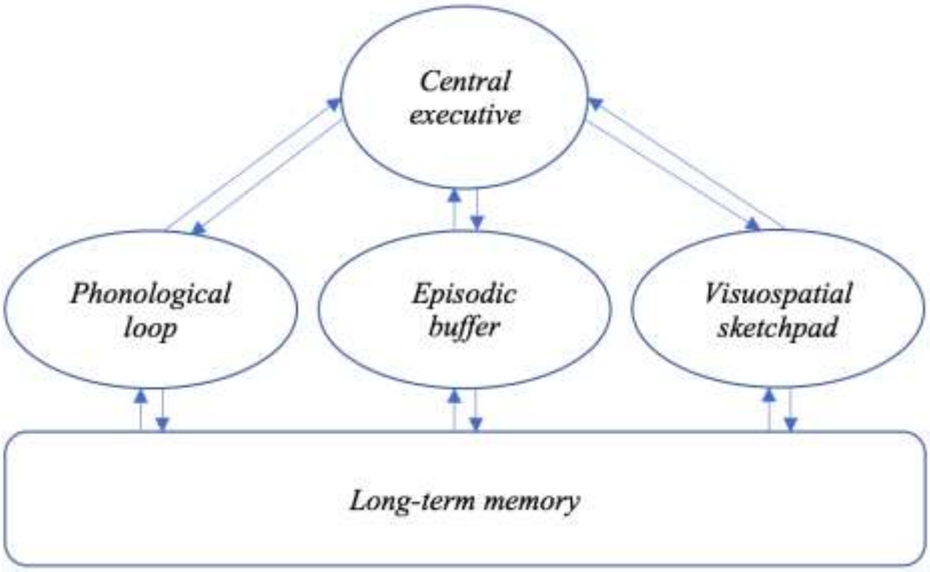


Figure 2.2. Baddeley's working memory model (adapted from Baddeley, 1992, 2006, 2007)

Given the fact that different kinds of input are stored in a separate system but processed in the central executive, a question remains if information from either the *visuospatial sketchpad* or the *phonological loop* could be too overwhelming, or with information overload, in the central executive channel. This is because working memory has very limited storage capacity[2], and that information from both channels might fill up working memory capacity to process efficiently (Klingberg, 2009, Linck *et al.*, 2013). Another problem arises when a learner's memory capacity retains information in a short time. So, when both channels of working memory storage store foreign language information in a person's memory, their cognitive abilities in dealing with short-time foreign language information could be efficient in a short time. A question remains, 'How could we manipulate working memory capacity to retain foreign language information in a longer period of time?'

[2] Miller (1956) found in his studies that working memory can hold only up to seven pieces of information at a time, which is considered limited in its capacity.

2.2.3 Working Memory and language learning

Taking both Cowan's and Baddeley's working memory (WM) models into consideration, several researchers (such as Wright, 2009, 2010, 2013, Anderson, 2010, Li *et al.*, 2014, Wen *et al.*, 2015) employed basic understanding of WM in application to language acquisition. For example, Anderson (2010) tested children's foreign language processing through central executive and phonological loop (i.e. Baddeley's WM model) and found that children's L1 working memory varies independently to predict foreign language performance. This means that a strong relationship between children's L1 and L2 led to a good prediction of foreign language processing (p. 469). When it comes to an immersion context, Wright (2009) found in her study that L2 postgraduate learners orally improved L2 simple questions faster on a timed grammaticality judgement (p. 7), and this means that learners improved L2 oral fluency in a one-year English immersion.

Regarding the above two studies, it could be argued that the WM could be used to account for individual variation in second language acquisition. It takes working memory measurements in accessing working memory capacity (as in Anderson, 2010) or in language fluency development (as in Wright, 2009). However, in language instruction, L2 skill development is also an important factor indicating an improvement of efficient learning and retention. Several researchers (e.g. Call, 1985, Ohata, 2006, Erçetin and Alptekin, 2013) studied the role of short-term working memory and language skill development, especially in terms of listening and reading as follows.

In 1985, Call investigated the role of auditory short-term memory in the prediction of listening skill development. He found in this study that participants improved L2 listening more significantly when they had memory for L2 syntactic knowledge. This means that when L2 learners learnt L2 sentence structures and registered the syntactic information in their memory, their ability to listen in a foreign language improved significantly. This finding was also confirmed by Ohata (2006) in Japan in that Japanese EFL learners' working memory capacity was limited, but when they engaged in EFL syntactic exercises, their abilities in L2 listening increased significantly. This can be concluded that in L2 listening comprehension, increasing L2 learners' working memory by learning L2 syntax could be a major factor to improved listening.

In terms of reading, Erçetin and Alptekin (2013) found in their study that L2 learners' working memory was in a significant relationship with implicit and explicit L2 knowledge. They further discovered that L2 explicit knowledge had a strong connection with L2 reading comprehension. This is in line with Sweller's (2017) suggested design of EFL instruction in that explicit instruction of foreign language learning could lead to efficient learning based on cognitive load perspectives. However, given the suggested idea by Sweller (2017) and the findings of Erçetin and Alptekin (2013), it is still unclear what happens in learners' cognitive processing when it comes to learning EFL reading and listening.

In the view of Verhoeven and Perfetti (2008), text comprehension concerns an activation of mental image which is linked through an imagination of external input. This mental image is also limited by linguistic and visual information in the text, how much cognitive capacity is used in processing, and how a person interacts with the world. With reference to the aforementioned studies in this section (such as Ohata, 2006, Wright, 2009, Anderson 2010, Erçetin and Alptekin, 2013), it was only found that working memory capacity related to L2 acquisition and L2 skill learning. However, what is involved in cognitive processing and working memory when learners learn L2 language skills needs further understanding.

Firstly, Craik and Lockhart's (1972) *levels of processing* concerns the 'depth of processing' (p. 675). It was argued in their studies that the more depth of semantic and cognitive analysis, the more level of deeper retention could be achieved. When a person processes more semantic information deeply[3] in cognition, especially with more attention, the ability to retrieve such information was found to be better. In a study by Ruder *et al.* (2013), aiming at testing the relationship between the organisation of memory storage and different types of processing, semantic processing led to a deeper level of processing than specific phonological and orthographic conditions in the context of sign- and speech-based language. The authors argued that there is an intermodality difference between phonological and semantic conditions in working memory storage and processing. This finding is in line with the *encoding-specificity principle* by Tulving and Thomson (1973) in that a person remembers more efficiently if the input and retrieval contexts are similar. It could be argued that, in text comprehension, if participants engage with the text with more attention, their ability in retrieving information from the text could be better from a cognitive processing perspective. However, if the input and retrieval do not share similar features, how would we measure cognitive processing of L2 skill learning?

[3] With reference to Craik and Lockhart (1972), 'depth of processing' refers to a series of processing stages, ranging from preliminary stages of perception, followed by assimilating the new input with previously stored knowledge. This results in 'pattern recognition and the extraction of meaning' (p. 675).

In studies by Rotello and Heit (2000) and Medina (2008), recognition memory has been found to be a type of declarative memory[4] – or memory of the main and contextual information (Beken *et al.*, 2018). Its aim is to accurately measure if previously learnt information and events have been experienced before. According to Medina (2008), recognition memory is 'the ability to access accurately that a stimulus has been encountered before' (p. 13), and there are two levels of recognition memory – recollection and familiarity. In terms of recollection, the exact detail of information and event that a person has experienced is recalled. However, if some of the information or event could be consciously recounted, familiarity is accounted for such an incident. In L2 learning, Al-Hammadi (2012) argued that recognition memory could be enhanced by means of language awareness, language attention and language consciousness. Language awareness refers to an ability to attend to language input and hole the input in long-term memory. When a learner focuses on a particular point of language input, language attention occurs to retain information longer in long-term memory (Carr and Curran, 1994, Nunan, 2004). According to Sweller (2017), attending to language consciously can also help learners retain language input more efficiently in long-term memory. The role of recognition memory is confirmed by a study by Beken *et al.* (2018) who found that, in L1 Dutch and L2 English reading, learners' performance on comprehension tests were not significantly different between L1 and L2 at intervals, i.e. a day, a week or a month later. Learners also reported to maintain their motivation in learning to the same extent at intervals, and neither L1 nor L2 had an effect on immediate and delayed post-tests. The researchers suggested that L2 could be used to test learners' recognition memory as there was no loss of information in either L1 or L2.

In terms of cognitive processes for listening, a renowned framework with top-down vs bottom-up processes is used in an explanation. According to Field (2008), the concepts of top-down and bottom-up signify the *'directions of processing*' (p. 132). In the bottom-up process, learners extract elements of linguistic content to build up meaning, whereas in top-down processes learners use listening context and information stored in their long-term memory to get a sense of the meaning. In an earlier study by Field (2004), L2 English top-down listening processes were found to be used in a similar way as in native language listening among low intermediate EFL learners, but the use of bottom-up strategies by L2 EFL learners was also found in learners during listening. His argument for teaching L2 listening is to balance the use of top-down and

[4] Declarative memory refers to '*something that you can declare*' (Medina, 2008, p. 13). To put it in another way, declarative memory contains 'episodic and semantic memory' (Beken *et al.*, 2018, p. 1). Semantic memory contains world knowledge information (or general knowledge), whereas episodic memory stores contextual information surrounding the stored information. If we declare 'George W. Bush was a president of the United States.', we are using our declarative memory, in that there existed the President of the United States (or semantic memory) and George W. Bush used to hold that position (or episodic memory).

bottom-up processes. This is supported by Henderson (2017) who found that, in his qualitative enquiry, weak L2 listeners employed different top-down and bottom-up strategies in processing listening than good L2 listeners. The researcher argued that weak L2 listeners gained more confidence in listening when their awareness was raised to use listening strategies. In a study by Vandergrift and Baker (2015), there were strong correlations between L2 vocabulary and L2 listening comprehension, as well as between metacognition and L2 listening comprehension.

These studies suggest that top-down processes, in terms of L2 language competence and L2 metacognitive skills such as awareness-raising and sound discrimination, help L2 learners process L2 listening more efficiently. However, Khunziakhmetov and Porchesku (2016) found in their study that training EFL Russian learners with bottom-up strategies, i.e. linguistic features of words and statistical model of linguistic description, resulted in more awareness in the use of strategies in L2 listening. This is similar to Call (1985) and Ohata (2006) mentioned above on the use of EFL Japanese learners' interlanguage syntax to help their overall listening. This is also supported by a psychological study by Shipstead *et al.* (2012) who found that bottom-up attentional guidance via visual stimuli led to a specific type of activation in working memory capacity which means that selective attention as a bottom-up process is one of the cognitive processes involved in working memory.

When it comes to researching L2 listening strategies in terms of cognitive processes, Santos *et al.* (2008) argued that when a researcher determines learners' proficiency and allows them to reflect on their use of strategies in verbal reports without prior training, the methodology in investigating listening strategies can increase reliability in the results. With regard to Simasangyaporn (2016), in her study on self-efficacy and listening comprehension, the use of simulated recall interview, i.e. a type of verbal reports, showed how EFL learners changed their strategies in listening during a listening intervention.

Inconsistency of findings in terms of L2 listening processes will be investigated in the present study, but the focus will be on top-down processes[5] since the aim of the present research is to look at learners' cognitive processes and working memory in both reading and listening. And taking the arguments by Graham and Vanderplank and the results of Simasangyaporn's study into consideration, the present study investigated cognitive load and cognitive processes in L2 reading and listening by 1) considering learners' proficiency prior to taking part in the present

[5] Evidence from neuroscience shows that working memory capacity is controlled by top-down mechanism in the brain system (Edin *et al.*, 2009). According to Ligeza *et al.* (2017), there is a trade-off between top-down and bottom-up processes in the brain, in that when there is an increase in top-down processing, bottom-up processing decreases and vice versa, as shown by ERPs and behavioural measures on attention. This means that, in the present study, top-down processing is investigated in terms of WM capacity and cognitive load with an awareness that there could be a trade-off between the two processes, i.e. top-down and bottom-up during processing.

study, and 2) employing verbal reports, in terms of semi-structured interviews, in conjunction with experimental studies to capture learners' cognitive processes in L2 listening and also reading.

At this point of discussion, it could be summarised that there is evidence for studies of WM capacity and L2 acquisition. In terms of language skill learning, WM memory plays a role in efficient learning. However, when considering cognitive processing, it seems that working memory capacity needs a further investigation in explaining what happens in L2 language skill processing, especially in terms of cognitive load. This will further been explored in the following section.

2.2.4 Conclusion on working memory models

At this point of discussion, we learnt that working memory is a short-time, limited storage of information in human mind. A unitary system of working memory, i.e. Cowan's model, is questionable when it comes to foreign language learning. This is due to the fact that some areas of long-term memory are activated through sensory stimuli, yet domain-general knowledge stored in long-term memory might not be able to supply language knowledge, which is domain-specific (Traxler, 2012, Sweller, 2017). As for the Baddeley's model of working memory, however, different kinds of domain-specific information are entered into two different channels based on visual and/ or oral stimuli. Yet, it is still questionable if the central executive channel could hold and process domain-specific information efficiently from both visual and oral channels, given the fact that working memory could hold information temporarily. In exploring existing literature, it was found that working memory enhanced second language acquisition in terms of linguistic knowledge (such as Wright, 2009, Anderson, 2010) and language skill learning (e.g. Ohata, 2006, Erçetin and Alptekin, 2013). In terms of cognitive processing, four major theories have been covered, i.e. *levels of processing*, *encoding-specificity principle*, *recognition memory* and *top-down process*, to explain how cognitive processing might occur in language learning.

Taking the WM models, WM measurements and cognitive processing into consideration, the next section explores the role of working memory in designing educational training, especially in foreign language instruction.

2.3 Human cognitive architecture for instruction

In the previous section, we learnt that working memory was conceptualised into two models of a unitary storage system (Cowan's model) and a separate domain-specific storage system (Baddeley's model). In this section, implications of educational design based on working memory will be considered.

In language education, task design and performance identify success in SLA and cognitive processes (Ellis, 2003, 2005). Task difficulty is also considered one of the major factors contributing to second language processes such as comprehension (Nunan, 2004). According to Field (2008), linguistic content, especially in listening, determines how difficult a task is in terms of the cognitive demands on learners' cognition of a task. As a result, several researchers (such as Duff, 1985; Robinson and Gilabert, 2007; Robinson, 2011) propose different frameworks relating to task design and the cognitive processes learners follow to deal with task difficulty.

With regard to Duff (1985), task types which lead to effective input and interaction are divided into convergent vs divergent tasks. Convergent tasks are those which lead to learning success in terms of shared goals and interactional achievement among learners, whereas divergent tasks allow for individual differences in applying different strategies in language learning (see also Nezzhad and Shokrpour, 2013; Nosratinia and Kounani, 2016).

In Robinson's (2011) task complexity (or Cognition Hypothesis), there are three componential factors in the complexity of a task: cognitive, interactive and learner factors. According to Robinson and Gilabert (2007), when the design and sequences of a task and its cognitive demands of tasks are taken into account, this can lead to more automatic and efficient task performances of EFL learners.

Duff's and Robinson's frameworks lead to the implications of task design in two perspectives. Firstly, tasks are related to L2 cognitive processes in terms of individual vs shared group performances. Secondly, cognitive processes in L2 learning depend on task complexity where the sequences of tasks help support L2 processing. However, in terms of the design of tasks which take into account cognitive processes, there is another theoretical framework that can combine elements of L2 task design and planning. This is Sweller's Cognitive Load Theory.

During the 1980s, John Sweller (1994) proposed an educational theory named, '*Cognitive Load Theory*'. The theoretical framework is that people's working memory is very limited, compared with a bombarding amount of information to learn. Educational implications for this idea is that a teacher or an educator needs to design and manipulate instructional materials so that efficient learning with limited working memory could be achieved (Sweller, 1994, Clark *et al.*, 2006, Sweller *et al.*, 2011, Pass and Ayres, 2014, Sweller, 2015).

Under the framework of Cognitive Load Theory, Sweller (2010, 2011, 2015, 2016, 2017) discussed how information processing has been considered in connection with Geary's (2002) evolutionary educational psychology of knowledge. The implication of the evolutionary view of knowledge is that different kinds of knowledge could lead to different instructional designs and trainings (Sweller *et al.*, 2011). In Geary's terms (2002, 2012; Geary and Berch, 2016), a person is born with two different evolutionary processes of cognitive development, namely biologically primary knowledge and biologically secondary knowledge. Both types of knowledge lead to a person's abilities of 'conceptual, procedural, and utilisation' knowledge in one's schema (*Ibid.*, p. 334). According to Sweller (2011, 2015, 2016, 2017) and his colleagues (Sweller *et al.*, 2011), a person is born, and then evolves, to process biologically primary knowledge naturally, such as abilities to listen and speak one's native language. This kind of knowledge automatically evolves without one's situated learning environment because of survival reasons. In other words, a person does not need to be institutionally taught how to listen and speak in their native language since these abilities are biologically evolved in human cognitive architecture (Geary, 2002, 2012; Geary and Berch; 2016, Sweller, 2017). A conclusive idea from biologically primary knowledge could be that domain-general knowledge (with some domain-specific knowledge), such as abilities to learn one's native language, could be embedded into one's long-term memory naturally through experiences. Such knowledge was perceived to act as background information to learn another specific type of knowledge, i.e. biologically secondary knowledge (Sweller, 2017).

Another kind of knowledge is that a person refers to the processing of both conceptual and procedural information naturally. However, one could also learn biologically secondary knowledge through social contacts and formal instruction. According to Sweller (2010, 2011, 2015, 2016, 2017), humans have evolved to learn biologically primary knowledge, i.e. domain-general knowledge, and it can then be used to learn biologically secondary knowledge, i.e. domain-specific knowledge, through trainings and instruction. The main aim of learning biologically secondary knowledge is to function in a society appropriately, and this becomes culturally important for instructional implications (Sweller, 2015, 2016).

In second language acquisition, the idea of biologically primary and secondary knowledge resonates with what Truscott (2015) calls implicit unconscious and explicit conscious knowledge. According to Ellis (2009) and Mitchell (2013), implicit knowledge is derived from implicit learning processes. This can include a learner generalises schematic linguistic input by means of responding subconsciously to statistical patterns in the linguistic input. This idea leads to several SLA processing theories which consider the natural stages of linguistic development such as Processability Theory (Pienemann, 1998, 2010), Efficiency-Driven Processor model (O'Grady (2010).

Implicit learning is an unconscious process, according to Truscott (2015), which is similar to the biologically primary knowledge where humans have evolved to acquire their native language naturally with no conscious effort (Geary, 2012, Sweller, 2017). In terms of explicit knowledge, learning takes place through controlled processing of linguistic input (Truscott, 2015). According to Ellis (2009), increasing learners' awareness in attending to linguistic form/forms, for example in a task-based approach, enhances second language learning. This idea of consciousness-raising awareness in the explicit learning takes up direct intervention and implicit/explicit instruction, similar to the biologically secondary knowledge where a person intakes input from teaching and training via conscious efforts (Sweller, 2017). In the present study, the terms biologically primary and secondary knowledge are used since they reflect the design of instructional materials, which is the aim of the present study.

At this point in the discussion, it can be observed that Cognitive Load Theory recognises SLA cognitive processes via instructional design. It takes an evolutionary concept of biologically primary knowledge (innateness and implicit knowledge in SLA) and biologically secondary knowledge (direct learning and explicit knowledge in SLA) into account in designing instructional materials. This resonates with Chomsky's concepts (see Section 2.2.1) in terms of domain-general and domain-specific knowledge, in that domain general excludes language acquisition, but includes language learning (via instruction) and domain-specific includes language acquisition (via exposure to primary linguistic data) (see Schwartz, 1993). The following discusses research on domain-specific knowledge from the view of Cognitive Load Theory.

A study of the implications of Cognitive Load Theory on domain-specific knowledge was carried out by Vogel-Walcutt *et al.* (2011) concerning computer-assisted learning. Participants in their study were undergraduate psychology students participating in two conditions of multimedia military skill learning – cognitive load tasks of worked-sample format (examples of military command and control tasks) and cognitivist tasks of scaffolding condition (asking trainees to think and question from the military tasks). The researchers found that participants learning from the Cognitive Load Theory tasks retained information slightly better than the other group exposed to a scaffolding task. Although there were no significant differences in declarative, procedural and conceptual knowledge and decision-making skill tests, domain-specific tasks, i.e. military skills, designed in accordance with Cognitive Load Theory helped trainees retain information more efficiently than thinking skill tasks.

In multimedia language learning, i.e. also domain-specific knowledge, Wang (2014) found that an integrated multimedia format using Cognitive Load Theory, i.e. the modality effect, resulted in better scores of cloze, vocabulary and structure, reading comprehension and paraphrasing tests than the traditional design of multimedia learning, i.e. learning from PowerPoint presentations with complete text and sound effects. Liu (2011) also suggested that, in the multimedia learning of English, learning with Cognitive Load Theory applied resulted in a better processing of information with a lower cognitive load than the traditional design of web-based language learning where a large amount of text, animation, sound and graphics were presented.

In summary, this evidence means that learners have brought their primary learning skills of domain-general knowledge to specifically learn specific military skills (Vogel-Walcutt *et al.*, 2011) and online language skills (Liu, 2011, Wang, 2014). We can conclude that the application of Cognitive Load Theory is justifiable in the acquisition of domain-specific knowledge, that is, the biologically secondary knowledge resulting from instruction. The processing of input for secondary knowledge needs biologically primary knowledge as a framework for stepping stones. This understanding is illustrated in the following figure.

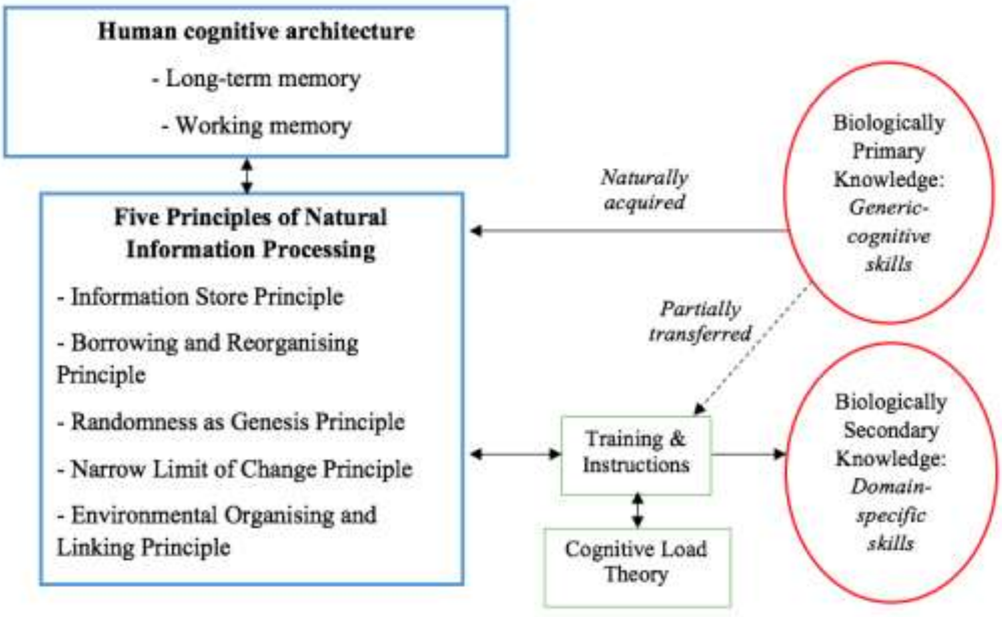


Figure 2.3. Human cognitive architecture and evolutionary knowledge

As Figure 2.3 illustrates, human cognitive architecture, i.e. long-term and working memory, is related to evolutionary knowledge, i.e. biologically primary and secondary knowledge. In order to understand how information is processed in human cognitive architecture, Sweller (2010, 2011, 2015, 2016, 2017) advocates the five principles of natural information processing shown in Figure 2.3 to explain how instructions under Cognitive Load Theory could be implemented in the processing process. The following discusses how the five principles could be understood for instructional implications.

2.3.1 Five principles of natural information processing

As noted above, with reference to biologically primary knowledge, information is naturally processed and results in knowledge base at human cognitive architecture, while a person needs to learn biologically secondary knowledge through instruction and training. What happens in human cognition in terms of information processing and cognitive architecture could be explained by the information-processing principles (Sweller, 2010, 2011, 2015, 2016, 2017) as follows.

2.3.1.1 Information store principle

In this principle, it is generally agreed that there is an immense amount of information available in the environment. Humans have innate abilities to store an immense amount of information in long-term memory. For performing different activities every day, domain-general information needs to be stored in one's memory capacity (Sweller, 2016).

When we consider language learners' abilities to learn information, it could be understood that, in learning one's native language naturally, primary abilities allow one to store as much linguistic, semantic and pragmatic information as possible in one's long-term memory to be used for specific activities. This relates to Cowan's (1988, 2005, 2014) working memory model in that one's long-term memory is used to store domain-general information through both visual and audio stimuli (Li *et al.*, 2014), and then, specific areas of long-term memory capacity are activated working memory to process new information efficiently.

It could also be argued that a person could perform a specific activity more competently than another person because the amount of information stored in their long-term memory (Sweller, 2016). In other words, when a learner becomes an expert with a vast and organised amount of information in long-term memory, learning and performance on a particular activity are more efficient. Beginners experiencing new information might not be able to competently complete a given task because little is stored in long-term memory (Sweller *et al.*, 2011).

In the following section, another principle of borrowing and reorganising will provide a clearer picture of how information is processed in human cognitive architecture.

2.3.1.2 Borrowing and reorganising principle

In this principle, in order to store a large amount of information in one's long-term memory, a person needs to acquire information which is already available in the environment. As Sweller (2017) argued a person learns a large amount of declarative and procedural knowledge by means of reading and listening from others' writing and speaking. The abilities to imitate others' long-term memory information, i.e. reading and listening from others' writing and speaking, cognitively involve biologically primary knowledge. This means human cognitive architecture acquires others' biologically secondary knowledge through their natural abilities of biologically primary knowledge. In this practice, a learner could imitate and acquire biologically secondary knowledge from other people by reading what they have written or listening what they said (Sweller *et al.*, 2011, pp. 28-30).

As this principle denotes, when a person borrows biologically secondary knowledge from another person through the assistance of biologically primary knowledge, concepts and procedures might not be perfectly stored or understood. This means that a learner might need to reorganise information from other people's information to construct new schema in their long-term memory. To put it in another way, the amount of information which is borrowed from other sources of primary and secondary knowledge will be reorganised in long-term memory during processing. This results in schema construction and automation, according to several researchers (such as Sweller, 1994, Cooper, 1998, Artino 2008).

At this point of discussion, we learnt that the borrowing and reorganising principle dominates human cognitive architecture to acquire information in order to function in a society efficiently. As a person possesses biologically primary knowledge to acquire biologically secondary knowledge, the aim of instruction could be that redesigning information in accordance with how a learner borrows or redesigns information in one's long-term memory could lead to efficient information processing. However, learning by means of imitation and reorganisation of information alone might not be sufficient as a person experiences new situations every day.

A learner might also need to create their own understanding of novel activities, but how they cognitively react to such activities in their information processing is still in question. The principle of randomness as genesis can be used to explain the process, and the next section deals with how a human processes information when facing with new or unfamiliar activities.

2.3.1.3 Randomness as genesis principle

In this principle, an argument for the borrowing and reorganising principle is that information is only obtained through borrowing and disseminating. However, novel information cannot be formulated using the borrowing and reorganising principle, in that a person schema is already constructed in cognitive architecture (Sweller, 2011, 2015, 2016). In order to create new knowledge for a novel activity, a person might supply the lack of knowledge by randomly generating information from their long-term memory and testing it. When a person consolidates different knowledge from long-term memory for a new action, they could track the best possible analogy of actions so that new information could be processed in working memory.

It could be understood in this principle that, when a person experiences a new activity or a problem, the lack of their knowledge in long-term memory or the inexistence of other people's information to borrow leads them to naturally generate and test as many solutions as possible. In order to successfully reach the best possible solutions, a person needs to test if choices generated in their long-term memory could efficiently be used in a novel situation (Sweller *et al.*, 2011). An example of this is a situation where someone learns a foreign language. When a person experiences a new language situation, s/he would try many possible ways to create a mutual understanding between interlocutors. Taking this scenario into consideration, we could argue that the biologically primary knowledge is involved in our cognitive ability to either borrow and reorganise information from other people or generate and test information from our own cognitive architecture. In other words, domain-specific knowledge can be generated as much as possible to reach the best efficient tests through the use of biologically primary knowledge. This results in a schema reconstruction generated in long-term memory (Sweller, 2011, 2016, 2017).

The above notion is framed by Sweller *et al.* (2011) in terms of the central executive channel in Baddeley's working memory model (2007). They discuss how the creation of knowledge based on randomness as genesis and test procedure is directly linked to knowledge stored in long-term memory, and this process is not independent of long-term memory as an independent central executive channel was hypothesised (pp. 35-36). According Baddeley (1992, 2006, 2007), a person gathers both visual and aural information to process concurrently in the central executive channel of working memory, but how the information processed in working memory links to long-term memory is still not clear. This is especially when the Baddeley's model is applied to explain how new knowledge is created based on randomness as genesis and test procedure in conjunction with long-term memory.

The presupposition of the randomness as genesis principle could directly be linked to Cowan's (1988, 2005, 2014) working memory model in that attention in a (novel) situation could lead to the activation of long-term memory in bringing about information to process in working memory. However, it could be argued in this principle that a person's random processing of information in long-term memory might be too overwhelming for working memory capacity because of too many generated choices and the low level of knowledge base (Sweller *et al.*, 2011). Although Cowan's working memory model might be able to supply an understanding of this principle in that certain areas of long-term memory are activated for a specific activity, working memory itself might not be able to hold generated information efficiently for a particular action.

The creation and test procedure of knowledge for a novel situation is initiated in long-term memory, but how information interacts with the environment is still in question. In the next section, the principle of narrow limit of change will be explained to alleviate the problem.

2.3.1.4 Narrow limit of change principle

As can be seen from the previous principle, in randomly generating novel information through information consolidation, the results of new possibilities may be too many for long-term memory to construct schema at a given time (Sweller, 2016). Working memory might not be able to hold new information from long-term memory efficiently because of its limited capacity (Cowan, 2001, Klingberg, 2009). The result is that a person's information processing system might have limited choices of new information to be processed in working memory for a specific activity or problem. The result of processing in working memory could then gradually be stored in long-term memory (Sweller, 2011, 2015, 2016).

In this principle, because of the limited storage of working memory capacity, information from the environment is limited. This is based on our general understanding that working memory's ability to hold information is limited and very short (Clark *et al.*, 2006, Sweller *et al.*, 2011). In order to process incoming information from the environment, human cognitive architecture needs to engage the minimum amount of information held in working memory with schema in long-term memory. This leads to a longer duration of information retention in working memory.

An instructional implication from this principle is that when a person formulates new knowledge, this will not be efficient when too much information is engaging in working memory. In order to construct and retain information from the environment efficiently, a learner needs to consciously, gradually intake information for it to be temporarily processed in their working memory. Then, s/he could reconstruct processed knowledge from working memory in long-term memory. A good example of this process is that we can only retain a telephone number temporarily in our memory when we have no means to record it. It takes repetition in our consciousness to hold the information for later recording or dialling (Sweller *et al.*, 2011, Sweller, 2017).

The narrow limit of change process principle leads to an understanding that the presentation of information as domain-specific knowledge is in relation to limited working memory. The goal of learning should be on how processed information in working memory leads to schema reconstruction in long-term memory. As a result, it is interesting to enquire how human cognitive architecture interacts with new information efficiently given the fact that schema reconstruction is slow and working memory capacity is limited.

In the following section, the principle of environmental organising and linking will be discussed to supply answers for the limited cognitive architecture question.

2.3.1.5 Environmental organising and linking principle

As can be seen from the previous section, all forms of domain-general knowledge and domain-specific knowledge generate, and these two principles explain how schema is constructed in long-term memory. We also learnt that new knowledge for long-term memory can be slow because a person's working memory is limited in processing new information. As Sweller *et al.* (2011) posited, information generated in long-term memory is not useful if it has not been used to engage with the external environment. In this section, a solution to limited working memory in relation to the external environment will be discussed.

In this principle, the external environment determines which information stored in long-term memory is activated in performing a particular action (Sweller, 2016). In other words, specific sets of stored information in long-term memory are transferred to working memory with no limit and duration when dealing with a particular action situated in the environment. According to Sweller (2017), in a particular situation, the environment determines which set of stored information in long-term memory is moved to working memory as many as possible so that working memory responds to the external environment effectively. The information store principle is used to deal with specific actions in practice, and information stored in long-term memory is activated in a specific area to transfer preferred information to working memory for a particular action in the external environment.

When considering the role of environment as an activation of long-term memory storage, we could understand that this principle is closely in connection with the Cowan's working memory model (2005) as an operational system for the environment as stimuli. Specific sets of information stored in long-term memory would then be transferred to working memory to process (Cowan, 1988, 2005 2014). However, according to Sweller *et al.* (2011, pp. 48-49), whether or not working memory is a separate system as in Baddeley's working memory model or a unitary system in Cowan's working memory model, instructional implications regard the executive functions of working memory as an information-processing system which mediates between long-term memory and the external environment. An example is when someone reads in a foreign language. When a learner sees strings of letters in a paragraph, they might activate lexical patterns in their long-term memory in understanding a vocabulary item. This means that the environment plays a role in linking information from long-term memory and organising information to perform a particular action effectively.

At this point of discussion, we can summarise that information stored in long-term memory is unlimited and the schema constructed in long-term memory could be transferred to working memory as many as possible when a person experiences a new situation or an action. This can be applied in learning, especially in language learning, in the next section.

2.3.2 Implications of the five principles of natural information processing for instruction

In the previous section, we learnt that human cognitive architecture, i.e. long-term memory and working memory, involves five principles of information processing. We, as humans, store information shared by others to randomly construct information in our long-term memory through a limited selection and to process novel information in our working memory in conjunction with unlimited long-term memory. In this section, implications of these five principles for language instruction will be considered.

With reference to Sweller (2016), information processing occurs naturally for biologically primary knowledge. In terms of foreign language learning, however, biologically secondary knowledge is an aim for instruction (Sweller, 2017). It includes domain-specific knowledge which requires domain-general knowledge as a foundation for instructional learning. For example, when a learner develops listening and speaking in their native language, the listening and speaking information stored in long-term memory is used as a basis for reading and writing instruction in that language. Domain-general knowledge of listening and speaking is regarded as biologically primary knowledge, whereas reading and writing are domain-specific knowledge, according to Sweller (2011, 2016, 2017) and his colleagues (Sweller *et al.*, 2011).

In foreign language instruction, listening and speaking is not a biologically primary knowledge when these skills are learnt through instruction (Sweller, 2017). This means that a person could not acquire foreign language naturally through domain-general knowledge. It is, in fact, domain-specific knowledge of listening, speaking, reading and writing which takes instructional implications for a learner to learn in biologically secondary knowledge. In other words, to learn a foreign language, a learner might need to access their cognitive architecture as a basis for domain-specific learning. As Chen *et al.* (2017) put it, when we understand what constitutes natural information processing in one's cognitive architecture, we could design instructional materials which are suitable for learners' limited working memory. This could then lead to a learner's efficient learning when one's cognitive resources are taken into consideration (Clark *et al.*, 2006).

Given the above notion, a teacher or an educator could design instructions in response to a learner's limited working memory and schema construction in long-term memory. It is important for a teacher to be aware that learning new information might be detrimental for long-term memory schema construction when the learner's working memory is limited. A question remains, 'How can the teacher design an effective instruction in response to the learner's limited working memory?'

In the next section, instructional design and instruction in relation to Cognitive Load Theory will be discussed.

2.4 Cognitive Load Theory and instructional design

As can be seen from the previous sections, two kinds of knowledge lead to different instructional implications. In foreign language learning, one's cognitive architecture might need to use biologically primary knowledge, i.e. domain-general knowledge, as a basis for domain-specific learning (or biologically secondary knowledge). What I have discussed above means that the information-processing principles inform the design of instructed language learning. In the next section, an intervention in terms of instruction as a process of biologically secondary knowledge learning will be discussed.

2.4.1 Cognitive Load Theory

Cognitive Load Theory (hence force, CLT) is an instructional design connected to human cognitive architecture (Sweller, 2010, 2011, 2015, 2016, 2017; Sweller *et al.*, 2011). As a beginning learner, when learning biologically secondary knowledge relying on limited working memory, they might not be able to retain and learn new information efficiently since they might not have enough knowledge base. If this is compared with an expert learner, learning new information might be more efficient than novel learners. According to Cooper (1998) and Cowan (2014), this scenario is related to working memory and the level of learners' cognitive expertise.

With reference to Cooper (1998) and Sweller (1994, 2011, 2015, 2016, 2017), cognitive load is defined as the mental effort required in working memory to solve problems, think and reason. The main argument is that when a teacher manipulates information, she can reduce cognitive load and the learner can learn more efficiently. When a teacher or an educator designs instructional materials without considering a limited memory storage, learning will be less efficient. Moreover, different types of mental effort should be considered: *intrinsic, extrinsic* and *germane* cognitive load (Sweller *et al.*, 2011). According to Sweller (1994, 2011, 2015, 2016, 2017), intrinsic cognitive load relates to learners' level of expertise. Extrinsic cognitive load relates to instructional designs. Finally, when information in instructional materials is used to activate learners' long-term memory, germane cognitive load can be increased, which then supports learning because of schema construction and automation (Sweller, 1994). This framework of Cognitive Load Theory and instructional design is summarised in my figure 2.4 as follows.

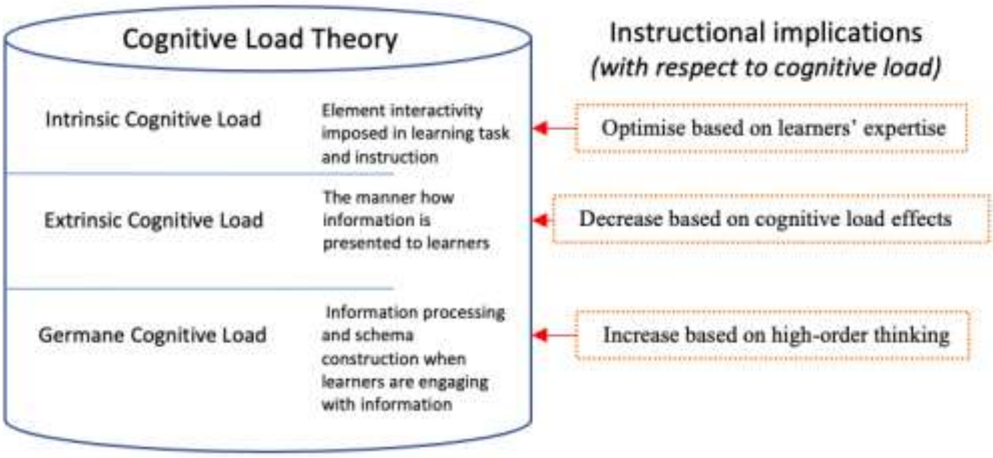


Figure 2.4. Cognitive Load Theory and instructional implications

As can be seen in Figure 2.4, Cognitive Load Theory consists of three types: *intrinsic, extrinsic and germane cognitive load*. Each category is combined into the overall cognitive load demands on working memory capacity (Sweller, 1994, Cooper, 1996). When a learner learns from instructional materials, it is important for an educator to consider these. In the next section, the three types of cognitive load will be illustrated and discussed.

2.4.2 Categories of Cognitive Load Theory and Instructional Materials

As we have mentioned above, instructional materials are directly related to the overall cognitive demands in two different ways. Firstly, intrinsic and extrinsic cognitive load are imposed by the nature and the structure of learning materials (Sweller *et al.*, 2011, p. 57). These two types determine cognitive load demands in learning. Secondly, germane cognitive load is learners' devoted load in learning. This type of cognitive load is related to schema construction in learners' long-term memory.

In this section, the three types of cognitive load will be discussed with instructional implications.

2.4.2.1 <u>Intrinsic cognitive load</u>

Intrinsic cognitive load deals with information imposed on instructional materials. In other words, the elements of information interact within instructional materials lead to a high or low mental effort on working memory when a person is learning. In addition to this, information available in instructional materials is similar to information in the external environment, in that the amount of information is abundant (Sweller, 1994, 2015; Clark *et al.*, 2006; Sweller *et al.*, 2011; Pass and Ayres, 2014). An example in EFL is when the teacher designs a reading text, the source text itself, i.e. biologically secondary and domain-specific knowledge (Geary, 2002, 2012; Sweller, 2010, 2011, 2015, 2016, 2017; Sweller *et al.*, 2011), contains strings of vocabulary into sentences, which also contain concepts and procedures. The element interactivity within the source text, i.e. vocabulary, sentences and semantic meaning, determines intrinsic cognitive load, which results in learners' mental effort in working memory.

When looking into information of biologically secondary knowledge, we can discuss that the amount of element interactivity is related to intrinsic cognitive load. When a beginner learns a new English word 'cat', for example, the strings of letters contain less cognitive demand in working memory than learning a new English sentence. According to Clark *et al.* (2006), efficient learning in terms of intrinsic cognitive load can also be optimised based on the levels of learners' expertise. If the element interactivity is high in instructional materials, expert learners can engage with it with ease. Being an expert means having stored a lot of organised information in long-term memory and this can be used to engage with high element interactivity, according to the *environmental organising and linking principle* (see Section 2.3.1) (Sweller, 2011, 2016, 2017). However, when a beginner tries to learn from high element interactivity in instructional materials, their working memory might be too overloaded because there is little stored information in long-term memory to engage with the external environment (Klingberg, 2009).

An example of an intrinsic cognitive load and instructional materials is a study by Mikk (2008) concerning sentence length for text comprehension. The researcher found that text of '130-150 characters' was the most appropriate length to enhance learners' text comprehension, and this correlated with learners' working memory capacity. Another example of an intrinsic nature of instructional material concerns speakers' accent variability. Gao *et al*. (2013) conducted a study of speakers' variability effects on EFL learners of English with foreign accents. They found that low-level EFL learners could benefit more when they listened to a single accent than multiple-speaker variability, but vice versa for expert EFL learners. This means that intrinsic cognitive load increases learners' cognitive capacity, but it can be optimised according to learners' level of expertise.

Taking the aforementioned notion, we could understand that, the level of learners' expertise is one of the factors in designing effective instructional materials. It is also the level of element interactivity of information which imposes high or low mental effort on working memory capacity. For instance, it is too difficult for beginner learners to read an EFL paragraph with a high number of complex sentences, compared with proficient learners. This is because many different levels of information, i.e. phonological, orthographic, lexical and syntactic knowledge, interact among each other for a high degree of element interactivity. However, when learning a new English word, both beginner and expert learners can learn a single word with ease because of less element interactivity to be processed in working memory (Pollock *et al.*, 2002, Sweller, 2017). However, when the goal of learning is altered, a variability effect of intrinsic cognitive load adds more cognitive capacity to working memory (Pass and van Merrienboer, 1994; Sweller, 2016). For instance, in reading comprehension, if learners are required to look up words at the same time as reading them in a sentence, the goal of learning is changed, and word information is added to processing, resulting in more element interactivity imposed in instructional learning.

At this point in discussion, we can conclude that element interactivity plays an important role in cognitive load, and that it is the job of the teacher to optimise how element interactivity of materials are in line with the level of learners' expertise, given the fact that information imposed in instructional materials is abundant. Alternatively, intrinsic cognitive load might be altered when the nature and goal of learning changes (Sweller, 2016). However, in terms of instructed learning, we need to manipulate instructional materials so that they can enhance learners' processing (Sweller, 1994, 2010, 2011, 2015, 2016, 2017).

In the next section, another type of cognitive load which deals with how to manipulate or present instructional materials will be discussed.

2.4.2.2 <u>Extrinsic cognitive load</u>

With reference to Sweller (2011, 2015, 2016, 2017) and his colleagues (Sweller *et al.*, 1998; Sweller *et al.*, 2011), extrinsic cognitive load is also related to element interactivity, but it is an external view of how the information is presented in instructional learning. If information to be learnt is regarded as biologically secondary knowledge (Geary, 2002, 2012; Geary and Berch, 2016, Sweller, 2017), the manner in which information is presented in learning imposes high or low cognitive load in learners' working memory. According to Sweller (2016), although the nature of intrinsic cognitive load cannot be altered in instructed learning, except for a change of learning goal and learners' expertise, extrinsic cognitive load can be controlled by teachers in terms of the manner of information presentation.

In presenting information for processing, a teacher or an educator can consider several cognitive load effects in preparing instructional materials to learners (Clark *et al.*, 2006, Sweller *et al.*, 2011). The main goal is to enhance processing when learners are interacting with instructional materials and/or procedures. In terms of extrinsic cognitive load and element interactivity, Sweller (2011, 2015, 2016, 2017) and his colleagues (Sweller *et al.*, 2011) discovered several effects which lead to ineffective instructional procedures imposed in instructed learning as presented in Figure 2.5.

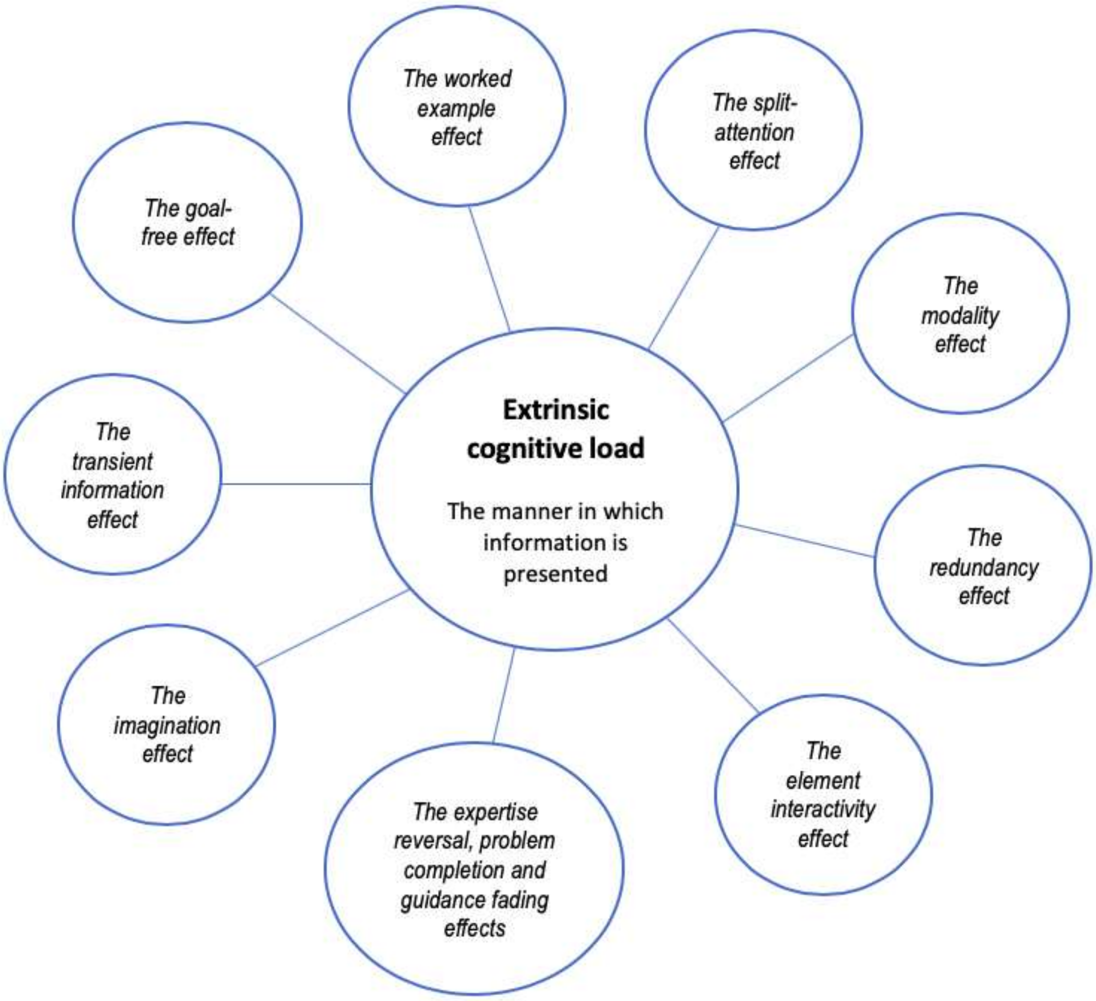


Figure 2.5. Cognitive load effects (adapted from Sweller *et al.*, 2011 and Sweller, 2016)

As Figure 2.5 depicts, extrinsic cognitive load consists of eight cognitive load effects which connects to the manipulation of instructional design and procedures. The followings are brief discussions of each type. For example, in *the goal-free effect*, i.e. posing problems with no required answer such as, 'if y = x + 4, x = z + 2, and z = 6, *find what you can*' (Cooper 1998), it was found that learning problem solving from the goal-free effect was significantly better than means-end analysis, i.e. posing problems with required answers such as, 'if y = x + 4, x = z + 2, and z = 6, *find the value of y*' (Cooper 1998), (Sweller *et al.*, 1998; Veena and Krishna Kumar, 2012). This is because of less element interactivity, i.e. less amount of information, imposed in the goal-free effect, where learners process information more efficiently through testing their personal hypotheses (or the information processing's randomness-as-genesis principle) (Sweller, 2016, 2017). In *the worked example effect,* i.e. providing a good example for students to study and follow a similar task, learners were able to learn problem solving skills through the borrowing and reorganising principle, where the level of element interactivity, i.e. the amount of information, was less than when learners process solving problems themselves with a high working memory load (Sweller *et al.,* 2011, Sweller, 2016).

When considering the cognitive load effects in language education, it was found that split-attention and redundancy effects were found most prominently in language education research (Diao and Sweller, 2007, Hung, 2009, Sydorenko, 2010, Sombatteera and Kalyuga, 2012, Moussa-Inaty *et al.*, 2012, Genç and Gülözer, 2013). According to Sweller (2011, 2015, 2016, 2017), *the split-attention effect* refers to the presentation of two or more unrelated sources of information, which requires learners to physically or mentally integrate different sources of information using working memory. The act of diverting attention to different sources of information and integrating information mentally results in cognitive overload and inefficient learning (Hung, 2009, Genç and Gülözer, 2013). To alleviate the problem of information overload due to the split-attention effect, several researchers (e.g. Hung, 2009, Schroeders *et al.*, 2010, Luchini *et al.,* 2015) advocate the idea of integrating different sources of information into an integrated format, which leads to better learning results.

When it comes to integrating information, two cognitive load effects can be considered in connection with working memory models. In Baddeley's (1992, 2006, 2007) model of working memory, visual and phonological information enters into two different loops of working memory — the visuospatial sketchpad and phonological loop. This means that if one loop of working memory is filled up, the other loop has capacity for the other type of information to be processed. This results in *the modality effect* of Cognitive Load Theory (Sweller, 2011, 2015, 2016, 2017). The idea is that when learners are exposed to instructional materials with both loops of information processing, i.e. the written form for the first half and the oral form for the second half, or vice versa, working memory capacity will not be overloaded (Plass *et al.*, 2003, Schroeders *et al.,* 2010, Sombatteera and Kalyuga, 2012, Lee and Mayer, 2015). However, if learners are exposed to the same information in both written and oral forms at the same time, both written and oral forms will be filled up because information is redundant in the phonological loop and sketchpad rather than complementing each other as in the modality effect. The result of redundant information in two channels of working memory lead to *the redundancy effect* in Cognitive Load Theory (Sweller *et al.*, 1998; Sweller, 2011, 2015, 2016, 2017; Torcasio and Sweller, 2010). With reference to Sweller (2016) and his colleagues (Sweller *et al.*, 2011), however, instructional materials, designs and procedures with low element interactivity, i.e. less amount of information as in learning an English word, might not affect retention and learning results, even though the materials contain either split-attention or redundancy effect. This is, working memory involves not being filled up by information presentation effects, i.e. split-attention and redundancy effects, and working memory resources are available for processing the low element interactivity (Pollock *et al.*, 2002; Sweller, 2015, 2016).

At this point in discussion, we have learnt that four types of cognitive load effects, i.e. goal-free, worked example, split-attention, modality and redundancy effects, relate to how to manipulate instructional materials, design and procedures. In terms of problem-solving learning, goal-free and worked example effects demand less cognitive load capacity because of less information processing in working memory, which results in more working memory capacity to learn efficiently. In terms of information presentation, split-attention and redundancy effects are regarded as imposing a high cognitive load during learning, but they could be supplemented through an integrated form and the modality effect to reduce load. The difference between the integrated form and the modality effect is that the integrated form disseminates different sources of information into an integrated form of presentation, such as integrating two texts into a single text, whereas the modality effect requires the use of different channels of sensory stimuli in learning from the presentation of different representations of information simultaneously, such as integrating an image with an audio. However, the level of learners' expertise is also a factor in designing instructional materials, design and procedures based on the level of learners' expertise being in relation to intrinsic cognitive load and element interactivity (Yeung *et al.*, 1997, Yeung, 1998, Chang *et al.*, 2011, Sweller, 2016). The section below describes cognitive load effects and the level of learners' expertise.

Several researchers advocate that learners can increase their cognitive capacity when they gain more proficiency (e.g. Kalyuga, 2009, Chang *et al.*, 2011, Gao *et al.*, 2013, González *et al.*, 2017) and feel less anxious during learning (e.g. Chen and Hsieh, 2011). According to Kalyuga (2009), when learners gain more proficiency in learning, guided-learning procedures, which are suitable for beginning learners, might increase the redundancy effects for advanced learners. When guided learning is presented to advanced learners, *the expertise reversal effect* occurs, and this could fill up working memory with more information to process. However, when advanced learners are required to control their own learning, with less guidance, as in *problem completion and guidance-fading effects*, learning and retention results will be more prominent than what beginning learners do because of much organised information stored as schema in advanced learners' long-term memory (Sweller, 2016, 2017). Another cognitive load effect which is related to learners' expertise level is *the imagination effect*. According to Cooper *et al.* (2001), expert learners, when exposed to worked example (or a model example to follow), for example, process information in their imagination significantly better than beginning learners. This is also due to expert learners possessing much more organised schema in their long-term memory. The result of new information retention is, therefore, better because of the availability of working memory capacity to process the imagined information.

Technology now plays an important role in learning and education, and so does a new cognitive load effect in dealing with technologically processing, i.e. *the transient information effect* (Sweller *et al.*, 2011; Sweller, 2015, 2016; Leahy and Sweller, 2016). According to Leahy and Sweller (2016), listening and animation information which is transient tends to be less efficient in learning and retention, compared to a reverse modality effect, where learners can both see and listen to information concurrently. Several researchers of educational technology (such as Ari *et al.*, 2014, Mayer *et al.*, 2014, Studente and Garivaldis, 2014) found that because of the counteract effect, the reverse redundancy effect in presenting the same information in both visual and audio form helps learners learn from e-learning materials better than presenting a single representation of information online.

In this point in discussion, we have learnt that several cognitive load effects lead to effective or ineffective learning. In language education, the split-attention and redundancy effects impose high cognitive load in language learning, whereas the modality effect or an integrated form of information can help decrease incoming information processed by working memory. However, when learners become more advanced in language learning, whether information contains detrimental effects, i.e. split-attention and redundancy effects, or supportive effects, i.e. modality effect, might or might not affect learning results. Taking this scenario into consideration, this research project aims to investigate whether detrimental or supportive effects infused in instructional materials could help or hinder students' learning. The context of which, i.e. environmental linking and organising principle, is in English as a foreign language (EFL).

In the next section, the last type of cognitive load will be discussed, followed by related research studies in relation to EFL text presentation and cognitive load learning.

2.4.2.3 Germane cognitive load

In previous sections, we discussed intrinsic and extraneous cognitive load types. In this section, germane cognitive load, or supportive load, will be discussed.

Germane cognitive load is a supportive load which increases learners' processing in working memory. According to Sweller (2011, 2016), when a learner interacts with instruction and brings organised information from long-term memory to the interaction, schema construction and automation can be implemented in working memory. As we have discussed in Section 2.3.1, when the external environment activates long-term memory, the information triggered in long-term memory is transferred to working memory as much as possible (Cowan, 1988, 2005, 2014; Sweller, 2011, 2016, 2017). This means that, in instruction, the familiarity of conceptual and procedural knowledge can be used to trigger long-term memory knowledge, and the result is schema construction and automation. According to Sweller *et al.* (2011) and Jiang (2017), because information in instructional materials trigger the information stored in long-term memory, germane cognitive load could be viewed as a part of intrinsic cognitive load, which links the element interactivity of materials to the one stored in long-term memory.

In terms of information stored in long-term memory, several researchers (such as Anderson, 2000, Merriam *et al.*, 2007) proposed the idea of schema as 'schema theory' to explain how information stored in long-term memory is processed, organised and retrieved in learning. According to Anderson (2000), schemas change all the time and they employ both declarative and procedural knowledge in processing. Merriam *et al.* (2007) also supported schema theory by postulating several tools, such as 'advance organisers', which can be used to engage new and prior knowledge in learning. However, what constitutes a schema is still in question. We will return to this in section 2.5.2.2.

Besides task performance and external environment which are factors in determining germane cognitive load, a study by Chen and Hsieh (2011) advocated that an affective factor, i.e. motivation, was correlated with germane cognitive load. They found that, in EFL learning, learners brought in motivation in engaging with a learning task, i.e. germane cognitive load, which was also related to task performance. This means that learners' internal feelings in engaging with instructional materials also determine the amount of germane cognitive load, in addition to the external tasks.

When it comes to learning and instruction, it could be argued that because learners activate their long-term memory information to learn from external stimuli, their working memory capacity becomes unlimited according to the *environmental organising and linking principle* (see section 2.3.1). However, it is questionable to measure if learners bring in their prior knowledge in long-term memory to interact with instructional design, materials and procedures. Another question arises in how to measure learners' germane cognitive load when they are interacting with instruction. This could lead to another measurement, which is a research gap of Cognitive Load Theory (Brünken *et al.*, 2010*)*.

At this point of discussion, we have learnt that Cognitive Load Theory could be used as a framework in designing instructional materials and measuring cognitive load learning. However, in understanding foreign language learning through the lens of Cognitive Load Theory, we might need explore more deeply students' learning so that we can understand what happens when they are interacting with instructional materials. Also, since learners are learning from instructional materials, their self-reports could yield more evidence of germane cognitive load as well as their perception on their cognitive load in relation to learning.

In the next section, related research studies in relation to human cognitive architecture and their instructional implications will be discussed.

2.5 Instructional materials in foreign language learning

In previous sections, we have learnt that human cognitive architecture involves long-term memory as a foundation for dealing with cognitive load when processing information in working memory. The limited storage of working memory could result in ineffective learning, whereas, when learning is situated in germane cognitive load, the availability of resources from long-term memory to transfer to working memory is as many as possible. To trigger long-term memory, the presentation of information as well as learners' level of expertise should be taken into consideration so that information can be retained and learnt effectively.

In this section, instructional materials in a foreign language in relation to learning will be discussed.

2.5.1 Split-attention effect and integrated format in EFL instructions

Split-attention effect is a detrimental effect which leads to an overload of information in working memory and ineffective learning (Yeung *et al.*, 1998, Yeung, 1999, Sweller *et al.*, 2011).

With reference to many researchers (such as Cierniak *et al.*, 2009, Hung, 2009, Al-Shehri and Gitsaki, 2010), when learners read in a foreign language, the presentation where split-attention applies results in information overload of learners' working memory capacity. The suggested way of solving this problem is to disburse all information into a single, physical configuration so that there is no need for a mental integration of information (Sweller *et al.*, 2011). This can be exemplified as follows.

In 2009, Hung conducted an experimental study on EFL geography reading for university students. The researcher found that, in the learning phase, students who learnt from the split-attention effect on EFL geography reading, i.e. reading the text first and comprehension questions later, obtained significantly lower scores than those who learnt from an integrated format, i.e. integrating comprehension questions into the reading text. However, the comprehension score results were not significantly different in the testing phase. This means that cognitive load effects, i.e. split-attention and an integrated format, result in only learning, but not in information retention. This result of an effective learning from the integrated presentation of information was also in line with online reading (Cierniak *et al.*, 2009, Al-Shehri and Gitsaki, 2010).

According to Cierniak and his colleagues (Cierniak *et al.*, 2009), in their experiment, L1 university learners who read from an integrated format of physiology text performed better on knowledge tests than those in the split-attention group, but there was no significant difference in the inference test. The researchers also discovered that learners from both treatments did not perform differently on a cognitive secondary task, where learners reported whether they saw red or green colour during reading online. This means that when native-speaking learners learnt in their native language, different presentations resulted in different learning performance, but their cognitive capacity was used in a similar manner, which is reflected in the inference test and cognitive secondary task.

At this point in discussion, it is clear that both Cierniak *et al.* (2009) and Hung (2009) show that the integrated format of reading in both L1 and L2 supports university students in learning information from reading texts. However, from the perspective of Hung (2009) in an EFL context, university learners could not retain information in the testing phase statistically significantly better after reading from the integrated text, even though the learning phase was significantly better than the split-attention reading. In addition to this, when a cognitive secondary task was used to measure university learners' cognitive load in the study of Cierniak *et al*. (2009), both integrated and split-attention L1 reading showed no statistically significant difference in learners' cognitive load in the learning phase. These studies do not show how learners' cognitive load in interacting their learning with the integrated and the split-attention formats was used to understand EFL reading information. Also, in the later stage of both studies, how learners retained information from their cognitive EFL reading was still unclear. The present study looks for answers to these questions.

When turning to integrated and split-attention online EFL/ESL reading, Al-Shehri and Gitsaki (2010) discovered in their experiments on multimedia ESL reading that the integrated reading format was statistically significantly better than other types of reading formats. They found that when intermediate ESL learners learnt from an integrated format of online reading with an access to an online dictionary, the reading comprehension test scores were significantly better than other types of formats, i.e. an integrated format with no access to an online dictionary, a split-attention format with an online dictionary and a split-attention format with no access to an online dictionary. The researchers also discussed that when ESL learners learnt from the integrated format, the reading speed was faster than those in the split-attention format. In fact, learners in the split-attention format switched between the text and questions 'four to six times on average' (pp. 367-368), which increased cognitive load during online split-attention reading.

At this point in discussion, we see that reading from an EFL integrated format is more beneficial for comprehension and knowledge tests than the split-attention format. However, in online learning, the results of comprehension tests are inconsistent, in that more advanced learners benefit from the split-attention effect than the integrated format. This could be explained by Yeung and his colleagues (Yeung *et al.*, 1998, Yeung, 1999), where the presentation format of information as a split-attention effect depended on learners' level of expertise. In their many experiments on split-attention effects, Yeung (1999) found that learners with less experience benefited from the integrated format in terms of comprehension, but vocabulary learning was deficient since the integrated format caused an increase in redundancy effects. However, proficient learners experienced the integrated format as containing redundancy effects. In other words, more experienced learners' performance was found to be significantly worse in comprehension results when they learnt in the integrated format (Yeung *et al.*, 1998). This means that when learners with different levels of expertise are exposed to the split-attention format, a similar treatment can result in different learning results. Less proficient learners benefit from learning from the integrated format more than advanced learners, whereas advanced learners found the integrated format redundant, and this affected learning negatively.

The studies by Yeung and his colleagues are in line with present-day online reading research. For example, according to Genç and Gülözer's study (2013), pre-service EFL teachers in Turkey performed online reading significantly better than those who read from a printed text and from an online hypertext, i.e. the split-attention effect. Also, the subjects in this study obtained significantly higher test scores when they only read online in a single mode, not integrated.

At this point in discussion, we can conclude that the split-attention effect was found to affect learning in an EFL context. However, the dominant findings of an integrated format were found to be only effective in language learning under the experimental treatments, but not in retention results in later stages. The majority of studies are reading, not listening. So, this research aims to measure learners' retention from reading and listening since, according to Schroeders *et al.* (2010), reading and listening are basic receptive skills for second language learning, and learners' ability to retain information efficiently, i.e. efficient learning, is the goal of Cognitive Load Theory (Sweller *et al.*, 2011).

In the next section, other cognitive load factors which are important for designing EFL instructional materials will be considered.

2.5.2 Redundancy and modality effects in EFL instructions

As discussed above, redundancy effect is a cognitive load effect which causes cognitive overload in working memory. It occurs when a learner uses only one channel of sensory input on two or more redundant sources of information. When a learner is exposed to the same information from reading and listening, i.e. the phonological loop and the visuospatial sketchpad, both reading and listening information is redundant in working memory capacity (Moussa-Inaty *et al.,* 2012, Jiang *et al.*, 2017). This is because a learner only uses the phonological loop for obtaining language information, but the capacity of visuospatial sketchpad is used minimally since pictures and images may not be present to process. To accommodate working memory, several researchers (Paivio, 1990, Plass *et al.*, 2003, Schroeders *et al.*, 2010, Sombatteera and Kalyuga, 2012, Lee and Mayer, 2015) suggest an integrated form of information presentation for the *modality effect*. In other words, when a learner uses both channels of working memory, i.e. graphic and aural information, working memory capacity might be enough to obtain both graphic and audio information.

Given the fact that the same information presented in both listening and reading, i.e. the redundancy effect, could interfere with effective learning, some scholars (e.g. Chang *et al.*, 2011, Chen *et al.*, 2012) suggest that, in EFL online learning, the presentation of information to result in redundancy effects could benefit learners to learn online more efficiently. This inconsistency will be discussed in the following section.

2.5.2.1 Redundancy effects in reading and listening

A number of researchers (Dao and Sweller, 2007, Schroeders *et at.*, 2010, Sydorenko, 2010, Chang *et al.*, 2011, Chen *et al.*, 2012, Moussa-Inaty *et al.*, 2012, Ari *et al.*, 2014, Studente and Garivaldis, 2015, Luchini *et al.*, 2015, González *et al*., 2017) carried out experiments on cognitive load effects on reading and listening and found different results on the presentation of written and listening texts at the same time from two perspectives. Firstly, in foreign language learning, the presentation of the same reading and listening information simultaneously, i.e. the redundancy effect, is detrimental to the acquisition of knowledge and/or language. However, when learners' level of language proficiency is low, the redundant presentation, especially in an online platform, can be beneficial for the acquisition of knowledge and/or language. The following table illustrates how different studies yielded these different results.

Table 2.1. *Summary of studies on redundancy effects*

Redundancy effect (Negative)		**Reversed redundancy effect (Supportive)**	
Studies	Results	Studies	Results
González, Vázquez and Luchini (2017)	Reading only > Reading and listening (on reading comprehension)	*Jiang, Kalyuga and Sweller (2017)*	Reading and Listening > Listening only (on listening task) **low-proficiency only*
Luchini, Ferreiro and colalillo (2015)	Reading only > Reading and listening (on reading comprehension)	*Chen, Chang and Yen (2012)*	Reading and Listening > Listening only (on mobile listening comprehension)
Diao and Sweller (2007)	Reading only > Reading and listening (on lexical knowledge and text comprehension)	*Chang, Lei and Tseng (2011)*	Reading and Listening > Listening only (on mobile listening comprehension)
Jiang, Kalyuga and Sweller (2017)	Reading only > Reading and listening and listening only (on listening comprehension)	*Studente and Garivaldis (2015)*	Narration and Text > Narration and Graphics and Text and Graphic (on knowledge tests online)
Moussa-Inaty, Ayres and Sweller (2012)	Reading only > Reading and listening and listening only (on word learning, word translation, sentence learning, sentence translation, CLOZE and sentence creation)	*Ari, Flores, Inan, Cheon, Crooks, Paniukov and Kurucay (2014)*	Listening with Text Label > Listening only (on knowledge tests)

As can be seen in Table 2.1, reading only supported language learning more than exposure to reading+listening (e.g. Luchini *et al.*, 2015; González *et al*., 2017). In terms of listening comprehension, reading only helped support EFL learners in listening, rather than reading+listening (e.g. Moussa-Inaty *et al*., 2012; Jiang *et al.*, 2017). The followings exemplify how each study is related to redundancy effects.

In terms of reading, Diao and Sweller (2007) designed a series of reading experiment on Chinese undergraduate EFL students. They found that reading only scored significantly better in both word coding, i.e. translating words from reading passages into Chinese, and text comprehension, i.e. writing main ideas in Chinese, than reading and listening simultaneously. The authors argued that, for beginners, both reading and listening imposed more cognitive load to process since, in their working memory, learners need to match reading text with listening. This causes an information overload in learners' memory to later process word coding and text comprehension. The study by Diao and Sweller informs EFL scholars concerning Cognitive Load Theory and EFL reading in recent years. In 2015, Luchini *et al.* found in their experiment that a group of young EFL learners who read from PowerPoint slides only performed significantly better in reading comprehension than the other group of reading and listening. The researchers claimed that the presentation of reading and listening in a dual mode imposed more cognitive load in learners' memory which resulted in less efficient reading. This result is in line with the study of González *et al.* (2017) who found that reading only resulted in better recall results than reading and listening for both groups of low-intermediate and advanced EFL learners. The difference of redundancy effect, i.e. reading and listening, between low-intermediate and advanced EFL learners is that of learners' expertise. The researchers argued that, because advanced learners had more linguistic knowledge than low-intermediate learners, 'redundancy effect is not as detrimental for advanced learners as it is for less proficient students' (p.100). The three studies discussed above confirm that redundancy effect, i.e. reading and listening simultaneously, results in more cognitive load demands than reading only.

When it comes to listening, a surprising result is discovered. According to Moussa-Inaty *et al.* (2012), in three experiments on undergraduate Arabic EFL learners, reading only was found to result in significantly better scores in word learning, word translating, sentence learning, sentence translating and listening comprehension than reading+listening and listening only. It was argued that, in listening only, learners might try to match sounds they heard with in their background knowledge. When learners have less background knowledge, the process of randomness as genesis principle, i.e. guessing and testing personal hypotheses, causes more load in their memory than reading only. As for reading+listening, low intermediate learners might try to match listening with reading, and process language information simultaneously. This explanation is similar to the study of Diao and Sweller above that redundant information fill learners' working memory to further process reading or listening. However, in the experimental studies of Jiang *et al.* (2017), reading only and reading+listening played different roles in supporting listening. It was found that, in EFL listening, advanced Chinese learners scored significantly better in reading only than listening only and reading+listening, whereas beginning Chinese learners performed significantly better in reading+listening. The researchers argued that advanced learners might rehearse the printed text mentally during reading, and this process helps support listening. As for beginning learners, however, listening and reading at the same time is argued to reduce cognitive load as they could relate sounds of the printed text through reading+listening. The inconsistent results of Moussa-Inaty *et al.* and Jiang *et al.* mentioned above are unclear if redundancy effect supports or hinders EFL listening for beginning learners, and the present study looks for an answer for this question.

The studies on redundancy effects, however, did not always result in negative cognitive load, especially in online learning, as in Chang *et al.* (2011), Chen *et al.* (2012), Ari *et al*. (2014) and Studente and Garivaldis (2015). According to Chang *et al.* (2011), undergraduate EFL learners in Taiwan participated in learning from two different media presentation modes, i.e. sound only and sound+text. The researchers found that, in listening tests, those who learnt from the dual mode, i.e. sound+text, scored significantly more than those in the single mode, i.e. sound only. They also found that, in cognitive load rating scale, the dual mode imposed less load in learners' memory than the single mode. The researchers argued that, in EFL listening, dual mode helped reduced intrinsic cognitive load in the materials as the existence of text during listening helped learners to process listening with less cognitive demands. The results of supportive redundancy effects were further explored in Chen *et al.* (2012) concerning mobile language learning. It was found that, in recall listening tests, Taiwanese EFL learners learning from the dual mode performed significantly better in an immediate recall than those in the single mode. The cognitive load rating scale used by the researchers also confirmed that the single mode imposed more load than the dual mode. However, Chen and his colleagues found no subsequent listening skill transfer from the single and dual modes. This means that the presence of text during listening facilitated online EFL learning, but it did not help learners to (re)construct schema in long-term memory.

To test whether the redundancy effect is efficient for online learning, two studies show similar results as follows. In a study of Ari *et al.* (2014) concerning online phonetics learning, overall, undergraduate native English speakers of non-linguistic background who learnt from on-screen text labels with audio description, i.e. the dual mode, performed significantly better in reconstruction and labelling tests than those who learnt from audio only. The researchers further found that, in examining the number of clicks as a study pattern, learners in the dual mode had a greater number of clicks than those in the audio only. This means that the redundancy effect helped native English learners to learn new knowledge online, i.e. phonetics, when they could control over their multimedia learning, i.e. the number of clicks. In 2015, Studente and Garivaldis (2015) conducted a study of online music learning for undergraduate EFL learners among three conditions – redundancy mode (an online text with audio narration), modality mode (statics graphic with audio narration) and mixed mode (statistic graphics with onscreen text). Although all modes indicated significant increases in post-tests, the researchers found learners learning from the redundancy mode scored significantly better than the modality and mixed modes. They argued that, in online learning from redundancy mode, learners processed audio and text as 'identical information' (p. 8). At the same time, the presence of text during listening supported learners to attentively focus on information, which means they processed foreign language information in a 'deeper level of learning' (p. 8).

At this point in discussion, it could be argued that redundant information in EFL reading+listening resulted in less efficient reading and listening as more mental effort in learning from reading+listening is imposed in learners' working memory capacity. Reading only seems to be the best presentation mode in EFL reading and listening. On the other hands, in online learning, a number of studies indicated efficient results of online learning from redundancy effects, or the *reverse redundancy effect* (Mayer *et al.,* 2003; Mayer, 2004; Mayer *et al*., 2014). It is argued that redundant information is identical for EFL learners to process reading and listening simultaneously (as in Chang *et al.*, 2011; Chen *et al.*, 2012; Studente and Garivals, 2015). However, according to Chen *et al.* (*Ibid.*), it is not always the case that redundancy mode results in better retention or schema construction. This present study aims to test whether the redundancy effect helps EFL learners to learn and later retain listening efficiently.

2.5.2.2 Modality effects in reading and listening

Regarding the simultaneous presentation of aural and visual information in instructional materials, two major theoretical frameworks can be used to explain how learning takes place in this kind of presentation.

- *Baddeley Working Memory Model*

The first theoretical framework comes from Baddeley's (1992, 2006, 2007) working memory model in that there are two major sensory pathways to intake separate types of information for the central executive function. As noted earlier, these are *visuospatial sketchpad* and *phonological loop.* The former refers to nonverbal information, such as pictures and other visual information, whereas the latter refers to verbal information in both audio and written forms[6]. Several studies by Baddeley (*ibid.*) found that both sources of receptive sensory input can overwhelm the working memory since its capacity is limited with a short time span. To cognitively process language and non-language information, another theoretical framework of *dual-coding approach* can be used.

[6] According to Paivio (1990), verbal information can be represented in both listening and reading. A question in this notion is whether information from reading enters the phonological loop or the visuospatial sketchpad. In the present research, reading is regarded as a part of language, entering the phonological loop, and the presentation of listening and reading is regarded as a dual mode of redundancy effects. This means information from listening and reading enters the same phonological loop, overloading working memory.

- *Dual-coding approach*

An extended theoretical framework from Baddeley's working memory model was the *Dual-coding approach* by Paivio (1990, Sadoski and Paivio, 2001). Paivio (*ibid.*) advocated two separate *representation units* available for cognitive processing, i.e. verbal information and nonverbal images. The two representation units are separate, and one can be active without the activation of the other. However, the two systems are interconnected and work in parallel. In other words, when a learner hears a word '*cat*', the representation of the image '*cat*' or the written word '*cat*' could be activated in the learner's mind.

According to Paivio (*ibid.*), processing can be categorised into three levels – *representational, referential and associated* (pp. 69-70). *Representational processing* refers to a direct activation of processing from the same representation units. For example, a person could repeat the word '*boy*' when they hear the word '*boy*'. However, when a person sees the word '*tiger*', they might imagine the actual image of tiger in their mind. This kind of processing is regarded as *referential processing,* where there is a cross activation of sensory input from one representation to the other unit. When activation of sensory input from one representation unit leads to another representation in the same category, the *associated processing* occurs. For example, when a person hears a word '*tiger*', they might think of other related words, such as *forests, lions,* or *cats*. With regard to Sadosky *et al.* (1991), the three levels of representation provide a clearer picture of two subsystems in cognition than what schema theory calls single prior knowledge. Paivio (2014b) argued that verbal and non-verbal representations are processed and stored in a person's long-term memory as semantic memory, i.e. a total sum of all knowledge, which is used to link with external environment for processing. In a study by Jared *et al.* (2013) on Chinese-English bilinguals' processing speed of congruent and non-congruent language during picture naming, it was found that participants named pictures by means of culturally-supported language faster than non-supported language. The researchers argued that there is a stronger connection between images and referential representation in one language than the other. This means that there is a deeper level of processing when both images and language are referentially connected (see the *level of processing* by Craik and Lockhart, 1972, in section 2.2.3).

The three different levels of processing in accordance with two representation units of visual and aural stimuli have implications for educational implementation. According to Sadoski and Paivio (2001), L1 children can develop literacy better through the processing of both images and language simultaneously. In a recent development of dual coding theory in multilingual processing, Paivio (2014a) offers a framework called *Bilingual Dual Coding Theory*. In his framework, two or more language systems constitute both visual and verbal knowledge[7] to process interchangeably via representational, referential and associated processing in a person's long-term memory. When new input (in language or images) enters a person's working memory, the new input triggers stored knowledge of verbal language and images to result in a deeper level of processing called *semantic memory*, thereby resulting in schema reconstruction. As can be seen in the study of Jared *et al.* (2013) mentioned above, the deeper level of processing results from learners' processing both images and language similar to learners' language competence. In this research, learners' schema refers to the deep level of semantic memory, constituting language competence in terms of vocabulary and discourse, and non-verbal knowledge.

The notion of two representation stimuli are analogous to the *modality effect* of Cognitive Load Theory (Mayer *et al.*, 2014, Lee and Mayer, 2015), in that the presentation of both images and language in instruction can lead to dual-coding processing of representation. The result is that learning is more efficient with the presentation of dual-modes of information. A question concerning this is whether a learner processes both stimuli concurrently or ignores the other stimuli to process. This is a gap for the present study to investigate.

The next section entails what a modality effect is in terms of Cognitive Load Theory.

- *Modality effects*[8]

A modality effect is related to the split-attention effect, according to Sweller *et al.* (2011). It is stated that, instead of presenting information from the two sources of the same modality, it is better for cognitive processing to offer attention to two different modalities of information. In other words, in split-attention effect, a person needs to mentally integrate information from two different sources of information. For example, when EFL learners read a text and spared their attention to consult an online dictionary (as in Al-Shehri and Gitsaki, 2010), they had to mentally integrate word meaning from an online dictionary with words in the text. However, in

[7] The interconnected area between two or more language competences in learners' memory is similar to what Cook (2008) calls multi-competence in SLA, where there is 'knowledge of two languages in the same mind' (Cook, 1992, cited in Cook, 2008, p. 15).

[8] In SLA, modality refers to a single mode of intake, such as aural input or linguistically defined input (Leow, 1995, Porter, 2009). For several modes of intake to occur, a person is said to process multimodalities, in terms of phonetic, syntax and pragmatic (Porter, 2009). However, in Cognitive Load Theory, modality refers to a combined construct of semantic memory where both verbal and visual intake are processed deeply in long-term memory (Paivio, 2014a). So, modality in this research refers to a combination of visual and verbal information into a single mode of semantic meaning.

the modality effect, a person is exposed to two or more different sources of information in a combination of visual and verbal form (Sweller, 2011, 2015, 2016, 2017). An example is from the study of Studente and Garivaldis (2015), in that EFL learners are exposed to static graphics with audio narratives, resulting in a significant improvement of music knowledge in post-tests.

The modality effect is also different from the redundancy effect in terms of information integration. The difference is that the modality effect deals with *different types of information in isolation* whereas the redundancy effect is related to redundant information from listening and reading (Sweller *et al.*, 2011, p. 129). This means that, in presenting information in modality, i.e. both visual and verbal information, images+texts or images+audio can be used to supplement each other.

Several researchers (e.g. Schroeders *et al.*, 2010, Sydorenko, 2010, Torcasio and Sweller, 2010, Sombatteera and Kalyuga, 2012, Schüler *et al*., 2013, Mayer *et al.*, 2014, Lee and Mayer, 2015) carried out experiments to measure the effective use of modality effects in learning. Their findings fell into both supportive and negative results as follows.

Table 2.2. *Summary of studies on modality effects*

Modality effect (Supportive)		**Modality effect (Less effective)**	
Studies	Results	Studies	Results
Lee and Mayer (2015) *Mayer, Lee and Peebles (2014)* *Sydorenko (2010)*	Video and audio > audio only (on comprehension tests) Video + audio > audio with captions (on comprehension test) Video with audio and captions, and video with captions > video with audio (on aural word recognition)	*Leahy and Sweller (2016)*	Shorter-text modality > longer-text modality Longer visual modality > longer audio modality (modality effect reversal) (Longer text – higher rating of difficulty)
Amir (2015)	Reading + picture + audio and reading + picture + L1 > Reading with no annotation (on vocabulary recall, but not reading comprehension)	*Torcasio and Sweller (2010)* *Plass, Chun, Mayer and Leutner (2003)*	Reading with no illustrations > reading with illustrations (on decoding tests) Text with no visual > text with visual (on text comprehension)
Sombatteera and Kalyuga (2012)	Audio with partial text > full text with audio, and keywords with audio (on comprehension tests)	*Schüler, Scheiter and Gerjets (2013)*	Animation presentation / system-paced and learner-paced > modality (text+audio) (on multimedia learning)

As can be seen in Table 2.2, we can conclude that studies concerning the modality mode can be categorised into two areas: visual and listening information (Mayer *et al.*, 2014, Lee and Mayer, 2015); visual and reading information (Torcasio and Sweller, 2010, Amir, 2015, Leahy and Sweller, 2016). The followings exemplify how each study is related to modality effects.

In terms of images and listening, Lee and Mayer (2015) found that Korean EFL high school and college students scored significantly higher in comprehension tests when they learnt Antarctica in English from audio+video than audio only. Participants in their study also rated audio+video less difficult with more positive effort in learning than audio only. However, when college students learnt from Korean audio+video and audio only, comprehension results were not significantly different. The researchers argued that adding videos to L2 listening provides learners with opportunities to see objects related to words, and they have more memory capacity to process listening with less load of images to impede listening. In online listening, Mayer *et al.* (2014) discovered that non-native English students in a university in USA had more comprehension scores after learning chemical reactions in English from audio+video than from audio+video+caption. It was argued that videos enhanced word meaning, which requires less memory capacity to process EFL listening, but learners' memory capacity is filled up to include additional captions of audio+video. At this point in discussion, it can be argued that visual images (or video) and listening enhanced listening comprehension, but adding more mode, i.e. either L1 listening (Lee and Mayer, 2015) or L2 text (Mayer *et al.*, 2014), causes cognitive overload in learners' memory capacity.

In vocabulary learning, Sydorenko (2012) discovered that non-native learners of Russian performed differently in word recognition tests when they learnt from different types of video. When learners learnt from video+audio+caption and video+caption-audio, they scored significantly better than video+audio-caption in the written tests, and vice versa in the audio tests. Learners also reported to attend to captions (or written form) more than video and audio. The researcher argued that, in learning vocabulary, captions helped learners to recall words as they are closely linked to the images in the video.

From the above studies, it can be argued that images play an important role in processing listening (e.g. Lee and Mayer, 2015 and Mayer *et al.*, 2014) and vocabulary recall (e.g. Sydorenko, 2012) for L2 learners. During listening, images help visualising word meaning, leaving more memory capacity for L2 learners to process listening. In other words, adding videos or other images to the transient information of listening could help learners to use both *visuospatial sketchpad* and *phonological loop* (Baddeley's working memory model, 1992, 2006, 2007) to process information in these modalities concurrently, according to the *Dual-mode approach* by Paivio (1990). However, the role of images on L2 reading is still unclear, even though there was a positive result of vocabulary recall from videos with caption in Sydorenko's study. This will be discussed in the following.

In terms of images and reading, Plass *et al.* (2003), Torcasio and Sweller (2010) and Amir (2015) found a reversed effect of reading and visual information. Comparing a longer text with visual information and a shorter text with visual information, Leahy and Sweller (2016) found in one of their experiments that there was no statistically significant effect in the modality, but the shorter text with visual slides resulted in better comprehension scores than the longer text with visual slides. In young learners of L1 English, Torcasio and Sweller (2010) found that, for learners who learnt English with no illustrations (no visual information), their memory was enhanced compared to reading English with illustrations. The researchers argued that pictures of facial expression used to illustrate English stories deviate learners' attention to process pictures rather than reading. The result of processing pictures is less memory resource to decode text. This result also happens in foreign language learning. In multimedia learning, Plass *et al.* (2003) found that text comprehension was enhanced when English university learners learnt from online German text with no visual information than online German text embedded with visual information. However, the researchers found that annotations of visual and verbal information (pictures, videos and L1 translation) on words or phrases in the text resulted in higher scores of vocabulary tests than no annotations and one type of annotation. This positive result of visual and verbal modality on vocabulary learning is also similar to a study by Amir (2015). In her study on online reading with or without annotations, Amir found that reading with annotations (or with pictures with L1 translation, or with pictures with L2 audio) enhanced vocabulary recall by young Kuwaiti EFL learners, but not reading comprehension. In a focus group report, learners reported to focus on annotated words which linked to pictures and L1 translation or pictures with L2 audio during reading. The researcher argued that learners disoriented their attention to word learning, i.e. annotations with pictures and audio information, more than reading.

From the above studies, it can be argued that the modality of images and reading is less efficient in reading comprehension. As discussed in Torcasio and Sweller (2010) and Amir (2015), when both visual and verbal information is present, there tends to be a possibility that learners pay too much attention to one modality, leaving no overall working memory capacity to process information in the other mode. According to Schroeders *et al*. (2010), EFL viewing, listening and reading were found to be correlated in processing. This means that when one's memory capacity is devoted to a representation unit of EFL learning, the overall cognitive capacity could be filled up for other units to be processed. However, in online learning, the annotations of verbal and visual information enhanced vocabulary learning as they capture learners' attention during listening (e.g. Sydorenko, 2012) and reading (e.g. Plass *et al.*, 2003; Amir, 2015). It is still unclear what happens when the modality effect is applied to reading+listening. This will be discussed below.

In reading+listening as modality, Sombatteera and Kalyuga (2012) found that, in EFL listening on psychosexual development, Thai EFL undergraduates scored significantly higher in listening comprehension tests when learning from listening with partial texts, i.e. phrases containing main ideas, than from listening with full text and listening with keywords, i.e. words of main concepts. The researchers argued that meaningful phrases provided support for learners to process EFL listening, whereas full text is redundant for learners to process listening and keywords are not sufficient for processing listening. In online learning, Schüler *et al.* (2013) found that, when both spoken and written texts were presented with animations, German undergraduates scored significantly higher in biology transfer tests than those with no animations. They also rated animations to be as less difficult than no animations. This means that images, i.e. animations, support learners to visualise long spoken or written information. The researchers further investigated whether animations with spoken only, written only or redundant spoken-written was more efficient in learning when learners could or could not control their learning pace. They found no significant differences among the three conditions in both system-paced and learner-paced conditions, but argued that, in learner-pace environment, replaying segments of written only and redundant texts resulted in a more positive outcome than spoken only. When text length is a main factor in designing information for a modality, Leahy and Sweller (2016) speculated that, between longer written and longer listening texts, the longer written text with visual was more favourable than the longer listening text with visual. This is due to the fact that learners rated the longer audio text as containing complex text structures (p. 116).

At this point in discussion, we can conclude that modality effects require human working memory capacity to draw on both visual and verbal information through two working memory channels. It takes the Baddeley's working memory model to deal with modality representations in the mind, whereas the Paivio's dual-coding approach to deal with two different representational units of information. In EFL practices, modality effects could lead to enhanced comprehension rather than the redundancy effects. One reason underlying successful learning is that learners can use separate channels of their working memory to deal with different representation units of information. However, when learners' cognitive processing is limited to attending to a particular representation unit of information, the modality effect is redundancy effect because of information overload.

2.6 Implications of Cognitive Load Theory for research design

In this chapter, we have seen that learning with cognitive load can be related to the design of instructional materials. However, there are two research gaps which need further investigation.

Firstly, there is an inconsistency in working memory models for cognitive load. As discussed in Section 2.2, human cognitive architecture is important for learning, but the two models of working memory by Cowan and Baddeley need further investigation in terms of learning with cognitive load. Sweller *et al.* (2011) further discussed that the executive function within working memory is the main focus of learning since it deals particularly with cognitive processing, no matter where it is situated in a working memory model. However, even though there are some studies contributing to access to the executive function of working memory (e.g. Cierniak *et al.*, 2009) during learning with cognitive load, an actual working memory test of cognitive load and what happens in cognitive processing are still in question.

Secondly, in looking at the cognitive load construct, according to Cognitive Load Theory, relevant literature reviewed in this chapter was found to be based on experimental studies, with few studies looking at learners' mental efforts. It was spelled out in Sweller *et al.* (2011) that Cognitive Load Theory could be applied to experimental studies. Foreign language learning is a process, and processing should be as important as the results of learning. Although some studies (e.g. Pass *et al.*, 2003, Leppink *et al.*, 2013, Lee and Mayer, 2015) on Cognitive Load Theory employ subjective-rating scales as a measurement of mental efforts to supplement experimental studies, there are no learners' self-reports on their learning with instructional materials.

To bridge the above two gaps of enquiry, the basis of the present research project was that cognitive load learning can be viewed from both product and process perspectives. In terms of cognitive load construct, learning results are studied through the existing methods of Cognitive Load Theory, i.e. experimental studies. However, addition of psychological measurements with the product result can yield more understanding of working memory and cognitive load learning. This is due to the fact that cognitive load is perceived to be part of working memory.

The present study, therefore, employed two measures of working memory to co-constructively supply an understanding of cognitive load learning from a process perspective.

Another gap in research methodology that can be used to bolster Cognitive Load Theory is learners' self-reports. As can be seen in this chapter, it was questionable what happens when learners are learning from instructional materials. Although there exist secondary tasks and subjective-rating scales to understand cognitive learning processes (e.g. Cierniak *et al.*, 2009; Leppink *et al.*, 2013), learners' self-reports on their learning can also be used to offer another process perspective. This is because learners can reliably reveal their own mental efforts during learning (Leppink *et al.*, 2013; Pass *et al.*, 2003). Semi-structured interviews as well as subjective-rating scales can concurrently reveal the process and product results of mental effort and cognitive processing. This way, cognitive load learning from the product point of view and learners' self-reports from the process point of view could yield a comprehensive understanding of cognitive load construct in question.

At this point of discussion, we can note that Cognitive Load Theory is the main framework of research design in the present study. Additional psychological measurements, i.e. working memory measurements and semi-structured interviews, can co-constructively offer an understanding of cognitive load learning from a new and original product-process perspective, especially for language education. In the following chapter, the research design based on the gaps in research on cognitive load learning will be presented.

Chapter 3. Methodology

This chapter presents how the present study was designed and conducted. It will be presented into the following order. Firstly, research questions and ideological stance will be discussed. This is followed by detailed descriptions of research methods, samplings and analysis. The chapter ends with how a pilot study shaped the present project into a researchable manner.

3.1 Research questions

As discussed in the previous chapter, to be a successful language learner, one needs to be exposed to different forms of language information, available in various presentation modes. The present study aims to find answers for the following research questions.

Can learners process information in their working memory better from modified listening and reading materials?

To answer the main research question, different aspects of enquiry were needed to supply the overall picture of answers. This is because learners might need to explore different forms of language information (i.e. listening and reading) in various organisational formats (i.e. modified materials). The question includes the implications of their learning results and personal perceptions toward learning from instructional materials. As a result, the following sub research questions were designed to address different aspects of the main research question.

1. Is there an association between learners' information retention and English listening, reading and reading-listening materials?
2. What kind of modified materials best supports learners' language learning?
3. How much mental effort do learners perceive to use in working with instructional materials?

The first sub research question aims to test hypotheses regarding whether learners' information retention is associated with English listening, reading and reading-listening materials. As anticipated in Chapter 2, an orderly presentation mode of information might help a learner to learn and retain information effectively, whereas a format resulting in information overload might hinder a learner's learning. Therefore, the hypotheses for this sub research question are as follows:

H_{1a}: Integrated reading results in better retention than split-attention reading.
H_{1b}: Integrated listening results in better retention than split-attention listening.
H_{1c}: Modality listening-reading results in better retention than redundancy listening-reading.

In sub research question 2, learners' learning results from different presentation modes are taken into consideration, but it is also important to obtain preference information from learners since learning takes place when a learner interacts with materials. Test results of learning (or product) and learners' preference information (or process) could co-constructively supply answers for sub research question 2. As anticipated in Chapter 2, instructional materials with supportive cognitive loads, i.e. integrated format and modality effect, resulted in efficient learning, and reading only enhanced processing from reading and/or listening. Therefore, the hypotheses for this sub research question are as follows:

H_{2a}: In supportive cognitive load, integrated reading supports learning more than integrated listening and modality listening-reading.
H_{2b}: In hindering cognitive load, split-attention reading supports learning more than split-attention listening and redundancy listening-reading.

In terms of sub research question 3, two measures might be able to supply answers. Firstly, objective measurements of cognitive load during learning (or product) might yield a systematic understanding of cognitive load when learners are interacting with instructional materials. In addition, learners' self-report of cognitive load they perceive during learning with instructional materials (or process) might also co-constructively supply another aspect of answers for this research question. As also anticipated in Chapter 2, learners rated instructional materials with supportive cognitive load, i.e. integrated formats and modality effects, as less difficult than hindering cognitive load, i.e. split-attention and redundant effects. Therefore, the hypotheses for this sub research question are as follows:

H_{3a}: Integrated reading is perceived by learners as less difficult than split-attention reading.

H_{3b}: Integrated listening is perceived by learners as less difficult than split-attention listening.

H_{3c}: Modality listening+reading is perceived by learners as less difficult than redundancy listening+reading.

At this point in discussion, it can be stated that the main construct for the present study, *cognitive load,* will be reflected in learning results from different modes (or product) and learners' self-perception report (or process). Factors supporting or hindering cognitive load are *cognitive load variables,* i.e. various presentation modes to modify instructional materials. The variables can be categorised into 'supporting cognitive load' variables and 'hindering cognitive load' variables. This will further be discussed in section 3.4.

In the following section, how the research design was developed will be discussed.

3.2 Ontology and epistemology

Regarding the previous section, the present project aimed to investigate whether modified instructional materials based on different presentation modes, i.e. *cognitive load variables,* can help learners to learn and retain information. In this section, what construct is and how to research the construct will be discussed.

3.2.1 Ontology

In Chapter 2, we understand that Geary's (2012) five principles of information processing explains how a person learns biologically primary and secondary knowledge. In words of Sweller *et al.* (2011), efficient learning is biologically secondary knowledge, and the construct determining efficient learning outcome is a person's cognitive load.

In this research project, *cognitive load* is the subject of investigation, or ontology. It takes a position that, for efficient learning, learners' cognitive load determines how to design instructional materials. Instructional materials with supportive cognitive load is hypothesised to help learners learn and retain information, especially in EFL, than hindering cognitive load. In the next section, how to obtain the construct, or epistemology, will be discussed.

3.2.2 Epistemology

As discussed in Chapter 2, the construct of 'cognitive load', or the ability of a person to learn and think within their memory, can be viewed in two different perspectives. In a *cognitive* perspective, several researchers (such as Mayer and Moreno, 2003, Valcke, 2001, Upu and Bustang, 2014) argued that 'cognition' is a construct of learning hypothesis, where learners manipulate their own learning based on their construct of thinking, memory, problem solving and intelligence. Researchers in cognitivism can access and investigate cognition through psychological tests, such as learning results and memory tests. However, in the view of Seedhouse (2010), the use of referral tests in cognitivism is argued to lack the quality of learners' self-report on their own active participation. As a result, another view of human cognitive construct could be used to co-constructively design means of attaining the cognitive load knowledge. According to Vygotsky (1978) and Liu and Matthews (2005), *constructivism* explains what learning is through the lens of social interactions. Learners can design their own learning based on social engagement (Atherton, 2013). However, an enquiry into how social interaction leads to cognitive construction in the human mind might not be practical to investigate since what really happens in learners' minds cannot be viewed directly through the lens of social engagement.

Taking the two views of 'cognitive load' into consideration, it could be argued that measuring learners' cognitive load might not be practical to investigate in either cognition or constructivism. However, as suggested in Cohen *et al.* (2000), Liu and Matthews (2005), Creswell (2014), an eclectic approach in combining different views in accessing a construct might supply answers to a big question through different angles of enquiry. As a result, it can be viewed that both *cognitivism* and *constructivism* might be able to play important roles in attaining knowledge about cognitive load, in that *cognitivism* can look at the construct from an etic point of view, whereas *constructivism* can supply knowledge from an emic viewpoint. In other words, psychological tests on learning and memory tests from *cognitivism* can yield knowledge about cognitive load from an external point of view, involving an investigation of learning outcomes (or product) from manipulation of cognitive load during language learning. As for *constructivism*, a language learner could report their own cognitive perception toward learning. This could supply the researcher with 'cognitive load' knowledge in terms of both a learner's personal cognitive perception and their personal perception toward learning manipulation from *cognitivist's* means of enquiry. This *constructivist's* point of view could yield an inner perspective from language learners, thus co-constructing knowledge of 'cognitive load'.

The following section will demonstrate the ontological and epistemological design of the present study.

3.2.3 Ontology and epistemology of present study

In the present study, the ontology and epistemology of enquiry could be seen as *cognitive constructivism*, where both elements of *cognitivism* and *constructivism* co-constructively answer research questions. From the *cognitivism* point of view, the construct of 'cognitive load' is viewed as the final attainment of existing knowledge. Learning and memory results can be obtained to investigate the 'cognitive load' (Ozer, 2004, Satterly, 2004). With regards to *constructivism*, 'cognitive load' involves an interaction process, where learners' self-perception reports during their engagement with instructional materials can co-constructively supply answers (Blandón-Giltin *et al*., 2014). This leads to a mixed-methods approach where the actual practice of attaining answers for research questions is made possible through two lenses.

In the next section, the research methodology of the present study will be examined against the *cognitive constructivism* ontology and epistemology.

3.3 Research methodology and theoretical frameworks

As specified in the above sections, this present study aimed to investigate whether modified instructional materials, i.e. different presentation modes in different linguistic forms, help supporting or hinder learners' information retention within the cognitive load construct. The construct of enquiry is 'cognitive load', and major variables affecting the construct are *cognitive load effects*, or different modes, in instructional materials. The enquiry therefore also includes different linguistic forms of reading, listening and listening-reading since these forms could be a factor affecting processing in second language learning.

To design the present project, the ontological and epistemological of *cognitive constructivism* was employed. This is because the construct of 'cognitive load' could originally be investigated in *cognitivism* view as well as from the *constructivism* perspective of learning interactions. In the following, theoretical frameworks in relation to *cognitive constructivism* will be presented.

According to Baddeley (2007, 2008) and Sweller *et al.* (2011), cognitive construct is a psychological idea which explains what happens in human brain when one thinks and learns. For Baddeley (2007, 2008), a person perceives sensory input through visual and phonological channels, which is then temporarily stored in one's working memory and then can result in learning. Within working memory research, evidence of language learning can be measured by either *recall* or *recognition* in the phonological loop. In terms of recall, prior linguistic knowledge is crucial for a person to depend on and retrieve. In other words, a learner might be able to retain information after learning a foreign language in formal interaction. In recognition tests, however, a learner is not influenced by language input, and he or she can recognise pieces of information organised in a serial way (Baddeley, 2007, p. 25, 2008, p. 12). With reference to Postman *et al.* (1974), in terms of measuring long-term retention, recognition was proposed to add to the retrieval process, i.e. recall, because it represents both learners' occurrence and retrieval information from different conditions of the learning processes. According to Budiu and her colleagues (Budiu *et al.*, 2009; Budiu, 2014), recognition was found to familiarise online users to use online interfaces more efficiently since tasks and items which had been seen before increase users' ability to remember and retrieve information from long-term memory. Taking the two tests of working memory into consideration, the present study employed recall as an information retention test and the recognition test as an additional measure of working memory access, possibly from long-term memory processes.

Regarding the *cognitive constructivism* perspective of the present study, both recall and recognition in working memory tests could co-constructively supply knowledge for the 'cognitive load' construct in question. Information obtained by the researcher from recall could be used for evidence of learning or information retention after a learner interacts with input, in either reading and/or listening forms. Additional tests of recognition can also co-constructively yield answers regarding cognitive load construct of the present study.

To measure whether learning has occurred (or *recall* in working memory), Cognitive Load Theory (hence forth, CLT) is taken into consideration in that human cognitive architecture is in relation to designing instructions and learning (Pass *et al.*, 2003; Sweller *et al.* 2011). As discussed in Chapter 2, cognitive load plays an important role in supporting learners to become an expert in learning and problem solving, and researchers in CLT (such as Hung, 2009, Sweller, 2010, Moussa-Inaty *et al.*, 2012) used experimental designs to measure the relationship between learners' cognitive load and their learning outcome from different presentation formats.

In this research project, experimental designs following Cognitive Load Theory were used to measure learners' cognitive load and their learning outcome. In terms of measuring cognitive load, measurements of cognitive load reported by learners during their own language learning and their self-report on learning with instructional materials were used. For learning outcome, the researcher used *recall* and *recognition* from Baddeley's Working Memory framework. In the following, research design based on Cognitive Load Theory and Baddeley's Working Memory frameworks will be discussed.

3.4 A mixed-methods approach

As discussed above, working memory and Cognitive Load Theory frameworks yield the product of enquiry, i.e. cognitive load construct, but the whole process can be co-constructively investigated through *cognitive constructivism*. Figure 3.1 demonstrates how research design was formulated for the present study.

As can be seen in Figure 3.1, the present research was designed into three experiments, and each experiment constitutes three phases. As discussed in the previous sections, language learning in different linguistic forms can support or hinder learners' processing. As a result, the three experiments were categorised into reading, listening and listening-reading experiments to reflect different modes of input presentation.

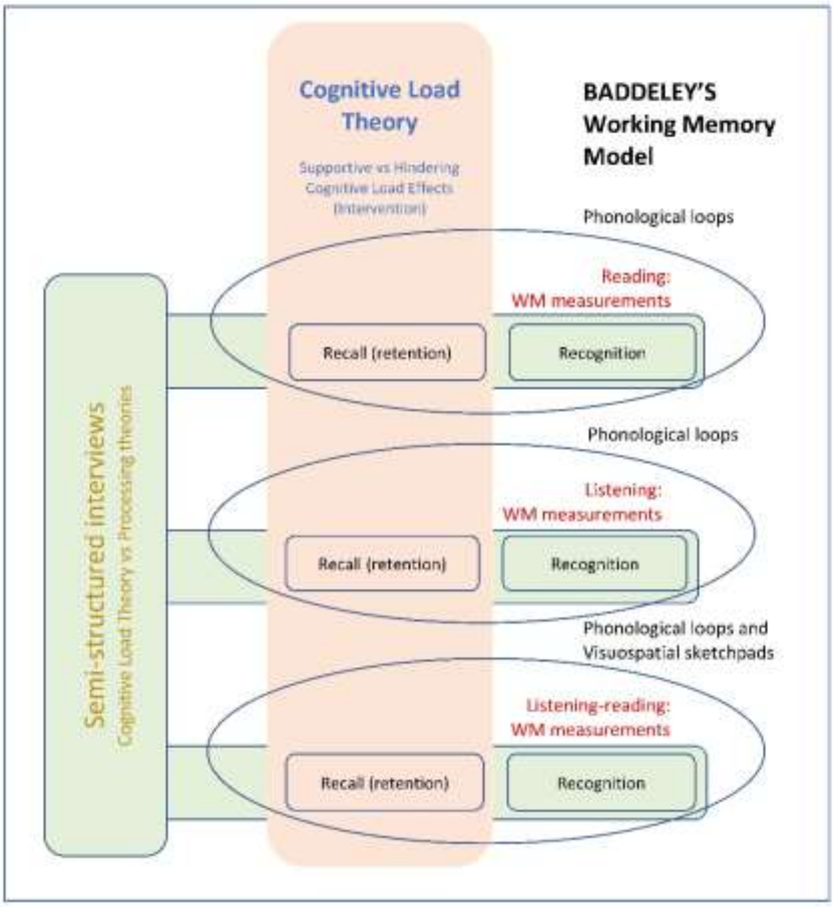


Figure 3.1. Theoretical Framework and Research Design

In each experiment, both assumed supportive cognitive load effects, i.e. *integrated and modality tasks*, and detrimental cognitive load effects, i.e. *split-attention and redundancy effect tasks*, were compared to figure out if different presentation modes could yield answers for the cognitive load construct in question. To reflect the *cognitive constructivism* viewpoint, each of the three experiments constitutes cognitivists' testing and constructivists' learner self-report. In other words, each experiment consists of learning, testing and recognition phases to yield answers from the *cognitivism* viewpoint. Learning and testing phases supply learning results, which, in the present study, could be regarded as *information retention* (or *recall* in working memory measurement), whereas a recognition test and a reading span task in the recognition phase yield working memory results. The reason why the recognition phase was included in the design of the present study is to explain the results of cognitive load studies via the lens of working memory measurements. As for the *constructivist's* perspective, each phase of experiment includes learners' self-perception reports, in that learners could supply their personal self-perception of cognitive load when interacting with instructional materials in the learning phase. They were also able to voice their perception toward different cognitive load variables that they experienced in the learning and testing phases. This qualitative information could co-constructively yield answers for the cognitive load construct in question. To conclude, this present study employed a mixed-methods approach, constituting three experiments: subjective rating-scales, semi-structured interviews, recognition tests and reading span working memory tests.

According to Creswell (2012, 2014), when quantitative and qualitative data are collected concurrently, and the data are combined to answer research questions, the research design is categorised into the *convergent parallel mixed methods*. As described in Creswell (2014, p. 15), the *convergent parallel design* is a type of a mixed-methods approach, where a researcher collects quantitative and qualitative data approximately at the same time. The data are then merged to provide a comprehensive understanding of a research problem. As shown in Figure 3.1, in each experiment, the three phases constituted the nature of *convergent parallel* mixed-methods design. In other words, the three experiments employed mixed-methods in a way that each phase supplied concurrent answers for each research question. In phase 1, i.e. the learning phase, quantitative information from experimental tests and subjective-rating scales were used to co-supply answers for the learning results, which was used to answer research questions 1, 2 and 3 quantitatively. In phase 2, i.e. the testing phase, the experimental tests and subjective-interview data yielded quantitative data of retention results and learners' self-reports of learning with instructional materials, providing answers for research questions 1, 2 and 3 quantitatively and qualitatively. In phase 3, i.e. the recognition phase, both working memory measurements were used to quantitatively co-supply answers for the learning and retention results of phases 1 and 2. The results from each phase were then combined to co-constructively answer at least two aspects of the same research question, satisfying the design of *convergent parallel mixed methods.*

At this point in discussion, it is cleared that the mixed-methods approach was the major research design of the present project. The main aim of the design was to probe the availability of cognitive load construct in relation to English as a foreign language (EFL) learning through the lens of information retention. Two theoretical frameworks, working memory and Cognitive Load Theory, were interwoven in the design of different aspects of the present research under the *cognitive constructivism* perspective. How each phase of research design was used to answer the three research questions still needs discussion. In the following this will be presented.

3.4.1 Three experiments

The present study employed three experiments to reflect different linguistic forms of a foreign language where a learner learnt and retained information effectively under the cognitive load construct. The following describes detail of the experiments.

Firstly, two groups of Thai EFL learners were categorised into a supportive cognitive load (CL) group and a detrimental cognitive load group. In each experiment, both groups of participants participated in three phases: the learning phase, the testing phase and the recognition phase.

Prior to participating in the experiments, both groups of participants participated in a proficiency test to test for normality, and the Rey Auditory Verbal Learning (RAVLT, Schemidt, 2010) to measure participants' working memory in terms of recall and recognition (see Section 3.8.1 for more information on RAVLT). The results of RAVLT were used to predict whether WM was associated with learners' information retention when they were participating in the three experiments. The following discusses each phase of the three experiments.

In the learning phase, participants read from integrated (supportive CL) and split-attention reading (detrimental CL) in Experiment 1, listened from integrated (supportive CL) and split-attention listening (detrimental CL) in Experiment 2, and listened and read from modality (supportive CL) and redundancy listening-reading (detrimental CL) in Experiment 3. Then, the participants completed a subjective rating-scale, where they rated the cognitive load that they perceived during learning from the materials (see Appendix 6). The main aim of this phase was to figure out how modified instructional materials based on cognitive load types could help learners retain learning information and to test which cognitive load type affected learners in retaining information effectively. The following table describes each CL type.

Table 3.1 Details of supportive and detrimental cognitive loads in each experiment.

Experiment 1 Reading	
The integrated reading task	*The split-attention reading task*
A 600-word reading text on 'time management' with 10 short-answer questions embedded in each paragraph. The reason for the organisation of the text is that learners would not need to attend to different places of different information, thus supporting learners to learn and retain information effectively with suitable cognitive load (see Appendix 2a).	The same 600-word reading text with vocabulary and expression boxes embedded in the text, and the 10 short-answer questions listed after the text. The main reason for the design of split-attention task is to have participants attend to different texts, which could be regarded as detrimental to cognitive load because of information overload (see Appendix 2b).
Experiment 2 Listening	
The integrated listening task	*The split-attention listening task*
The listening text on 'discrimination' was played and stopped after a paragraph of 50-60 words to ask short-answer questions. The task continued until the end of the last question. The main reason why the listening task was organised in this matter is that participants could only attend to the listening information and answer the questions that follow one at a time, suitable for the available cognitive load of learners (see Appendix 3a).	The entire text on 'discrimination' was played once, not at intervals, and participants were required to answer the ten short-answer questions after listening. In this split-attention task, participants had to attend to the entire listening text and to hold in memory the listening information to answer all questions after listening, thereby increasing cognitive load (see Appendix 3b).
Experiment 3 Listening-Reading	
The modality listening-reading task	*A redundancy listening-reading task*
Participants in the *modality* group listened to a 600-word text on 'innovative business' recorded by a native speaker of English and studied a summary diagram of the listening text (see Appendix 4a). After learning from the modality task, participants were required to answer 10 short-answered questions.	Another group of *redundancy* listened to the same listening text and, at the same time, read the listening script. After learning from the task, they were required to answer 10 short-answer questions (see Appendix 4b).

The topics of reading, listening and listening-reading were similar to units of foundation English course where participants were studying. The main reason why the topics were chosen is that both groups of participants would have equal background knowledge and there would be no extraneous variable in not being familiar with the topic, which could cause working memory to be filled up prior to participating in the experiments. Texts consisted of 600 words because this was to test whether presentation modes affected learning results when learners could not control the overload length of text beyond the optimal comprehension of 150 characters, according to Mikk (2008), i.e. intrinsic cognitive load.

After a week with no formal interaction with learning materials, the participants participated in the testing phase to complete ten short-answer questions without the reading, listening and listening+reading texts so that the short-answer questions tested what the participants learnt and retained from the learning phase. After answering the short-answer questions, ten volunteer participants were recruited to participate in a semi-structured interview (see Appendix 7). The main purpose of the interview was to obtain information concerning participants' perceptions toward learning based on the cognitive load type.

After another week of no formal interaction with the learning texts, the participants participated in the recognition phase, where they judged 10 true-false recognition sentences (see Appendices 5a, 5b and 5c). The true-false recognition sentences contained information from the reading, listening and listening-reading texts of the learning phase, and participants had to judge the true-false sentences based on the retention of information. After judging the true-false statements, participants were given a blank paper to write last words of the ten recognition sentences. This activity is called *reading span task*. The main aim of this task was to test memory of participants subconsciously after they used their cognitive load in the recognition phase.

At this point in discussion, it could be summarised that, in the three experiments, cognitive load types were independent variables and scores from learning and testing phases as well as the recognition phase were dependent variables. The following diagrams demonstrate each experimental process.

Experiment 1: Reading

Two groups of Thai EFL learners were categorised into *an integrated task group* and *a split-attention task group*, where the integrated task was regarded as a supporting cognitive load and the split-attention task as a detrimental cognitive load.

Experiment 1: Reading

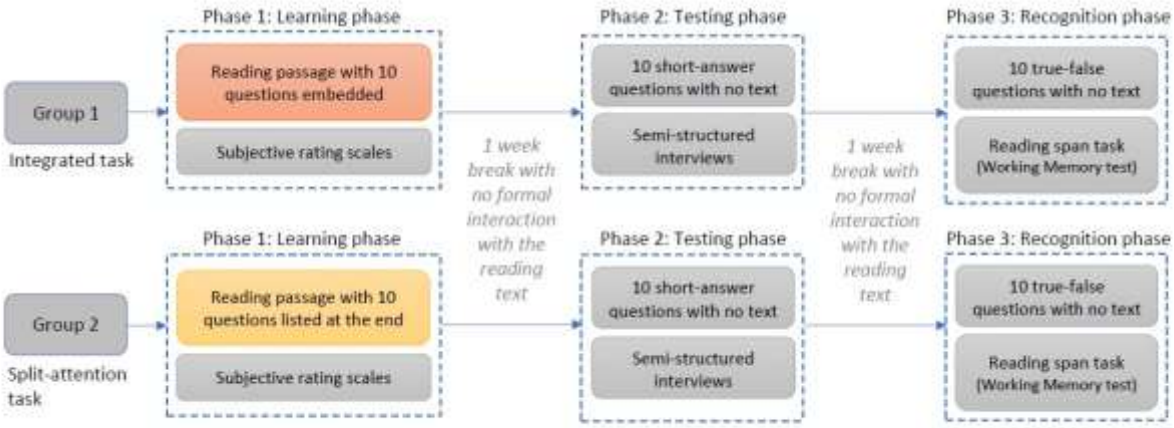


Figure 3.2a. Experiment design 1: Reading

The topic of the reading text was time management which was similar to a unit of foundation English course where participants were studying. Ten short-answer questions were designed based on the reading text. These questions were used in the learning phase and the testing phase. In the testing phase, the reading text was removed from both groups so that testing results could be based on information retention only.

Both the reading text and ten short-answer questions were piloted and judged by two Thai EFL experts, and they were adjusted and edited accordingly in response (see Section 3.8.3).

The next section describes the listening experiment.

Experiment 2: Listening

In experiment 2, two groups of participants from experiment 1 participated in the research process. Participants from both groups listened to a listening text of approximately 600-700 words recorded by a native speaker of English, speaking at a normal rate in British, with different tasks (see Figure 3.2b). The *integrated listening task* was regarded a supporting cognitive load task, whereas *the split-attention task* was a detrimental cognitive load task.

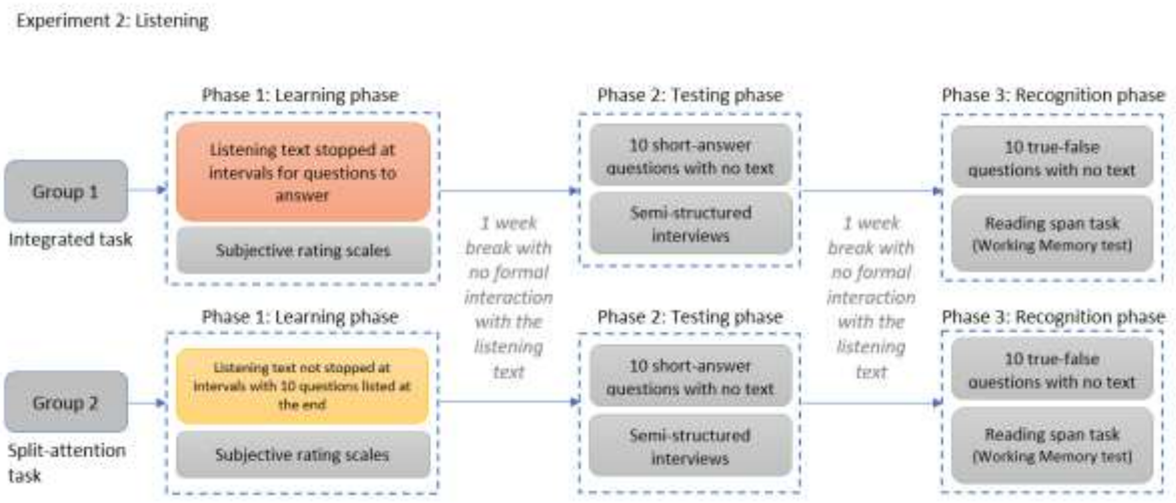


Figure 3.2b. Experiment design 2: Listening

The topic of listening was discrimination which was a topic of the English foundation course that participants were taking. This topic was chosen because participants could be expected to have same knowledge of the topic. Ten short-answer questions were designed based on the listening text. In the testing phase, the listening text was removed from both group in order that testing results could only be drawn from information retention.

As with the reading text, the listening text and ten short-answer questions were piloted and judged by two Thai EFL experts. After a pilot study and the expert judge, both listening text and ten short-answer questions were revised and edited (see Section 3.8.3).

In the next section, detail of listening-reading experiment will be discussed.

Experiment 3: Listening-reading

In this experiment, two groups of participants from experiments 1 and 2 participated in the research process. In the two groups, participants who participated in the integrated group of experiments 1 and 2 participated in the *modality* group, and those who were in the split-attention task group were in the *redundancy* group. The modality task was regarded as a supporting cognitive load task, whereas the redundancy task was a detrimental cognitive load task.

The topic of listening-reading task was innovative business which was a unit of English foundation course that participants were taking. The main reason why the topic was selected was that both groups of participants would have equal background knowledge of the topic.

Ten short-answer questions were created based on the information in the designed materials. Both listening-reading materials and the ten short-answer questions were piloted and judged as difficult by two Thai EFL experts. The listening material was, then, simplified and re-recorded by an English native speaker, speaking at a normal rate in British.

Figure 3.2c illustrates the research process in the listening-reading experiment.

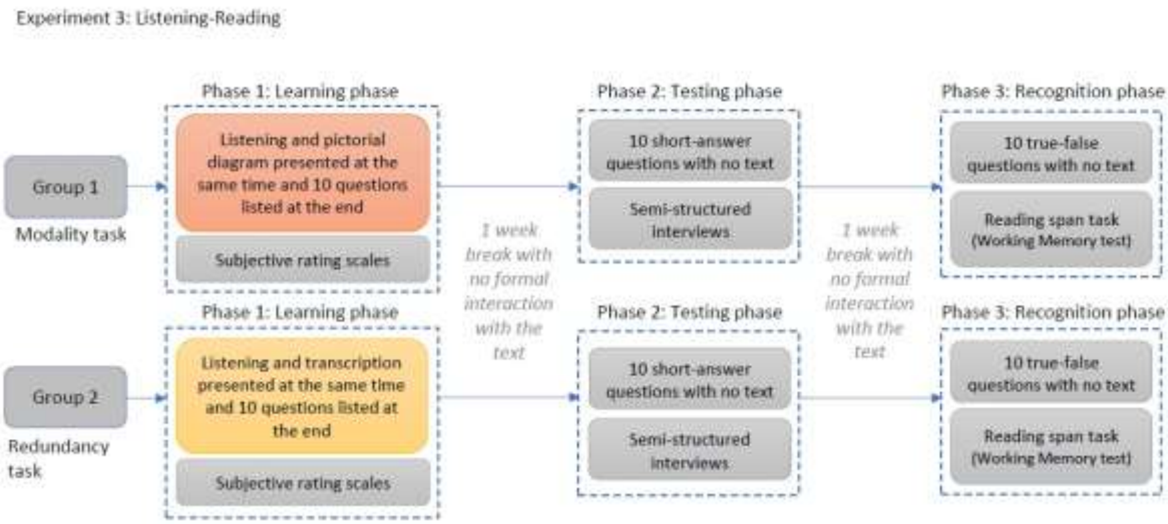


Figure 3.2c. Experiment design 3: Listening-reading

The reason why *modality* was considered to support cognitive load is that different modes of learning from different sensory inputs was predicted to enhance learners' processing of complementary information at the same time with available working memory capacity, according to the working memory framework. However, when a learner is required to learn from the same piece of information through different sensory inputs in the *redundancy task*, it was predicted that information in both sources is redundant and the result is information overloaded in the working memory capacity. Both types of materials were piloted and judged by two EFL experts, and they were adjusted and edited in response (see Section 3.8.3).

As can be seen from the three experiments, two different variables in each experiment were tested to find the best candidate for type that helped learners to retain information effectively. Results from the learning phase and the testing phase yielded relevant information for retention, which was used to answer research questions 1 and 2. In the following section, each research method in learning, testing and recognition phases, i.e. subjective rating-scales, semi-structured interviews, a recognition test and a reading span task, will be discussed.

3.4.2 Subjective Rating Scales

As depicted in Figures 3.2a, 3.2b and 3.2c, participants were asked to rate 7-point-scale items on a questionnaire after the learning phase (see Appendix 6). The 7-point-scale subjective rating scales were adapted from Pass *et al.* (2003) and Leppink *et al.* (2013). They consisted of eleven questions which could be categorised into three types of cognitive load construct, according to Cognitive Load Theory, i.e. *intrinsic, extrinsic* and *germane* cognitive loads. Since the present study focused on *cognitive constructivism,* where learners actively engaged with instructional materials, subjective rating scales could provide information concerning learners' subjective assessment of the task demands, satisfying the constructivists' view of learners' interaction with instructional materials, according to Brünken *et al.* (2010).

It should be noted at this point that the cognitive load types in the rating scales were different from different cognitive load effects in the experiments. In the three experiments, cognitive load effects were types of text presentation which lead to an engagement of cognitive load during learning, and they are independent variables which lead to the results of learning. In subjective rating scales, different cognitive load types are constructs within cognitive load, entailing the results of cognitive load effects on different cognitive constructs in cognitive load. In other words, cognitive load effects are mental effort factors influencing learning which takes place within cognitive load types in cognitive load construct. The subjective rating scales were categorised into the following types of cognitive load.

Questions 1-4 on the subjective rating scales were categorised into *intrinsic cognitive load*. They asked about topics concerning element interactivity (Pass *et al.* 2003; Sweller *et al.* 2011), which determined how complex the presentation of text was. Subtopics included *complex topic, complex concepts and definitions, complex sentence structures* and *complex format of the text*.

Questions 5-7 were grouped into *extrinsic cognitive load*. These questions were related to instructions (Sweller *et al.*, 2011, Pass *et al.*, 2003). The subtopics covered *unclear instructions, ineffective instructions* and *unclear language in instructions*.

Questions 8-11 consisted of subtopics which support schema construction, i.e. *germane cognitive load* (Pass *et al.*, 2003; Sweller *et al.*, 2011). Subtopics included *supporting topic understanding, subject knowledge understanding, understanding concepts and definitions* and *the English language support*.

The 7-point-scales were pretested and edited based on the reliability tests (see Section 3.8.4), and then they were put to use in the actual experiments. Results from subjective-rating scales would be used to co-constructively answer research question 3, enquiring how much cognitive load participants perceived to use when they were learning from instructional materials. Also, the results of subjective-rating scales were reanalysed in conjunction with RAVLT in the pre-tests to test whether WM and cognitive load were in relation, and relevant for answers for research question 3.

At this point in discussion, it can be concluded that results from the three experiments will yield some answers for research questions 1 and 2, whereas the subjective rating-scales can supply answers for research question 3. However, to find answers for the three research questions co-constructively, it is also important to integrate other research methods into the testing and recognition phases. In the following, the methodology of the semi-structured interviews which were used in the testing phase will be presented.

3.4.3 Semi-structured interviews

For relevant researchers (e.g. Pass *et al.* 2003, Sweller *et al.*, 2011, Kanokpermpoon, 2013), Cognitive Load Theory is a psychological theory of learning, whose investigation employs objective enquiry (or cognitivism). However, some scholars (such as Kvale, 1996, 1999, 2003; Valcke, 2001) propose the use of qualitative methods in gathering more insights into learners' knowledge.

With reference to Kvale (2003, pp. 28-36), psychological theories at present have been investigated using psychological interviews, such as Piaget's children cognitive development (McLeod, 2018) or Hawthorn's study (McBridge, 2013). This is based on the important points of participants' views and feelings which can be uncovered through psychological interviews. Since Cognitive Load Theory is a psychological theory, psychological interviews, in terms of semi-structured interviews, can be used to supply an underlying view of learners' cognitive processing when they interact with instructional materials (Blandón-Gitlin *et al.*, 2014).

In the present study, ten volunteers from each experimental group were asked to participate in semi-structured interviews with the researcher in the testing phase. There were seven questions in the interviews (see Appendix 7). All participants who participated in the interview were asked the same questions for internal validity (McNamara, 2009). Data from the interviews were transcribed and translated by the researcher. All transcripts were coded based on cognitive load themes, i.e. *intrinsic*, *extrinsic* and *germane* cognitive load, and all emerging themes, such as learning strategies, from each experiment were selected for qualitative analysis. The thematic and discourse analytic approaches were used to analyse the interview data.

Results from the interviews were used in conjunction with learning results from the three experiments and subjective rating-scales in the learning phase. Firstly, along with learning results from the three experiments, learners' perceptions on the intrinsic nature of materials and text presentations, obtained via interviews, were used to co-constructively supply answers for research question 2, which tried to find the best candidate of cognitive load effects for information retention. Results from interviews, i.e. germane cognitive load, were also used to yield learners' perception toward their own cognitive capacity which co-constructively supplies answers for research question 3, along with the results of subjective rating-scales.

At this point in discussion, it can be summarised that results of interviews were used to supply answers for research questions 2 and 3, in that qualitative data from the interviews can illuminate learning from learners' cognitive processes. Also, the qualitative data from interviews can be used to explore results from subjective rating-scales to yield more detail of the use of memory capacity from learners' perspective. Now we turn to the next phase.

3.4.4 Recognition test

Within working memory research, Baddeley (2007, 2008) proposed that working memory could be tested by either *recall* or *recognition* in the phonological loop (see Chapter 2). In terms of recall, it is crucial for learners to depend on prior linguistic knowledge to retrieve information. In recognition, however, learners are not influenced by language knowledge, and they only recognise pieces of information as they are heard or read in a serial way (2007, p. 25; 2008, p. 12). As discussed in the previous sections, 'recall' was relevant to information retention which is involved in learning results from the three experiments. To verify learning results from a working memory perspective, the recognition test was also used to further measure information.

As discussed in Section 3.3, the familiarity of information was found to measure long-term retention from different conditions of learning (Budiu *et al.*, 2009; Budiu, 2014). According to Baddeley (2007), identifying items as true/false tests recognition, and in the present research project, a recognition test consisted of ten true-false statements. Learning materials from each experiment were removed from the recognition test, and to respond to each sentence, participants could only use the retained information.

With reference to Sweller (2019), immediate tests after learning were found to result in WM resource depletion. In other words, when learners were immediately tested after learning, their WM resources tend to deplete because of the cognitive demands on them during learning. To measure learning results after learning, Sweller *et al.* (2019) propose that delayed tests are a more efficient measure of cognitive load and learning results. In the present study, the recognition test was added to each experiment to verify two measures: 1) to test whether delayed test was effective to test information retention (as suggested in Sweller, 2019; Sweller *et al.*, 2019); and 2) to verify whether information familiarity in the recognition test leads to long-term retention, thereby explaining the connection between long-term and working memory (as suggested in Budiu *et al.*, 2009; Budiu, 2014).

The results from the experiments were verified in conjunction with the recognition test to answer research question 1, based on the working memory framework. However, to measure cognitive load during learning, another working memory, a reading span task, which does not refer to prior linguistic knowledge was used.

3.4.5 Reading span task

Reading span task has been generally used in assessing working memory during reading comprehension (Alptekin and Erçetin, 2009, Farmer *et al.*, 2016). The main aim is to assess learners' memory storage after learning from different language tasks (Alptekin *et al.*, 2014). Although some researchers (e.g. Daneman and Carpenter, 1980, Barrett and Tugade, 2004) claimed that reading span tasks yield varied results depending on an individual's traits and experience, it could be argued that a reading span task, when statistically controlled, could be used as an index to measure memory storage with respect to language comprehension (Osaka and Osaka, 1992, Alptekin *et al.*, 2014, Farmer *et al.*, 2016).

In the present project, in the recognition phase, participants were required to write the last word of ten true/false questions from the recognition test after they had completed the test. As participants were concentrating judging on the true/false sentences in the recognition test, they were using their cognitive capacity in comprehending the recognition sentences. To assess memory storage where cognitive load is situated, asking participants to recall last words of sentences was expected to yield traces of information stored in working memory. The reason why this activity was used was to measure if there was an immediate test effect to deplete WM resources, especially after the recognition memory (Sweller, 2019; Sweller *et al.*, 2019), so that the results of the reading span task did not affect the memory depletion if it was immediately used after the learning and testing phases.

It can be concluded that both the recognition test and reading span task in the recognition phase were used to assess memory storage of participants. As for the recognition test, recognition results were used to verify the results of learning in the learning and testing phases, whereas the reading span task was used to measure traces of memory regarding memory depletion in the recognition test. Both tests in the recognition phase as well as their reanalysis against RAVLT in the pre-tests were used to co-constructively answer research question 1 via the lens of working memory measurement.

3.4.6 Summary of research design and instruments

The present project had its aim to discover if modified instructional materials based on different types of cognitive load effects had an effect on Thai EFL learners' foreign language learning and information retention. In order to find answers for the enquiry, a *convergent parallel* mixed-methods approach employing different research methods was used in line with *cognitive constructionism* perspective. Research question 1 tests hypotheses whether there was the relationship between modified instructional materials and learners' information retention. Research question 2 seeks to find the best candidate of cognitive load effect for information retention. Research question 3 asks how much cognitive load participants perceived to use during learning from instructional materials.

To answer research question 1, three experiments with reading, listening and listening-reading were used to collect data in the learning and testing phases. The question was also addressed with the recognition data in the recognition phase of the three experiments. Taking the two sets of data into consideration, i.e. learning data and recognition data, research question 1 could be answered co-constructively through working memory and Cognitive Load Theory frameworks.

Research question 2 could be answered through the learning data as well as semi-structured interviews. Learning data was in the form of scores of information retention. In terms of semi-structured interviews, learners' perception toward learning from instructional materials added a more exploratory view to these data. This way, both methods could co-constructively supply answers for research question 2 from a cognitive constructionist's perspective.

To answer research question 3, two methods were used. The first method was a subjective rating-scale, where learners rated their own cognitive load they perceived to use during learning based on different cognitive load types of Cognitive Load Theory. The other method was semi-structured interviews, where learners shared their perception of their own cognitive load during learning from instructional materials. The two methods, i.e. a subjective rating-scale and semi-structured interviews, were intermingled from both cognitivism and constructivism perspectives to supply answers for research question 3. The following demonstrates how each research question is answered by means of research design.

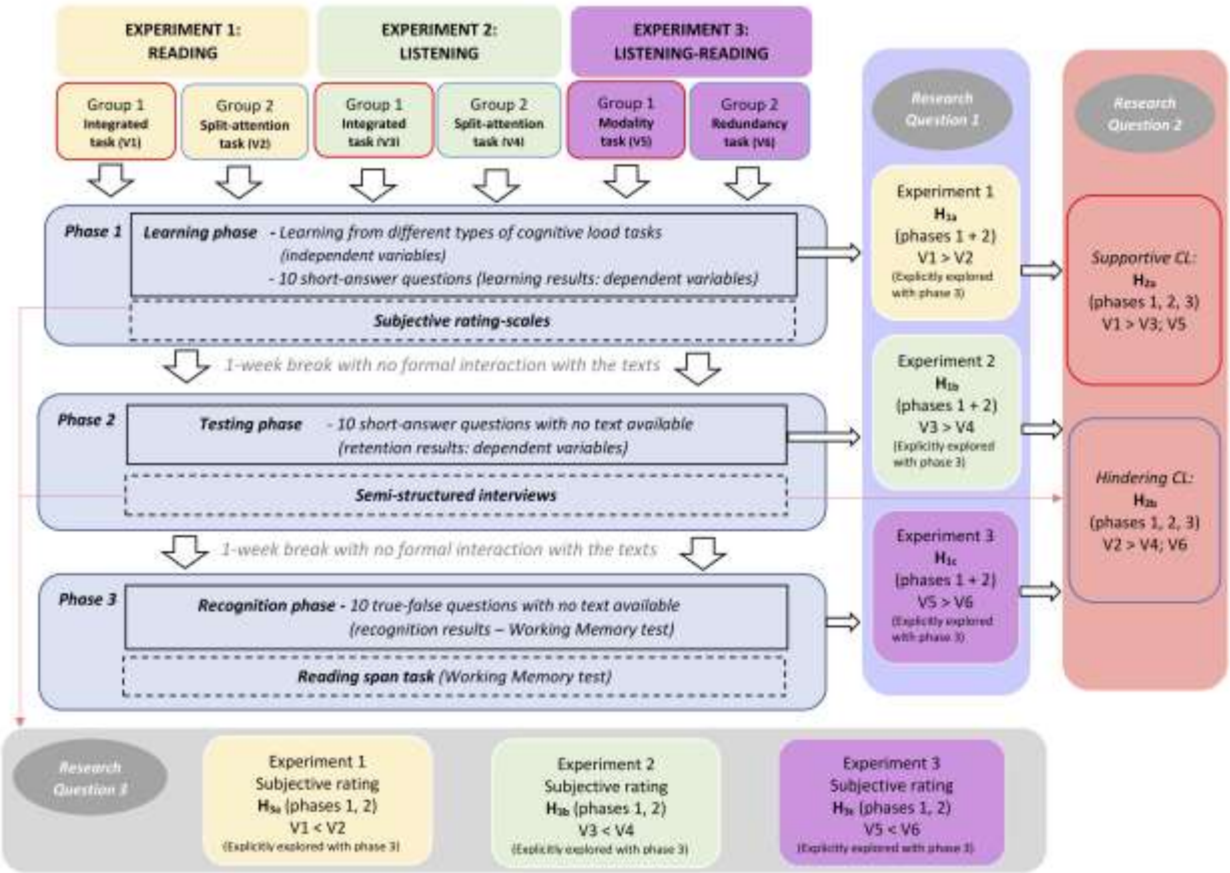


Figure 3.3. Research Design and Data Analysis

At this point of discussion, we could conclude that the mixed-methods approach was used to supply answers for the three research questions through the lens of cognitive constructivism perspective. In the following, ethical consideration and the reliability and validity of research will be presented.

3.5 Ethical considerations

In recruiting participants for the present study, I followed *the Code of Good Practice in Research* regulated by Newcastle University (2011, 2018) and *BERA Ethical Guidelines for Educational* Research (2011) for ethical considerations. The following are the stages of how ethics was addressed.

To recruit participant, all those in the foundation English course at Thammasat University were given detailed information of the research, i.e. information sheet (see Appendix 1). This was to ensure that potential participants acknowledged what the research would entail. Potential participants could then choose to participate in the research. Those who agreed to participate in the research then signed a consent form (see Appendix 1), maintaining confidentiality of data and name and one's option to opt out of research.

During conducting research, equal treatment was given to both experimental groups, in that both were given extra training after the experiment to supplement what was lacking in the experiment. Participants know they could leave the experiment at any stage when they felt they could not carry on with the treatment. No punishment with grading was given so that there was no effect on their studies after leaving the experiment.

Finally, personal information of participants was kept confidential, and in presenting information about the research, a denomination system of student 1, 2, 3, etc. was employed for anonymity.

3.6 Validity and reliability of research

To ensure validity of research, there were two issues to be taken into consideration. Firstly, content and topics in research materials were carefully considered. These were selected based on the units of study in English foundation course that the participants were studying. This was to make sure that the content and topics satisfied content validity (Hughes, 2003, pp. 26-27). Secondly, tests in each experiment were specifically designed into short-answer questions and true-false statements that participants were familiar with. This satisfied the face validity (Hughes, 2003, p. 33).

According to Bachman and Palmer (2012), tests can be valid, but they might not be reliable. In the present research, reliability of research and data analysis was considered. Firstly, when developing the materials, all reading, listening and listening-reading materials were piloted, and then judged by two Thai EFL experts based on content and text presentation criteria[9] adapted from Day (1994). As for the subjective-rating scales, the Cronbach's alpha for each experiment were reading 0.75, listening 0.815 and listening-reading 0.79. In each category of the

[9] According to Day (1994), reading and listening texts should be suitable at learners' level of proficiency in terms of vocabulary, grammatical structures, cohesion and rhetorical structure. Texts should coherently be organised with an appropriate length. Topics should be interesting, and politically and culturally suitable. They should help motivate learners to read/listen. Layout, font and text size should be appropriate for reading.

subjective-rating scales, three cognitive load variables were intrinsic, extrinsic and germane cognitive loads. The intrinsic cognitive load variables were reading 0.866, listening 0.903 and listening+reading 0.923. The extrinsic cognitive load variables were reading 0.839, listening 0.834 and listening+reading 0.859. The germane cognitive load variables were reading 0.873, listening 0.881 and listening+reading 0.913. According to Bachman and Palmer (2012) and Woodrow (2014), all of the values of Cronbach's alpha were above 0.70, which satisfied the reliability tests. In transcribing interview data, the researcher and two EFL experts looked at the transcription in Thai and translated it into English for analysis. The whole process of research preparation was to ensure reliability.

In analysing data quantitatively and qualitatively, reliability was also taken into consideration. In terms of quantitative data, a pilot study was conducted with sample with similar characteristics, and their learning results and subjective rating results were statistically tested to make sure that test reliability was satisfied. Experimental data were also tested statistically against two or more tests so that reliability of the test could be confirmed. In qualitative data, interview questions were asked consistently and interview data were systematically coded into themes, and the theme and analysis were checked by experts. The consistency of questions asked, coding and the correction of coding were meant to confirm reliability and validity.

As discussed in this section, validity and reliability were carefully considered, in that instructional materials and tests were tested and judged, and interview data were systematically analysed. In the next section, how data were analysed systematically and ethically will be presented.

3.7 Data analysis

In this section, details are presented of how the data obtained from the experiments, subjective rating-scale and semi-structured interviews were analysed.

3.7.1 Analysing data from the experiments

Comprehension tests used in both learning and testing phases consisted of ten questions. One correct answer scored 1 point and an incorrect answer scored 0. To determine how each question was answered correctly, the researcher looked for the correct semantic meaning in each answer, although some sentences or phrases in the answers contained ungrammatical sentences and wrong word choices. The total score for each set of comprehension tests in each phase was 10 points. To analyse data from the three experiments, statistical tools from the SPSS program were employed to find the relationships among variables. Tests were independent t-tests, paired t-tests, coefficient correlations, effect sizes and ANOVA tests. To compare scores from two variables in each experiment, independent t-tests were used along with effect sizes and coefficient correlations to find learning results (or information retention) in the learning and testing phases and recognition results in the recognition phase between two treatment groups. Paired t-tests were used to compare scores of a cognitive load variable in different phases in an experiment. This is to find the retention results and to discover the best candidate which helped learners to retain information effectively. As for the ANOVA analysis, scores of cognitive load variables from the three experiments were compared to find the results for information retention and the best candidate which supported retention In addition to the analysis of each experiment, scores of RAVLT pre-tests were reanalysed against retention results in the learning and testing phases and recognition results in the recognition phase. This is to predict if WM affects information retention and recognition. The table below summarises the statistical analysis.

Table 3.2. *Summary of statistical analysis used in analysing quantitative data*

Research question 1	Research question 2
Part 1: Experimental results (between groups) Independent-samples t-tests and effect sizes - Learning, testing, recognition, reading span task *Part 2: Cognitive load effects on information retention and recognition* Paired t-tests (within group) - Learning vs testing - Learning vs recognition - Testing vs recognition - Recognition vs reading span - RAVLT vs learning, testing and recognition tests	*Part 3: Comparisons of supportive and hindering cognitive load effects* 1. ANOVA (3 x 3) - Learning (R / L / L-R) - Testing (R / L / L-R) - Recognition (R / L / L-R) 2. Tukey HSD post hoc analysis - Learning (R / L / L-R) - Testing (R / L / L-R) - Recognition (R / L / L-R)

As can be seen from the Table 3.2, different statistical tests were used on the data relevant to information retention and to find the best candidate which supported information retention. This was to ensure that internal reliability was maintained for analysis of experimental data. Also, to collect data from the experiments, participants agreed to participate in the experiments and signed for the consent form.

Data obtained from the experiments was quantitative from the statistical point of view for research questions 1 and 2. However, to maintain cognitive constructivism perspective, it was also important to include another two methods of data collection into answering research questions.

3.7.2 Analysing subjective rating scales

For data from learners' perceptions toward learning with instructional materials, all eleven items of subjective rating scales from each experiment were calculated. An average score of each item was computed, and a similar item from two experimental groups was compared to see the trend of rating.

In terms of data interpretation, average scores of similar items between two groups of experimental treatments were compared using ANOVA. This is to depict the overall comparison of three cognitive load types, i.e. intrinsic, extrinsic and germane cognitive loads, of the two experimental treatments. Descriptive statistics were also employed to explore trends in differences among different cognitive load types of the two experimental groups. It indicated that a high average score in intrinsic and extraneous cognitive load types and a low average score of germane cognitive load was considered as pointing to a high cognitive load (Sweller *et al.*, 2011). A low average score in intrinsic and extraneous cognitive loads and a high average score in germane cognitive load was interpreted as low cognitive load.

To understand the relationship between WM and cognitive load, the results of subjective-rating were reanalysed against RAVLT using independent-samples t-tests. This was to measure if learners' WM prior to participating in each experiment related to the cognitive demands as perceived by the participants.

Data from the subjective rating scales was used to answer research question 3 concerning learner's perception of cognitive load during learning from instructional materials. To verify whether the data from subjective rating scales was valid, it was also important to include a qualitative element of semi-structured interviews in the interpretation. In the following section, how qualitative data from semi-structured interviews was analysed will be discussed.

3.7.3 Analysing semi-structured interview data

In analysing semi-structured interview data, several factors were involved as follows. Firstly, in transcribing interview data, the researcher transcribed and translated interviews from Thai into English interview scripts. When the participants used English in the interviews, some words and phrases were slightly modified to ensure semantic understanding of the message, such as 'I see questions difficult.' (original) → 'I found questions difficult.' (modified). The transcription and translation were checked by two Thai EFL experts so that data reliability and validity were satisfied.

In analysing qualitative data, thematic analysis and discourse analytic method were used. According to Gibbs (2009), thematic analysis is a systematic way of analysing qualitative data. Data were coded into themes, which ensured a consistent way of validating data, and the themes were related to provide a big picture of data from either data-driven or concept-driven coding. However, in the present research, the theme itself was variable since Thai EFL participants provided different views of instructional materials from different contexts. As Talja (1999) puts it, the variability of data in discourse analysis is viewed as a resource of context-dependent analysis.

In analysing qualitative data using both thematic and discourse analytic methods, the interview scripts were coded into three different themes. The themes were derived from research questions into 'characteristics of materials', 'text presentation', and 'self-perception on instructional learning', similar to the three cognitive load types of Cognitive Load Theory. This is called 'concept-driven coding' according to Gibbs (2009). In each theme, there were different subthemes, and they were different from the two experimental groups in three different experiments since each participant offered different angles of the same treatment. In deriving the subthemes, I used the *Information Processing Principles* under the evolutionary knowledge (Sweller *et al.*, 2011) and the *Dual-coding approach* by Paivio (1990) so that cognitive processes from the two perspectives were co-constructively used to bridge the gap of Cognitive Load Theory. The coding and interpretation were co-checked by two EFL experts to ensure a consistent coding and analysing, satisfying the validity and reliability of data. The results were used to co-constructively supply answers for research questions 2 and 3.

3.7.4 Data analysis for research questions

To summarise, the quantitative data of experiments was used to answer research questions 1 and 2. Descriptive statistical data from subjective rating scales supplied answers for research question 3, and qualitative data from semi-structured interviews was used to answer research questions 2 and 3. The following section discusses how data was combined to answer the research questions.

To answer research question 1 and test the hypotheses on the relationship between instructional materials and learners' information retention, different statistical tests were employed to triangulate quantitative data from the learning, testing, recognition and reading span tasks. These statistical tests revealed whether there was an association between instructional materials and learners' information retention.

To answer research question 2, both quantitative and qualitative data were used to reveal learners' preference on the best cognitive load candidate for instructional learning. Statistical tests on learning, testing and recognition results (or product) were compared to find the best cognitive load effect that supported learning. Qualitative data from semi-structured interviews (or process) was used to explain participants' perspectives on different material characteristics and text presentation, and their preference on learning from different instructional materials. The combination of data co-constructively revealed the best cognitive load effect and its underlying reasons.

To answer research question 3, two types of data were integrated from subjective rating scales and semi-structured interviews. Descriptive statistical data from subjective rating scales (or product) was used to reveal how learners reported on how much information was loaded by cognitive load type during interacting with instructional materials, and qualitative data from semi-structured interviews (or process) could explore what happened in learner's cognitive capacity in terms of cognitive processing when they were interacting with instructional materials. The two data sets yielded answers about the perceived amount of cognitive load in instructional learning.

As can be seen from the above discussions, the design of a study with an integration of subjective rating scales and semi-structured interviews was expected to support the analysis of data for answering different research questions co-constructively under the 'cognitive constructivism' perspective.

3.8 Research procedure and a pilot study report

In this section, the research procedures and pilot study results of reading, listening and reading-listening experiments will be reported.

3.8.1 Participants

Participants recruited for the research project were two English foundation classes (Group 1 = 41 participants and Group 2 = 38 participants) of seventy-nine first-year undergraduate students from Thammasat University in Thailand, studying in the first semester of academic year 2016. They were from a mixed class of various majors but were undertaking the same foundation English course. Convenience sampling technique was employed since participants had already been assigned to classes based on similar university admission English scores. Their ages of ranged from 17 to 20 years old with the majority of students aged 18 (62%) and 19 (31.6%). The majority of participants reported to have already learnt English officially for approximately 12 years (70.9%). All participants were Thai with Thai as their native language.

All seventy-nine students, i.e. Group 1 (n = 41) and Group 2 (n = 38), were pre-tested for normal distribution. The pre-test was adapted from an English proficiency test designed by the Language Institute, Thammasat University, consisting of fifty listening-speaking questions and thirty reading questions. There were three parts in the listening-speaking section: twenty questions-answers, three conversations and two talks. After listening, participants were required to choose the best answer for fifty multiple-choice questions. In reading, participants were required to read five passages and choose the best answer for each question that follows each text. The total score for the pre-test was 80. Statistically, the two recruited groups were normally distributed with no statistically significant difference in the pre-test scores.[10] This means that 41 participants in Group 1 and 38 participants in Group 2 could be recruited to experimental treatment tests in this research project (see Table 3.3a).

Table 3.3a. *Test of normality and pre-test scores of two participant groups*

Test of normality (Shapiro-Wilk test)				
	Statistic	***df***		***Sig.***
Pre-test	0.991	79		0.881
Independent samples t-test				
	Statistic	***t***	***df***	***Sig.***
Group 1 (N = 41) **Group 2 (N = 38)**	M = 59.51, SD = 6.871 M = 57.58, SD = 6.537	1.279	77	0.205

Statistically, it could be assumed from the test of normality and the independent samples t-test that both groups of students were randomly distributed, suitable for parametric measurement (Woodrow, 2014, Field, 2018). In other words, participants from the two experimental groups shared similar English language abilities based on the pre-test scores. According to Wanpintu (2014), EFL learners with an average score of above the mean could be considered as high-beginner to intermediate level students, or roughly at B1 according to the Common European

[10] According to Cohen *et al.* (2000), Bryman (2012) and Field (2018), the test of normality (Shapiro-Wilk test) is used to determine whether participants are randomly distributed. This is an important factor for parametric tests which suggest that the inferential statistical tests for the participant treatments are reliable and valid.

Framework of Reference for Languages (CEFR). They could therefore be purposively and randomly assigned into the two groups.

This also meant extraneous variables were excluded, which might have affected participants' test results. According to Sweller *et al.* (2011), in measuring learners' cognitive load, one must ensure that all participants are randomly distributed so that cognitive load variables can be extracted directly from inferential statistical tests. In this study, 41 participants from Group 1 were assigned to *supportive cognitive load variables* and 38 participants from Group 2 were assigned to *hindering cognitive load variables.* Test results from different cognitive load variables could be measured statistically since participants from the two groups were normally distributed. Also, in semi-structured interviews, a volunteering sampling was employed. Approximately 20 participants, i.e. 10 from each group, were asked to participant in interviews. This is because all interview volunteers share an equal chance of being selected due to the normal distribution test.

Although participants shared a similar language ability as determined by the pre-test, their working memory capacity in dealing with foreign language learning, i.e. English, was not clear. In this study, the Rey Auditory Verbal Learning Test (RAVLT, Schemidt, 2010) was used to measure participants' working memory capacity, especially on the central executive channel or a platform for information processing. The reason why this test was used in the present project is that it deals with simple word lists, which involved reading and listening. It was also applicable in language learning when 'recall' and 'recognition' were both measured, reflecting the design of the present research project as looking into *information retention* (or recall in working memory) and *recognition*. Participants were asked to listen to 10 English words and, after listening, wrote the 10 words on a paper (i.e. recall listening). After that, they were shown the same 10 English words on PowerPoint slides (one at a time), and then were required to write the 10 words on a paper with all slides removed (i.e. recall reading). They were then shown another 10 Thai words on PowerPoint slides (one at a time), but this time were asked to write the previous 10 English words (i.e. delayed recall). Following the listening and reading recall, participants were given a list of 20 words, and were asked to choose 10 English words from the recall listening (i.e. recognition words in isolation). Finally, participants were given an English story and were required to choose 10 words in the story which were similar to the recall listening. The results of working memory measurement were as followed.

Table 3.3b. *Rey Auditory Verbal Learning Test results between Group 1 and Group 2 participants*

Tests	***N***	***Mean***	***SD***	***F***	***df***	***Sig***
Recall Listening	Group 1 (N = 41)	7.22	1.969	11.170	1	0.001*
	Group 2 (N = 38)	5.89	1.503			
Recall Reading	Group 1 (N = 41)	9.63	1.670	6.565	1	0.012**
	Group 2 (N = 38)	8.71	1.523			
Delayed recall	Group 1 (N = 41)	8.15	2.490	2.673	1	0.106
	Group 2 (N = 38)	7.24	1.386			
Recognition words in isolation	Group 1 (N = 41)	12.83	3.820	10.063	1	0.002*
	Group 2 (N = 38)	14.82	0.563			
Recognition words in context	Group 1 (N = 41)	13.68	1.955	11.841	1	0.001*
	Group 2 (N = 38)	14.82	0.563			

* Significant level at p < 0.01, ** Significant level at p < 0.05

As shown in the above table, it could be summarised that participants from the two groups could recognise words similarly. In other words, there were no statistically significant differences between participants in Group 1 and Group 2 in word recalls from reading and delayed recall ($F(1, 78) = 0.106$, $p > 0.05$, respectively). However, there were statistically significant differences between participants in Group 1 and Group 2 in reading recall ($F(1, 77) = 6.565$, $p < 0.05$) listening recall ($F(1, 77) = 11.170$, $p < 0.01$) and recognitions from words in isolation and words in context ($F(1, 77) = 10.063$, $p < 0.01$ and $F(1, 77) = 11.841$, $p < 0.01$, respectively).

This means that, although participants shared a similar language ability based on the pre-test and parts of the WM measures, their dealing with reading and listening recall and language recognition might yield different learning results due to differences in working memory capacity (as seen in Table 3.3b). Therefore, it is interesting to see how these working memory differences related to learners' self-perception of learning.

In the following sections, pilot study results of reading, listening and reading-listening will be reported.

3.8.2 Pilot participants

Preliminarily, in August-October 2016, seventy-seven Thai EFL students who were assigned to the same English foundation course based on their national English test scores and university screening tests were recruited for a pilot study. 37 students were grouped as a supportive cognitive load group and 40 participants were grouped into a hindering cognitive load group.

Based on the average mean scores of participants' Ordinary National English Test (ONET) and Thammasat Competency Test Centre Tests (TCTC) tests, it could be regarded that all 77 student participants were homogenous, which is shown by an analysis of ANOVA below.

Table 3.4a. *Comparison of average mean scores of pilot participants' national English test and university screening test*

ONET		***TCTC***	
Group 1 Group 2	N=37 (M=52.973, SD 4.93) N=40 (M=50.6, SD 8.62)	Group 1 Group 2	N=37 (M=34.919, SD 3.34) N=40 (M=35.9, SD 4.33)
Condition F(1, 50.301 = 2.152), p=0.147		*Condition F(1, 15.098 = 1.225), p=0.727*	

* Significant level at p < 0.01, **Significant level at p < 0.05

All pilot students were assigned to participate in a 3-week experimental design to test whether the designed learning materials were effective for students learning English as a foreign language. However, during the whole experiment, the number of participants decreased since nine students chose to opt out of the research process.

In summary, the number of students participating in each pilot study were as follows.

Table 3.4b. *The number of pilot participants participating in each research process*

Experiment 1: Reading		***Experiment 2: Listening***		***Experiment 3: Listening-reading***	
Group 1 Group 2	37 40	Group 1 Group 2	37 40	Group 1 Group 2	35 33
N = 77		N = 77		N = 68	

According to Dörnyei (2007, pp. 99-100), the agreed minimum sample size for correlational studies is 30 participants. Taking this into consideration, the pilot groups of the three phases could be regarded as satisfactory.

3.8.3 Learning results of pilot instructional materials

In this section, learning results of Thai EFL learners learning from reading, listening and listening-reading instructional materials will be discussed.

Table 3.4c. *Summary of an independent-samples t-test of the learning and testing phases from the three experiments*

Experiments	*Mean*	*SD*	*t*	*df*	*Sig*
Experiment 1: Reading					
Integrated	6.216	2.2808	5.954	75	0.00
Split-attention	3.238	2.1092			
Experiment 2: Listening					
Integrated	4.457	1.50	6.645	69	0.00
Split-attention	2.028	1.58			
Experiment 3: Listening-reading					
Modality	0.143	0.355	4.974	66	0.00
Redundancy	1.061	1.029			

Independent-samples t-tests were computed to compare learning results (or information retention) of the three experiments. In reading, there was a statistically significant difference in the learning results between integrated reading task (M=6.22, SD=2.28) and split-attention reading task (M=3.24, SD=2.11, conditions; $t(75)=5.954$, p=0.00). This means that this task shows differences between the two conditions, and test validity is confirmed.

For listening, the statistically significant difference between the two conditions also shows it is valid.

When taking the mean score results into consideration, even though the integrated group outperformed the split-attention group, both groups scored low in the listening task.

A surprising result from the listening-reading was a statistically significant difference in the learning results between the modality effect task (M=0.14, SD=0.36) and the redundancy effect task (M=1.06, SD=1.03, conditions; $t(66)=4.974$, p=0.00).

Given the results of listening+reading separately, the expected results of better learning from modality were the reverse, in that the pilot learners learning from the redundancy effect would score less than those in the modality effect group. In this case, information on learners' opinions toward instructional design was obtained to try to explain what really happened in the learning process.

Interestingly, even though there existed statistically significant differences in learning listening+reading, both groups again performed poorly, resulting in an average score of 1 or below.

These materials and tests show that they could be retained as is to use in the actual research study, except for the listening+reading materials which needed some modification.

While the pilot study shows that the three experiments yielded significant results to answer research questions 1 and 2 effectively, to co-constructively discover answers for the learning results, a qualitative element was included to explore what really happened as in the case of the experiment 3. This is important as the pilot results showed lower scores and the reverse results.

3.8.4 Subjective-rating scales

In each phase of the experiments, participants were asked to rate their opinion against items in the subjective rating scale, which ranges from *not all the case* (=0) to *all the case* (=7). There were 11 items on the scale, which were adapted from Pass *et al.* (2003) and Leppink *et al.* (2013).

In the scale, items 1-4 were designed to measure learners' perception of element interactivity (or a factor determining intrinsic cognitive load), items 5-7 for instructional design (or a factor of extrinsic cognitive load), and items 8-11 for efficient learning (or germane cognitive load). In other words, items 1-4 could be used to find *intrinsic cognitive load,* items 5-7 for *extraneous cognitive load*, and items 8-11 for *germane cognitive load*.

The results of item analysis for each set of cognitive loads were computed using Cronbach's alpha. The following reported an internal reliability of items in each set.

Table 3.4d. *Summary of internal reliability of items for each set of cognitive loads*

Experiment 1: Reading	*Experiment 2: Listening*	*Experiment 3: Listening-reading*
Reliable items Intrinsic: 1, 2, 3 Extrinsic: 6, 7 Germane: 8, 9, 10, 11	Reliable items Intrinsic: 1, 2, 3, 4 Extrinsic: 6, 7 Germane: 9, 10, 11	Reliable items Intrinsic: 2, 3 Extrinsic: 6, 7 Germane: 8, 9, 10

After an analysis of internal reliability for each cognitive load type, potential problematic questions (as they scored below 0.70 on Cronbach's alpha), i.e. items 4, 5 in reading; items 5, 8 in listening; and items 1, 4, 5, 11 in listening-reading, were rewritten to be more simplified. In addition, Thai translation, which was checked by two EFL experts, was provided for participants to better understand each item of subjective rating scales.

In the following section, a summary of pilot study and actions taken to modify the research design will be presented.

3.8.5 Pilot study adjustments for main study

Note that participants in the pilot study were not different from the present study in that their language ability was at high-beginner to intermediate level and this represents validity of sample in the present study.

This is important because the instructional materials used in the learning phases of the pilot study were too difficult for learners based on the pilot results. Also, some items of subjective rating scales were ambiguous and needed to be revised. All materials and tests were then assessed by two Thai EFL experts. The following shows results of experts' assessment.

After piloting the instructional materials for the experiments, all materials were judged by two Thai EFL experts. The criteria for judgement was adapted from Day (1994). The following were comments from the experts.

Reading texts:

> *There appear some lexical items that seem to be slightly higher than the L2 level of high-beginner students.*
>
> *The topic of reading is interesting for the students' age.*

The reading text should have a title unless it's intentionally omitted for some research purposes.

Listening texts:

Quite hard.

Some lexical items seem to be slightly higher than the L2 level of high-beginner students.

The listening text is probably a bit too lengthy, which may hinder the students' concentration and understanding.

The listening topic runs in parallel with one of the chapters in the course book, which is conductive to their better understanding of the topic in question.

Listening+reading texts:

Too hard for first-year students

Some lexical items seem to be slightly higher than the L2 level of high-beginner students.

The topic of reading is interesting for the students' age.

The listening text is probably a bit too lengthy, which may hinder the students' concentration and understanding.

The listening topic runs in parallel with one of the chapters in the course book, which is conductive to their better understanding of the topic in question.

The experts' comments overall were that materials were in accordance with chapters in the course book, but both listening and reading texts were too long for Thai EFL students to learn. They also contained some difficult vocabulary items. As a result, the instructional materials were revised and simplified. Here is a summary of what was modified from the original materials.

Table 3.4e. *Summary of material modification after experts' judgements*

Original design	Actions taken
Each text, i.e. reading, listening and listening-reading texts, ranged from 700-800 words.	Each text was rewritten to approximately 650 words.
Original texts with technical and difficult vocabulary items.	Difficult words were replaced with simplified ones. Where necessary, some items were maintained with more explanations in contextual clues.
Comprehension questions seemed lengthy and difficult to understand.	All questions were simplified and rewritten to contain one possible answer.

Taking these into consideration, actions were taken prior to the actual research study. In the following section, a revised research design is presented.

3.9 Revised research design

As can be seen from the pilot study, the materials could be used in the actual study, but the text in reading, listening and listening+reading needed simplification. In terms of subjective rating-scales, unreliable items were in need of modification, instead of deletion since all the items were needed to measure cognitive load types according to the Cognitive Load Theory framework.

The results of pilot experiments suggested that learning results might reveal different perspectives from the Cognitive Load Theory framework, and was important to include another method of enquiry, i.e. semi-structured interviews, discussed in depth above. Below is the revised instrument.

Table 3.5. *Revised research plan for actual research instrument*

Preliminary stage	
Research process Ethics Pre-test Students' personal data	*Research tools* - Information sheet and consent form - A standardised test of English - Students' data questionnaire
Experiment 1: Reading	
Research process Learning phase: Reading *(1 week with no formal interaction with text)* Testing phase: Reading *(1 week with no formal interaction with text)* Recognition phase:	*Research tools* - Reading text on time management (*simplified with 600-word length*) - 10 short-answer questions - Subjective-rating scales (*modified with Thai translation*) - 10 short-answer questions - Semi-structured interviews - True-false questions - Reading-span task
Experiment 2: Listening	
Research process Learning phase: Listening *(1 week with no formal interaction with text)* Testing phase: Listening *(1 week with no formal interaction with text)* Recognition phase:	*Research tools* - Listening text on discrimination (*simplified with 600-word length*) - 10 short-answer questions - Subjective-rating scales (*modified with Thai translation*) - 10 short-answer questions - Semi-structured interviews - True-false questions - Reading-span task
Experiment 3: Listening-reading	
Research process Learning phase: Reading-listening *(1 week with no formal interaction with text)* Testing phase: Reading-listening *(1 week with no formal interaction with text)* Recognition phase:	*Research tools* - Listening-reading texts (modality and redundancy tasks) on business innovation (*listening text was simplified with 600 words and graphic summary was changed to a flowchart*) - 10 short-answer questions - Subjective-rating scales (*modified with Thai translation*) - 10 short-answer questions - Semi-structured interviews - True-false questions - Reading-span task

Table 3.5 shows the process of research design was still the same as planned in the initial stage. However, texts reading, listening and listening-reading texts were modified; learning questions were revised into simple structures; and some items of subjective rating scales were simplified and adapted and were supplemented with Thai translation.

It was concluded that the research design under cognitive constructivism could be used to reveal answers for research questions. An adaptation and revision of instructional materials and subjective rating scales in the pilot study also strengthen the reliability and validity of research into cognitive load construct for different cognitive load effect variables.

3.10 Disclaimers

In conducting this research project, the researcher was aware that the context of research was conducted in a controlled EFL classroom environment, where there was only one computer and screen projector for the teacher and students used materials as a group. So, other innovative research methods which may be able to employ in accessing working memory capacity, such as brain-scanning or eye-tracking, were not practical in this project.

In addition, although the students were normally distributed and grouped into two experimental groups (Group 1 and Group 2), these Thai EFL students were in their late teens and were still studying with different paces and preferences. That is why the semi-structured interviews were employed to co-constructively provide another aspect of learning results and information retention.

Instructional materials which were designed by the researcher were paper-based rather than digital multimedia materials (see Appendices 2-4) apart from listening-reading instructional materials. The main argument for an inclusion of cognitive theory in multimedia learning (Mayer, 2009) in discussion is that the nature of listening is transient, and it requires the use of audio technology for EFL learners to learn from. The main difference in practice is that the participants in the research project interacted with paper-based instructional materials, while the cognitive theory of multimedia learning is mainly on a computer screen.

3.11 Limitations

The present research design could assess learners' cognitive load in Thai EFL classroom contexts, however, there are some limitations. Firstly, the present study focuses on EFL receptive skills only since it adapted the sensory input of Baddeley's WM model, i.e. visual and phonological input. So, implications of research findings could only be generalised for EFL reading and listening only. Secondly, interviews showed an individual learner's perceptions of their own learning, but the generalisability could only be achieved when a similar context is considered. Other learning situations beyond the present research need to be carefully considered since Thai learners might process EFL differently from learners of other disciplines or countries. Finally, topics of instructional materials in the present study followed units of the foundation English course at Thammasat University only. This means that the materials might not be applicable if English lessons in other universities or institutions are different from the present study.

In the next section, given limitations of the present study, some contributions of research will be presented.

3.12 Research contributions

The results of this research project were expected to contribute into two areas: theoretical and practical contributions. In terms of theoretical contribution, the design of instructional materials using Cognitive Load Theory was only from the results of learning. Although there are other scholars (e.g. Pass and Sweller, 2012, Paas and Ayres, 2014) who have proposed research methods and ideologies such as subjective rating scales, for Cognitive Load Theory to triangulate the results of learning, the researcher was not aware of mixed-methods approach to enquire into Cognitive Load Theory. The results of the research project can be used to bolster Cognitive Load Theory through the lens of both product (cognition) and process (constructivism) results. The implementations of working memory measurements and qualitative interviews can be used to co-construct another view of Cognitive Load Theory from learners' perspectives. We return to this in the discussion chapter.

In terms of practical aspects of the present research, in designing instructional materials, especially in EFL settings, most materials developers align with theories in TESOL (e.g. Nunan, 2014) or ELT materials development (e.g. Tomlinson, 2011). However, to practically use the instructional materials with EFL learners, a cognitive load construct of EFL learning is ignored as the main focus of EFL material design is on language skills (McDonough *et al.*, 2013) and the process of materials development (Mishan and Timmis, 2015). It is also important for materials developers to consider cognitive load construct in EFL learning since efficient learning is in close connection with a learner's cognitive development (Sweller, 2017), in addition to social communication. The results of the present research project can supply what happens in learners' cognition through the lens of a mixed-methods approach so that, in practice, learners' cognition can be integrated in designing instructional materials.

3.13 Conclusion

In this chapter, the design of research project was presented into a mixed-methods approach where the cognitive load construct was a major factor of enquiry. Research design, ethics, reliability and validity as well as contributions were presented. Also, the limitations in conducting the present research were taken into consideration, both through pilot studies and enquiry consideration, and how to redesign the research project was shown. In the following chapter, the results of findings from three experiments, subjective rating scales and semi-structured interviews and data analysis will be presented. This also includes an integration of quantitative and qualitative data in answering the three research questions.

Chapter 4. Data Presentation and Analysis

In this chapter, results of the study in relation to research questions will be presented. The chapter is divided into two major sections. The first part deals with results from experiments and subjective rating scales. The results of three experimental studies on reading, listening and listening-reading in general are discussed. Each phase of experiment is presented with statistical analysis as well as cross analytical sections to answer research questions 1 and 2. After that, the results of subjective rating scales are presented to supply part of the answers to research question 2. The second part presents results from semi-structured interviews. These qualitative data are presented to provide an insight into the answers to research questions 2 and 3. The following diagram demonstrates how the three experimental studies are related to the research questions.

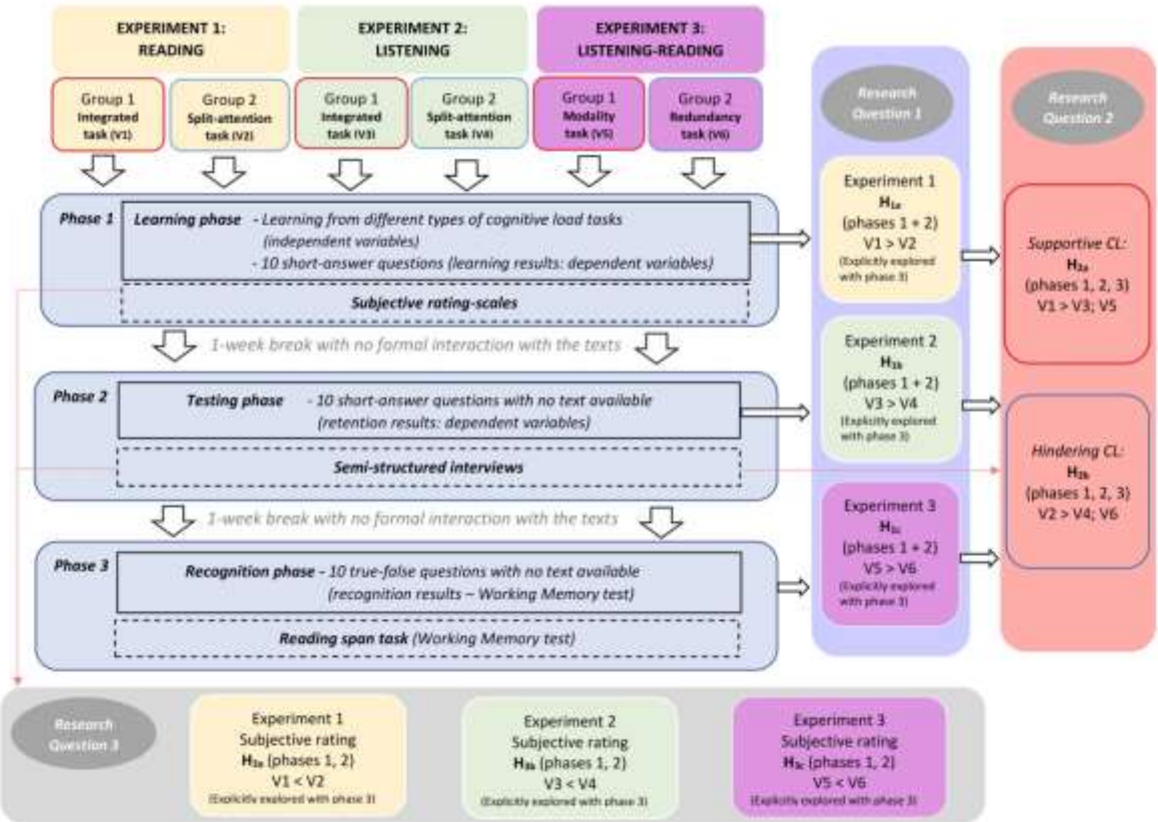


Figure 4.1. How data types of the three experiments are related to the research questions

Main research question: *Can learners process information in their working memory better from modified listening and reading materials?*

Sub research questions

1. Is there an association between learners' information retention and English listening, reading and reading-listening materials?

H_{1a}: Integrated reading results in better retention than split-attention reading.

H_{1b}: Integrated listening results in better retention than split-attention listening.

H_{1c}: Modality listening-reading results in better retention than redundancy listening-reading.

2. What kind of modified materials best supports learners' language learning?

H_{2a}: In supportive cognitive load, integrated reading supports learning more than integrated listening and modality listening-reading.

H_{2b}: In hindering cognitive load, split-attention reading supports learning more than split-attention listening and redundancy listening-reading.

3. How much mental effort do learners perceive to use in working with instructional materials?

H_{3a}: Integrated reading is perceived by learners as less difficult than split-attention reading.

H_{3b}: Integrated listening is perceived by learners as less difficult than split-attention listening.

H_{3c}: Modality listening+reading is perceived by learners as less difficult than redundancy listening+reading.

As can be seen in Figure 4.1, Experiments 1, 2 and 3 were conducted in three phases – a learning phase (Phase 1), a testing phase (Phase 2) and a recognition phase (Phase 3). In each phase, two variables of Cognitive Load Theory in each language skill were compared to present learning, testing and recognition results. Test scores from all phases were statistically compared to reveal answers for research questions 1 and 2, regarding information retention and specific types of effective cognitive load, respectively. For research question 3, the hypotheses predicting how difficult each task was relate to cognitive load. According to Sweller *et al.* (2011), task difficulties determine intrinsic cognitive load with respect to the cognitive demands on the learners. As also reported in Plass (2006), cognitive subjective ratings on learners' task difficulty perception were statistically significant in measuring learners' mental effort in learning, so the results of subjective ratings of task difficulties could yield how much mental effort participants used in learning from instructional materials.

To summarise, all of the hypotheses are related to all research phases in each experiment. Firstly, results from H1a, H1b and H1c predict retention (Phases 1 and 2) and recognition results (Phase 3), considering cognitive load effects. Secondly, results from H2a and H2b predict specific types of cognitive load which support retention (Phases 1 and 2) and recognition (Phase 3). Finally, subjective-rating results predict if H3a, H3b and H3c were relevant to participants' cognitive load perception of task difficulties as a result of learning from phase 1. However, in views\ of WM and cognitive load (CL), RAVLT in the pre-tests was used to predict the relationship among WM, CL and information retention in terms of recall in the learning and testing phases (Phases 1 and 2) and recognition in the recognition phase (Phase 3), which is presented in sections 4.2 and 4.4 to co-constructively answer research question 3.

The following section discusses statistical results of comparison between cognitive load variables, i.e. integrated tasks and split-attention tasks in reading and listening experiments, a modality task and a redundancy task in the listening-reading experiment.

Part 1: Quantitative Data

4.1 The results of the three experiments

In this section, a statistical analysis of the three experiments is presented. The data from learning phases between two types of cognitive load in each experiment were compared, followed by a comparison of testing scores. Each experimental phase ends in the recognition phase where comparisons between the two types of cognitive load against two working memory tests – recognition tests and reading span tests were presented. This aims to explain the results of cognitive load studies via the lens of working memory measurements.

In the following section, results of the experiments will be discussed in line with hypotheses H_{1a}, H_{1b} and H_{1c}.

4.1.1 Experiment 1: Reading (Integrated task and split-attention task)

In this experimental phase, there were seventy-six students participating in this study. Forty one students were in the integrated group and thirty-five students in the split-attention effect group.

The two groups of Thai EFL students were assigned to read from two different text presentation formats – the integrated format task or the split-attention task. They participated in the following phases.

Phase 1: Learning phase

In the learning reading phase, forty-one students in the integrated task read a reading passage with ten comprehension questions embedded within the text. They were requested to read the passage and answered the comprehension questions immediately right after each reading paragraph. Another group of thirty-five students read the similar passage, but they were required to read the entire reading passage with description boxes of vocabulary and extra information. Then, they were required to answer the ten comprehension questions without referring to the reading passage. It was hypothesised as follows:

H_{1a}: Integrated reading results in better retention than split-attention reading.

An independent-samples t-test was conducted to compare learning results in the integrated reading task and split-attention reading task. The following is the result of findings from learning reading.

Table 4.1a. *Learning phase results of reading*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Reading learning phase	Integrated (N = 41)	7.88	1.005	9.395	74	0.00*	2.12
	Split-attention (N = 35)	4.80	1.795				

* Significant level at p < 0.01; ** Significant level at p < 0.05

As can be seen in Table 4.1a, there was a statistically significant difference in the scores of learning reading between the integrated reading task (M = 7.88, SD = 1.00) and the split-attention reading task (M = 4.80, SD = 1.80, conditions; $t(74) = 9.395$, $p = 0.00$, $d = 2.12$). The results suggested that the integrated reading format did have an effect on information retention in the learning phase. Especially, results suggest that when learners read a reading passage with comprehension questions embedded within the text, they can retain the reading information to a greater extent because the mean difference is large with Cohen's *d* 2.12[11]. So, the hypothesis H_{1a} is accepted.

Phase 2: Testing phase

After a week of the learning phase, the seventy-six students were retested with the same ten comprehension questions as presented in the learning phase, without referring to the reading text. However, one student was absent from the integrated group and two students from split-attention group. An independent-samples t-test was calculated to compare the testing results of the integrated reading task and the split-attention reading task. The following are the results of the testing phase.

Table 4.1b. *Testing phase results of reading*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Reading testing phase	Integrated (N = 41)	5.08	1.886	2.853	73	0.006*	0.67
	Split-attention (N = 35)	3.91	1.597				

* Significant level at p < 0.01; ** Significant level at p < 0.05

As Table 4.1b shows, there was a statistically significant difference in the scores of testing reading between the integrated reading task (M = 5.08, SD = 1.89) and the split-attention reading effect (M = 3.91, SD = 1.60, conditions; $t(73) = 2.853$, $p = 0.05$, $d = 0.67$). The integrated reading format had a greater effect on information retention in the testing phase because the Cohen's *d* is beyond 0.5, and the hypothesis H_{1a} is accepted in the testing phase.

Phase 3: Recognition phase

After the learning and testing phases, all of the participants were required to complete another recognition phase, where they responded to ten true-false questions concerning the reading text.

An independent-samples t-test was performed to compare the scores of recognition test from both groups. The following are the results.

[11] According to Woodrow (2014), the measurement of effect size interprets 'the magnitude of statistical results' (p. 65), and the interpretation of effect size based on Cohen's *d* (for t-tests) and η^2 (for ANOVA tests) is '0.01 = small, 0.06 = medium and 0.14 = large effect' (p. 65).

Table 4.1c. *Recognition phase results of reading*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Reading recognition phase	Integrated (N = 41)	7.10	1.429	-0.947	73	0.347	0.22
	Split-attention (N = 35)	7.43	1.577				

* Significant level at p < 0.01; ** Significant level at p < 0.05

As can be seen from the Table 4.1c, there was no statistical difference on the effects of scores between the integrated group (M = 7.1, SD = 1.43) and the split-attention group (M = 7.43, SD = 1.60, conditions, $t(73) = -0.947$, $p > 0.05$, $d = 0.22$). That is, students in the split-attention group responded to true-false questions a little more correctly than those in the integrated group (with Cohen's *d* 0.22). However, the scores from both groups were not statistically different. It is also interesting to note here that the recognition results from both the integrated and split-attention groups were higher than those in the learning and testing phases. We will return to this in section 4.2.

After the three phases of reading experiment, students were required to write the last words of all the recognition sentences for the reading span working memory test. The following are the results of the reading-span task.

Table 4.1d. *Reading span results of reading*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Reading span task	Integrated (N = 41)	2.10	1.194	-1.601	73	0.114	0.38
	Split-attention (N = 35)	2.57	1.357				

* Significant level at p < 0.01; ** Significant level at p < 0.05

The above independent-samples t-test shows no statistically significant effect on the scores of the integrated group (M = 2.10, SD = 1.19) and the split-attention group (M = 2.57, SD = 1.36, conditions; $t(74) = -1.601$, $p > 0.05$, $d = 0.38$). When testing reading with the two groups of students under different presentation modes, we found a statistically significant effect on the scores between the integrated group and the split-attention group in the learning and testing phases, accepting the hypothesis H_{1a}. As for the recognition phase and the reading span task, there was no significant difference between scores of students in the integrated group and those in the split-attention group. This means that participants in the two groups recognised information during the two phases similarly, even though they learnt from different cognitive load variables. The non-significant difference in the reading span task reveals that both groups employed almost full capacity of working memory in a similar way, resulting in low scores in this test.

The results in this section reveal significantly that the integrated reading variable helped learners retain reading information better than the spilt-attention variable, but there was no effect of either variable when it came to the recognition phase, where both groups scored higher in the recognition phase than in the learning and testing phases. Both groups of participants performed similarly, with low working memory scores in both groups. However, the retention results from the learning and the testing phases can be questioned since the scores of the integrated testing phase were lower than the integrated learning phase. This will be discussed in Section 4.2.

In the following section, results from the listening phase will be presented.

4.1.2 Experiment 2: Listening (Integrated task and split-attention task)

In this experiment, the same eighty students participated in the listening task. Forty-one students were in the integrated group and thirty-eight students were in the split-attention group. The two groups were required to learn from listening with two different types of presentation – the integrated task and the split-attention effect task. They participated in the following phases.

Phase 1: Learning phase

The integrated group listened to a text which was stopped after each of ten comprehension questions. In other words, students in group 1 listened to a paragraph and answered each question. The process continued until all the ten comprehension questions were completed. The split-attention group (group 2) listened to a similar listening text, but to the entire text once and then answered the ten comprehension questions all at once. This is to test the following hypothesis:

H_{1b}: Integrated listening results in better retention than split-attention listening.

An independent-samples t-test was used to compare the learning data with the integrated listening task and the split-attention listening task. The following table shows the results.

Table 4.2a. *Learning phase results of listening*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Listening learning phase	Integrated (N = 41)	6.10	1.786	4.561	77	0.00*	1.02
	Split-attention (N = 38)	4.16	1.994				

* Significant level at p < 0.01; ** Significant level at p < 0.05

Table 4.2a shows a statistically significant difference in the learning results between the integrated listening task (M = 6.10, SD = 1.79) and the split-attention listening task (M = 4.16, SD = 1.99, conditions; $t(77) = 4.561$, $p = 0.00$, $d = 1.02$). The results suggest that there was a positive effect on Thai EFL learners' information retention when they listened during the integrated task. Especially, students retained the listening information to a greater extent when they listened for a few pieces of information and answered the questions immediately after each paragraph of text. This is due to the result of Cohen's *d* with 1.02. The hypothesis H_{1b} is accepted.

<u>*Phase 2: Testing phase*</u>

After a week of learning from listening, both groups of participants were required to answer the same ten comprehension questions as presented in the learning phase, without referring to the listening text. An independent-samples t-test was computed to compare the results of testing listening between the integrated listening group and the split-attention listening group to test long-term retention. The results could be found below.

Table 4.2b. *Testing phase results of listening*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Listening testing phase	Integrated (N = 41)	3.85	1.944	1.928	77	0.057	0.46
	Split-attention (N = 38)	3.11	1.448				

* Significant level at p < 0.01; ** Significant level at p < 0.05

Table 4.2b shows no statistically significant difference on the scores of testing listening between the integrated listening group (M = 3.85, SD = 1.94) and the split-attention listening group (M

= 3.11, SD = 1.45, conditions; $t(77) = 1.928$, $p > 0.05$, $d = 0.46$). When we measured closely at the *p* value, the scores of the integrated task variable were somewhat higher than the split-attention variable (with Cohen's $d = 0.46$). However, both variables revealed low average scores, with the average of 3.85 in the integrated group and 3.11 in the split-attention group. This means that students in both groups did not retain the listening information. Even though the integrated group obtained a little bit more information than the split-attention effect group, it was not significant, and the hypothesis H_{1b} is rejected in the testing phase.

Phase 3: Recognition phase

A recognition test of ten true-false questions concerning the listening text was designed and tested with both groups of participants one week after the testing phase. An independent-samples t-test was performed to compare the scores on the recognition test of the integrated listening group and the split-attention group. The following are the results.

Table 4.2c. *Recognition phase results of listening*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Listening recognition phase	Integrated (N = 41)	6.63	1.4275	-1.032	77	0.305	0.23
	Split-attention (N = 38)	6.97	1.5111				

* Significant level at p < 0.01; ** Significant level at p < 0.05

As can be seen from Table 4.2c, there was no statistically significant difference in the scores of recognition test between the integrated group (M = 6.63, SD = 1.43) and the split-attention listening group (M = 6.97, SD = 1.51, conditions; $t(77) = -1.032$, $p > 0.05$, $d = 0.23$). Students learning from both types of text presentations recognised the listening information equally well (with a small amount of standard deviation difference at Cohen's $d = 0.23$). Also, the types of text presentations did not affect them in recognising listening information. We can note here that the recognition scores of both group were higher than those in the learning and testing phases. We will return to this in section 4.2.

After the recognition task, the eighty students were required to write the last words of all the recognition sentences in the reading span task working memory test. An independent-samples t-test was used to compare the results of recognition task between the integrated listening group and the split-attention group.

Table 4.2d. *Reading span results of listening*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Reading span task	Integrated (N = 41)	2.63	1.6697	0.743	77	0.460	0.28
	Split-attention (N = 38)	2.37	1.4777				

* Significant level at p < 0.01; ** Significant level at p < 0.05

The results in Table 4.2d show no statistical difference in the scores of reading span between the integrated listening group (M = 2.63, SD = 1.67) and the split-attention listening group (M = 2.37, SD = 1.48, conditions; $t(77) = 0.743$, $p > 0.05$, $d = 0.28$). The groups of learners were not different in terms of working memory.

In summary, when the two groups of students participated in the listening task, those in the integrated listening group initially retained information from the listening text fairly better than those in the split-attention group in the learning phase. When they were measured by the recognition task and the reading span task, there were no statistical differences in the score results. This means that the cognitive load variable of integrated task in listening helped learners retain listening information better than the split-attention variable in the learning phase. However, neither types of cognitive load variables helped participants to retain and recognise listening information in the testing and the recognition phases since there were no statistically significant differences in the testing and the recognition phases. So, the hypothesis H_{1b} is accepted in the learning phase, but rejected in the testing and recognition phases. The results of the working memory test also yielded that both groups of participants employed almost full capacity of working memory similarly as the scores of the reading span tasks were low in both groups. Interestingly, the recognition scores of both groups in Phase 3 were higher than both the learning and testing phases. We will return to this in Section 4.2.

At this point in discussion, it is interesting that both types of cognitive load variables helped Thai EFL learners to retain information at the same extent in the testing phase. However, the question of why scores of recognitions from both groups of participants were higher than those in the learning and the testing phases needs to be addressed. This will further be discussed in Section 4.2.

In the following section, results on the third experiment will be discussed.

4.1.3 Experiment 3: Listening-reading (Modality task and redundancy task)

In this study, the same seventy-nine students participated in the listening-reading task. Forty-one students were grouped into the modality effect task (group 1), and the thirty-eight students were in the redundancy effect task (group 2). They participated in the following phases.

Phase 1: Learning phase

Students in the modality effect group were asked to listen to the text and, at the same time, to study a diagram summary of the text. After that, they were required to answer ten comprehension questions based on the text. The students in the redundancy effect group listened to the same listening text and read the listening script while listening. Afterwards, both groups of participants handed in their diagram summary and their listening script and answered the same ten comprehension questions. The hypothesis for this test is:

> *H_{1c}: Modality listening-reading results in better retention than redundancy listening-reading.*

An independent-samples t-test was used to compare the learning scores of students in the modality group and those in the redundancy effect group. The following table shows the results.

Table 4.3a. *Learning phase results of listening-reading*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Listening-reading learning phase	Modality (N = 41)	3.12	1.584	1.586	77	0.117	0.36
	Redundancy (N = 38)	2.55	1.606				

* Significant level at p < 0.01; ** Significant level at p < 0.05

As Table 4.3a demonstrates, there was no statistical difference in the scores of learning between students learning from the modality task (M = 3.12, SD = 1.58) and those from the redundancy task (M = 2.55, SD = 1.61, conditions; $t(77) = 1.586$, $p > 0.05$, $d = 0.36$). When students were exposed to the same listening text with different variables of reading presentation, i.e. the graphic summary and the listening scripts, both groups of students retained the listening information with no statistical difference, even though those in the modality group scored fairly higher than those in the redundancy group. The hypothesis H_{1c} is rejected in the learning phrase.

Phase 2: Testing phase

In the testing phase, both groups were required to answer the same ten comprehension questions as presented in the learning phase, without listening again. They were required to write short answers for the same questions used in the learning phase, and the following are the results.

Table 4.3b. *Testing phase results of listening-reading*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Listening-reading testing phase	Modality (N = 41)	3.56	2.025	4.177	77	0.00*	0.95
	Redundancy (N = 38)	1.89	1.448				

* Significant level at p < 0.01; ** Significant level at p < 0.05

An independent-samples t-test was used to compare the testing scores of the two groups. It was found that there was a statistically significant difference in the score of testing listening-reading between students in the modality group (M = 3.56, SD = 2.03) and those in the redundancy effect group (M = 1.89, SD = 1.45, conditions; $t(77) = 4.18$, $p = 0.00$, $d = 0.95$). Students who were exposed to the modality effect task retained the listening information significantly better than those in the redundancy group in the testing phase (Cohen's $d = 0.95$), although both groups obtained low scores in the testing task. The hypothesis H_{1c} is accepted in the testing phase.

Phase 3: Recognition phase

After this two-phase experiment, both groups took the recognition task, where they were asked to rate ten statements concerning the listening text as true or false. An independent-samples t-test was used to compare the recognition scores between the two groups, and the following table shows the results.

Table 4.3c. *Recognition phase results of listening-reading*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Listening-reading recognition phase	Modality (N = 41)	7.59	1.596	2.578	77	0.012**	0.59
	Redundancy (N = 38)	6.66	1.599				

* Significant level at p < 0.01; ** Significant level at p < 0.05

As can be seen from Table 4.3c, there was a statistically significant effect on the recognition scores between students in the modality effect group (M = 7.59, SD = 1.60) and those in the redundancy effect group (M = 6.66, SD = 1.60, conditions; $t(79) = 2.578$, $p < 0.05$, $d = 0.59$). These learners who learnt from the modality task of listening-reading retained information significantly better than those learning from the redundancy task. Also, the standard deviation difference between the two groups was high since the Cohen's *d* was at 0.59, which means the two groups performed differently at a large extent. It is also interesting to note that the recognition scores of both modality and redundancy groups were higher than those in the learning and testing phases. We will return to this in section 4.2.

When the recognition task was completed, participants were tested with the reading span task to measure their working memory. Both groups had to write the last words of all the recognition sentences. The results are as follows.

Table 4.3d. *Reading span results of listening-reading*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Reading span task	Modality (N = 41)	3.51	2.215	-2.111	77	0.038**	0.47
	Redundancy (N = 38)	4.63	2.498				

* Significant level at p < 0.01; ** Significant level at p < 0.05

An independent-samples t-test was used to compare scores of the reading span task, and it was found that there was a statistically significant difference between students in the modality group (M = 3.51, SD = 2.22) and those in those in the redundancy effect group (M = 4.63, SD = 2.5, conditions; $t(77) = -2.111$, $p < 0.05$, $d = 0.47$). This indicates that participants learning from the modality task employed more working memory capacity than those from the redundancy task, even though both groups obtained low scores in the reading span task. This means that students in the redundancy group had more working memory capacity left than the modality group, even though they scored lower than the redundancy group in the recognition task.

In summary, in the learning phase of listening-reading, the modality and the redundancy effect variables did not play a role in helping students retain listening information significantly. However, the statistical evidence of retention in the testing phase and in the recognition phase appeared to support the modality variable more than the redundancy effect variable, even though there was more working memory capacity left in the redundancy effect group than the modality group. So, the hypothesis H_{1c} is accepted in the testing and recognition phases.

Although the modality effect variable helped Thai EFL learners retain listening information in the testing and recognition phases, the scores of both testing and recognition phases were quite different in that the testing score was quite low, compared to a higher score in the recognition phase. Also, the working memory test reported contradictory results, even though the modality effect group performed better than the redundancy group in both testing and recognition phases. This will further be discussed in the following section.

4.2 Cognitive load effects on information retention and recognition

In this section, scores of information retention and recognition through different cognitive load effects in Experiments 1, 2 and 3 were retested with paired t-tests. This is to explore explicitly whether participants in each group could retain information after learning and being tested in each cognitive load variable. Scores from learning and testing phases, learning and recognition phases, testing and recognition phases, and recognition task and reading span task working memory were compared.

4.2.1 Cognitive load variables on reading

Data was drawn from Tables 4.1a, 4.1b and 4.1c. Each cognitive load variable on reading, i.e. integrated task and split-attention task, was tested to measure participants' retention in learning, testing and recognition phases. Tables 4.4a and 4.4b illustrate the results.

Table 4.4a. *Paired t-tests on learning, testing, recognition and reading span phases of integrated reading*

Tests and phases in integrated reading	***N***	***Mean***	***SD***
Phase 1: Learning results	40	7.88	1.017
Phase 2: Testing results	40	5.08	1.886
Phase 3: Recognition results	40	7.10	1.429
Phase 3: Reading span task	40	2.10	1.194

CORRELATION TESTS

Correlation tests	*r*	*p-value*
Learning vs testing	-0.035	0.830
Learning vs recognition	0.115	0.630
Testing vs recognition	0.330	0.037**
Recognition vs reading span task	-0.036	0.825

* Significant level at $p < 0.01$; ** Significant level at $p < 0.05$

PAIRED T-TESTS

Paired t-tests	*t*	*p-value*	*Cohen's d*
Learning vs testing	8.144	0.000*	1.85
Learning vs recognition	2.960	0.005*	0.63
Testing vs recognition	-6.553	0.000*	1.21
Recognition vs reading span task	16.690	0.000*	3.80

* Significant level at $p < 0.01$; ** Significant level at $p < 0.05$

As can be seen from Table 4.4a, in correlation tests, there were no correlations between learning and testing, learning and recognition and recognition and reading span task, but testing and recognition was found to be significantly related. This means that there is a relationship between testing and recognition, especially in terms of short-term and long-term retention. However, the prediction of testing to directly affect recognition cannot be implied here since the correlation tests only inform us about the relationship between two variables (Larson-Hall, 2012, Woodrow, 2014).

To predict the causal relation between two variables within the same group, the paired t-tests were used. As Table 4.4a indicates, there was a statistically significant effect between learning from the integrated reading (M = 7.88, SD = 1.02) and testing it (M = 5.08, SD = 1.89, conditions; $t(39) = 8.14$, $p < 0.01$, $d = 1.85$). In other words, no group of learners retained reading information significantly after learning from the integrated reading task. Similarly, the results of recognition after learning from the integrated reading were statistically lower ($t(39) = 2.96$, $p < 0.01$, $d = 0.63$), but the recognition of reading information after testing information from the integrated reading task was statistically significantly higher ($t(39) = -6.55$, $p < 0.01$, $d = 1.21$). The results revealed that, after learning from an integrated reading task, the learners could not significantly retain and recognise information. However, the results of recognition were better after they were tested after the testing phase, similar to the correlation tests.

The results of working memory after recognition revealed that there was a statistically significant difference between recognising reading information (M = 7.1, SD = 1.43) and working memory reading span task (M = 2.1, SD 1.19, conditions; $t(39) = 16.7$, $p < 0.00$, $d = 3.8$). This means that learners' cognitive demand on working memory capacity increased significantly after the recognition phase due to a low average score in the test. This means that there is an effect of memory depletion in an immediate test as predicted by Sweller (2019).

These statistics show that the integrated reading task did not help learners to retain and recognise information. However, there is a direct relationship between testing and recognition, in that testing was found to directly cause learners to recognise information significantly (as found in the paired t-tests). The higher score of recognition test in the integrated reading also confirms the delayed test effect as Sweller (2019) postulated it to measure working memory resources from learning from cognitive load effects. However, learners' demands on their working memory capacity increased significantly after the recognition phase since the scores of working memory were very low.

In the next section, the results of split-attention reading will be reported.

Table 4.4b. *Paired t-tests on learning, testing, recognition and reading span phases of split-attention reading*

Tests and phases in split-attention reading	***N***	***Mean***	***SD***
Phase 1: Learning results	35	4.80	1.795
Phase 2: Testing results	35	3.91	1.597
Phase 3: Recognition results	35	7.43	1.577
Phase 3: Reading span task	35	2.57	1.357

CORRELATION TESTS		
Correlation tests	***r***	***p-value***
Learning vs testing	0.578	0.000*
Learning vs recognition	0.187	0.282
Testing vs recognition	0.085	0.627
Recognition vs reading span task	-0.198	0.253

* Significant level at p < 0.01; ** Significant level at p < 0.05

PAIRED T-TESTS			
Paired t-tests	***t***	***p-value***	***Cohen's d***
Learning vs testing	3.343	0.002*	0.52
Learning vs recognition	-7.210	0.000*	1.56
Testing vs recognition	-9.683	0.000*	2.22
Recognition vs reading span task	15.406	0.000*	3.30

* Significant level at p < 0.01; ** Significant level at p < 0.05

Table 4.4b reveals that, in the correlation tests, there was only a significant correlation between learning and testing. This means that there is only a relationship in retention between learning and testing, but what really happens in the prediction of retention and recognition based on split-attention reading needs the results from the paired t-tests as follows.

In the paired t-test analysis, there was a statistically significant difference in the retention scores between learning from the split-attention task (M = 4.80, SD = 1.79) and testing it (M = 3.91, SD = 1.60, conditions; $t(34) = 3.34$, $p < 0.01$, $d = 0.52$). This means that learners did not retain reading information from the split-attention task after learning. However, with the acceptance of significant level at $p < 0.01$, they could recognise information from the split-attention reading task after learning from the task and being tested in the testing phase ($t(34) = -7.21$, $d = 1.56$ and $t(34) = -9.68$, $d = 2.22$, respectively). This means that both learning and testing caused learners to recognise information significantly.

In terms of working memory test, there was a statistically significant difference between the recognition scores (M = 7.43, SD = 1.58) and the working memory reading span task (M = 2.57, SD = 1.36, conditions; $t(34) = 15.41$, $p < 0.01$, $d = 3.30$). This means that learners' demands on their working memory capacity increased significantly after the recognition phase due to a low working memory average score.

Similarly to the integrated group, learners in the split-attention reading retained and recognised information after learning from the split-attention reading task and being tested in the testing phase. However, memory demands increased significantly after the recognition phase because of the low average score in the reading span task. It was found that both integrated reading task and split-attention task did not help the learners to retain reading information in learning and testing phases. However, the recognition paired t-tests revealed that the split-attention group recognised reading information to a greater extent from both learning and testing phases, whereas the integrated group only recognised reading information after being tested in the testing phase. The results of both groups confirm that there is an effect of immediate working memory depletion as the results of reading span tasks were not statistically significant compared to the recognition tests. Yet, the higher recognition results of both integrated and split-attention groups mean that delayed post-tests were efficient to test capture WM resources after learning and/or testing, confirming the recent development of Cognitive Load Theory.

To combine elements of Cognitive Load Theory with Working Memory, another tests of reading paired t-tests against the RAVLT WM pre-test will be presented here.

Table 4.4c. *Paired t-test between RAVLT WM tests and cognitive load in integrated and split-attention reading*

Tests	***N***	***Mean***	***SD***	***t***	***Cohen's d***	***Sig***
Integrated Reading						
RAVLT WM pre-test vs Experiment results	RAVLT (N = 40)	9.58	1.647			
	Learning phase	7.88	1.005	5.895	1.246	0.000*
	Testing phase	5.08	1.886	11.669	2.541	0.000*
	Recognition phase	7.10	1.429	7.681	1.608	0.000*
Split-attention Reading						
RAVLT WM pre-test vs Experiment results	RAVLT (N = 35)	8.63	1.516			
	Learning phase	4.80	1.795	10.609	2.305	0.000*
	Testing phase	3.91	1.597	13.689	3.031	0.000*
	Recognition phase	7.43	1.577	4.234	0.775	0.000*

* Significant level at $p < 0.01$; ** Significant level at $p < 0.05$

We can see from Table 4.4c that learners' WM verbal resources (as RAVLT tests the central executive and phonological loops in WM) had direct effects on learning, testing and recognition when they participated in either integrated or split-attention reading. This means that WM plays a role in reading from both types of cognitive load, i.e. integrated and split-attention tasks. This will further be explored in Section 4.4, concerning learners' mental efforts.

It is interesting from the results that in independent samples t-test between the integrated and split-attention tasks, the integrated group outperformed the split-attention in both learning and testing reading, and the hypothesis H_{1a} was accepted (see Section 4.1.1), but within each group, the results of learning and testing were contradictory. In other words, both integrated and split-attention tasks could not help learners to retain information significantly better from learning and testing phases. However, both groups of learners significantly recognised information from either integrated or split-attention reading. This needs to be explored in detail through the qualitative analysis.

In the next section, cognitive load effects on listening will be analysed.

4.2.2 Cognitive load effects on listening

In Section 4.1.2, the hypothesis H_{1b} was accepted only in the learning phase, i.e. integrated listening resulted in better retention than the split-attention listening in the learning phase. In this section, data drawn from Tables 4.2a, 4.2b and 4.2c were recalculated to measure participants' listening retention from each cognitive load variable. Tables 4.5a and 4.5b presented the results.

Table 4.5a. *Paired t-tests on learning, testing, recognition and reading span phases of integrated listening*

Tests and phases in integrated listening	***N***	***Mean***	***SD***
Phase 1: Learning results	39	6.10	1.786
Phase 2: Testing results	39	3.85	1.943
Phase 3: Recognition results	39	6.63	1.427
Phase 3: Reading span task	39	2.63	1.427

CORRELATION TESTS		
Correlation tests	***r***	***p-value***
Learning vs Testing	0.527	0.001*
Learning vs recognition	-0.180	0.272
Testing vs recognition	0.012	0.943
Recognition vs reading span task	0.086	0.601

* Significant level at p < 0.01; ** Significant level at p < 0.05

PAIRED T-TESTS			
Paired t-tests	***t***	***p-value***	***Cohen's d***
Learning vs testing	7.505	0.000*	1.20
Learning vs recognition	-1.391	0.172	0.33
Testing vs recognition	-7.120	0.000*	1.63
Recognition vs reading span task	12.438	0.000*	2.58

* Significant level at p < 0.01; ** Significant level at p < 0.05

The correlational analysis presented in Table 4.5a demonstrates that there was only a relationship in retention between learning and testing, but to test whether there is a direct causal relationship between the two variables, the paired t-tests were used.

As can be seen in Table 4.5a, there was a statistically significant difference in the retention scores between learning from the integrated listening task (M = 6.1, SD = 1.79) and testing it (M = 3.85, SD = 1.94, conditions; $t(40) = 7.51$, $p < 0.01$, $d = 1.2$). This means that learners did not retain information significantly better after learning from the integrated listening task. The results show that integrated listening caused learners to significantly lose information from the learning to the testing task, confirming the immediate test effects as predicted in Sweller (2019).

In terms of recognising information from the integrated listening task, it was found that there was no statistically significant effect between recognising information (M = 6.63, SD = 1.43) and learning from the integrated listening task (M = 6.10, SD = 1.79, conditions; $t(38) = -1.391$, $p > 0.01$, $d = 0.33$). This means that learners retained and recognised the listening information from the integrated listening task to the same extent, but after they were exposed to the information through the testing phase, they recognised the listening information to a greater extent (Cohen's $d = 1.63$) at the significant level at $p < 0.01$. Evidence of delayed test effect for capturing learners' WM resources (Sweller, 2019) was confirmed in the recognition test.

As for working memory capacity, it was found that there was a statistically significant difference between recognising listening information (M = 6.63, SD = 1.42) and the working memory reading span task (M = 2.63, SD = 1.66; $t(38) = 12.348$, $p < 0.01$, $d = 2.58$). This means that learners' working memory demands increased significantly after the recognition phase due to a low average score in the reading span task, confirming the immediate test effects to deplete WM resources as predicted in Sweller (2019).

Learners did not retain listening information from the integrated listening task, but they recognised the information to the same extent after learning from the integrated listening task, and also recognised the information after being tested in the testing phase. In terms of memory load, the capacity demands increased significantly after the participants recognised the listening information.

As Table 4.5b shows, there was a correlation between learning and testing and testing and recognition in the split-attention listening. This means that there was a relationship when learners learnt and were tested, and also when being tested and recognising listening. This will further be tested in the paired t-tests below.

In paired t-tests of the split-attention listening, there was a statistically significant difference in the retention results between learning information from the split-attention task (M = 4.27, SD = 1.84) and testing it (M = 3.47, SD = 1.33, conditions; $t(29) = 2.398$, $p < 0.05$, $d = 0.50$). This means that learners did not retain the listening information after learning from the split-attention listening task. When it comes to recognising the listening information, learners recognised the information significantly after learning from the split-attention listening task and being tested in the testing phase ($t(29) = -7.43$, $d = 1.76$ and $t(36) = -17.77$, $d = 2.66$, $p < 0.01$, respectively).

In terms of working memory capacity, there was a statistically significant effect between recognition (M = 7.03, SD = 1.48) and working memory reading span task (M = 2.32, SD = 1.49, conditions; $t(36) = 13.496$, $p < 0.01$, $d = 3.17$). This means that the working memory capacity of learners' demands increased significantly after the recognition phase (due to low working memory scores), confirming the WM depletion effects from immediate tests postulated by Sweller (2019).

Table 4.5b. *Paired t-tests on learning, testing, recognition and reading span phases of split-attention listening*

Tests and phases in split-attention listening	***N***	***Mean***	***SD***
Phase 1: Learning results	30	4.27	1.837
Phase 2: Testing results	30	3.47	1.332
Phase 3: Recognition results	30	7.17	1.440
Phase 3: Reading span task	30	2.32	1.490

CORRELATION TESTS		
Correlation tests	***r***	***p-value***
Learning vs Testing	0.370	0.044**
Learning vs recognition	0.165	0.383
Testing vs recognition	0.586	0.000*
Recognition vs reading span task	-0.017	0.922

* Significant level at p < 0.01; ** Significant level at p < 0.05

PAIRED T-TESTS			
Paired t-tests	***t***	***p-value***	***Cohen's d***
Learning vs testing	2.40	0.023**	0.50
Learning vs recognition	-7.42	0.000*	1.76
Testing vs recognition	-17.77	0.000*	2.66
Recognition vs reading span task	13.50	0.000*	3.17

* Significant level at p < 0.01; ** Significant level at p < 0.05

Learners did not significantly retain the listening information from the split-attention listening task, but they recognised the information after learning from the split-attention listening task, or even being tested in the testing phase. Also, participants' memory capacity demands increased significantly after the recognition phase. This means that, in split-attention listening, the immediate test effects caused WM to deplete, but, in terms of recognition, the delayed test effects proved that there was evidence in terms of learners' long-term recognition when they learnt from split-attention listening.

Although it was found in Section 4.1.2 that integrated listening resulted in better retention than split-attention listening in the learning phase, neither the integrated nor the split-attention listening tasks helped learners to retain listening information from the learning phase to the testing phase. As for the integrated listening variable, participants recognised listening information to the same extent after learning it, but they recognised the information better after they were tested. However, participants in the split-attention group recognised listening information better after both learning it and being tested. Learners' abilities to recognise listening information from both the integrated and split-attention tasks confirm that delayed test effects postulated by Sweller (2019), but the underlying reasons why both groups of learners recognised the listening information at the same extent will be discussed in the qualitative analysis.

To further test if WM plays a role in learning, testing and recognising listening information, the following paired t-tests against RAVLT WM pre-tests will be discussed.

Table 4.5c. *Paired t-test between RAVLT WM tests and cognitive load in integrated and split-attention listening*

Tests	***N***	***Mean***	***SD***	***t***	***Cohen's d***	***Sig***
Integrated listening						
RAVLT WM pre-test vs Experiment results	RAVLT (N = 39)	7.21	1.936			
	Learning phase	6.10	1.786	2.943	0.596	0.005*
	Testing phase	3.82	1.985	9.843	1.729	0.000*
	Recognition phase	6.62	1.462	1.714	0.344	0.095
Split-attention listening						
RAVLT WM pre-test vs Experiment results	RAVLT (N = 37)	5.81	1.431			
	Learning phase	4.16	1.994	4.245	0.950	0.000*
	Testing phase	3.11	1.468	7.087	1.862	0.000*
	Recognition phase	7.03	1.481	-3.889	0.838	0.000*

* Significant level at $p < 0.01$; ** Significant level at $p < 0.05$

As Table 4.5c demonstrates, learners' WM from both groups of integrated and split-attention listening had direct effects on learning and testing results. However, in terms of recognition, WM resources in the split-attention listening caused learners in this group to recognise information significantly, but not in the integrated listening group. A mismatch between WM prediction and test results on learners' information recognition in the integrated listening may possibly be explained by different learning conditions, which will further be explored in Section 4.4 and qualitative enquiry.

In the next section, cognitive load effects on listening-reading will be discussed.

4.2.3 Cognitive load effects on listening-reading

In section 4.1.3, modality listening+reading resulted in better retention than redundancy listening+reading in the testing phase, partially accepting the hypothesis H_{1c}. In this section, paired t-tests were performed on listening+reading learning, testing and recognition phases to measure learners' information retention from each cognitive load variable (data drawn from Tables 4.3a, 4.3b and 4.3c). The following tables show the results.

Table 4.6a. *Paired t-tests on learning, testing, recognition and reading span phases of modality*

Tests and phases in modality listening-reading	***N***	***Mean***	***SD***
Phase 1: Learning results	36	3.03	1.61
Phase 2: Testing results	36	3.67	2.12
Phase 3: Recognition results	36	7.72	1.56
Phase 3: Reading span task	36	3.18	1.94

CORRELATION TESTS

Correlation tests	***r***	***p-value***
Learning vs Testing	0.687	0.000*
Learning vs recognition	0.514	0.001*
Testing vs recognition	0.456	0.003*
Recognition vs reading span task	0.109	0.505

* Significant level at p < 0.01; ** Significant level at p < 0.05

PAIRED T-TESTS

Paired t-tests	***t***	***p-value***	***Cohen's d***
Learning vs testing	-2.47	0.019**	0.34
Learning vs recognition	-18.01	0.000*	2.96
Testing vs recognition	-12.46	0.000*	2.11
Recognition vs reading span task	11.24	0.000*	2.44

* Significant level at p < 0.01; ** Significant level at p < 0.05

As Table 4.6a shows, there were correlations between learning and testing, learning and recognition and testing and recognition in the modality listening-reading. This means that the three variables were related, but the prediction of whether variant in one variable causes another to change needs the results of paired t-tests presented below.

As can be seed in table 4.6, there was a statistically significant difference in the retention results between learning from the modality listening-reading task (M = 3.03, SD = 1.61) and testing it (M = 3.67, SD = 2.12, conditions; $t(35) = -2.47$; $p < 0.05$, $d = 0.34$). This means that learners retained the listening information from the modality listening-reading task. Also, they recognised the information significantly after learning from the modality listening-reading task and being tested in the testing phase ($t(35) = -18.01$, $d = 2.96$ and $t(37) = -12.46$, $d = 2.11$, $p < 0.01$, respectively). This means that the immediate test effects did not occur in the modality task where both listening and pictures were presented to learners at the same time. Also, the higher scores of recognition over the learning and testing scores are still in question. These will further be explored in the qualitative analysis.

In terms of memory load, there was a statistically significant difference between the recognition score (M = 7.58, SD 1.65) and the working memory reading span task (M = 3.18, SD = 1.94, conditions; $t(37) = 11.24$, $p < 0.01$, $d = 2.44$). This means that participants' working memory demands increased significantly after the recognition phase due to a low reading span task score. The immediate test effect was confirmed here in terms of WM depletion (Sweller, 2019).

Learners retained the listening-reading information after learning from the modality listening-reading task and being tested in the testing phase since there was no statistical difference in learning and testing phases. Also, they recognised the listening+reading information after learning from the modality task and being tested in the testing phase. However, learners' working memory demands increased significantly after the recognition phase. This means that there seems to be a role of verbal and visual presentations on retention and recognition in the modality task where there is no immediate test effects, especially on verbal tests. This finding is also confirmed when there was a significant effect between reading span task and recognition results, which means that, in verbal tests, immediate test effects depleted WM resources.

In the next section, listening-reading retention information from the redundancy task will be discussed.

Table 4.6b. *Paired t-tests on learning, testing, recognition and reading span phases of redundancy effect*

Tests and phases in redundancy listening-reading	***N***	***Mean***	***SD***
Phase 1: Learning results	21	3.24	1.411
Phase 2: Testing results	21	2.57	1.434
Phase 3: Recognition results	21	7.19	1.250
Phase 3: Reading span task	21	4.73	2.672

CORRELATION TESTS		
Correlation tests	***r***	***p-value***
Learning vs Testing	0.325	0.151
Learning vs recognition	0.030	0.898
Testing vs recognition	0.380	0.029**
Recognition vs reading span task	0.104	0.564

* Significant level at p < 0.01; ** Significant level at p < 0.05

PAIRED T-TESTS			
Paired t-tests	***t***	***p-value***	***Cohen's d***
Learning vs testing	1.848	0.079	0.47
Learning vs recognition	-9.755	0.000*	2.95
Testing vs recognition	-18.40	0.000*	3.58
Recognition vs reading span task	4.708	0.000*	1.11

* Significant level at p < 0.01; ** Significant level at p < 0.05

As Table 4.6b shows, there was a correlation between testing and recognition in the redundancy task. However, to test the direct effect of testing on recognition, a paired t-test was used. In paired t-tests, there was no statistically significant effect in the retention scores between learning from the redundancy listening+reading task (M = 3.24, SD = 1.41) and testing it (M =

2.57, SD = 1.43, conditions; $t(20) = 1.848$, $p > 0.05$, $d = 0.47$). This means that learners did not retain the listening-reading information after learning from the redundancy listening-reading task. In terms of recognition, learners recognised the listening-reading information significantly after learning from the redundancy listening-reading task and being tested in the testing phase ($t(20) = -9.755$, $d = 2.95$ and $t(32) = -18.40$, $d = 3.58$, $p < 0.01$, respectively), which indicates the effective use of delayed tests as proposed by Sweller (2019). Concerning working memory capacity, learners' working memory demands increased significantly (M = 4.73, SD = 2.672, conditions; $t(32) = 4.708$, $p < 0.01$, $d = 1.11$) after the recognition phase. This means that there is an immediate test effect in terms of WM depletion as postulated by Sweller (2019).

Although there seems to be a direct causality from learning and testing on recognition in the redundancy effect, both learning and testing scores were lower in comparison to the recognition scores. This means that the statistical analysis cannot explain why the recognition scores were higher. We will turn to this in the qualitative analysis.

To test further if the WM resources of learners in the redundancy group affect their learning, testing and recognition, the following Table 4.6c describes the scenario.

Table 4.6c. *Paired t-test between RAVLT WM tests and cognitive load in modality and redundancy listening-reading*

Tests	***N***	***Mean***	***SD***	***t***	***Cohen's d***	***Sig***
Modality listening-reading						
RAVLT WM pre-test vs Experiment results	RAVLT (N = 38)	7.16	1.939			
	Learning phase	3.12	1.584	11.249	2.536	0.000*
	Testing phase	3.61	2.087	9.162	1.986	0.000*
	Recognition phase	7.58	1.654	-1.000	0.017	0.324
Redundancy listening-reading						
RAVLT WM pre-test vs Experiment results	RAVLT (N = 33)	5.82	1.489			
	Learning phase	2.55	1.606	8.556	2.111	0.000*
	Testing phase	2.00	1.521	9.662	2.538	0.000*
	Recognition phase	7.06	1.298	-3.232	0.888	0.003*

* Significant level at $p < 0.01$; ** Significant level at $p < 0.05$

As demonstrated in Table 4.6c, learners' WM resources in both groups directly affected learning and testing. However, in terms of WM verbal resources and recognition, there was only a direct causation between WM resources and information recognition of redundancy effect task, not in the modality task. This means that WM verbal resources did not show a direct cause to recognition in the modality effects. A possible explanation on this scenario could be because of different modalities registered in learners' memory, which will be explored in the qualitative analysis.

We can summarise in this section that learners did not retain the listening-reading information after learning from the redundancy listening-reading task, but they recognised the information at a significant level at $p < 0.01$ after learning in the learning phase and being tested in the testing phase. Also, the learners' working memory demands increased significantly after recognising the listening-reading information.

Participants who learnt from the modality listening-reading task retained information to the same extent from the learning to the testing phases. However, the redundancy task did not help learners to retain listening-reading information. These findings confirmed the acceptance of the Hypothesis H_{1c} that information retention from the modality effect was better than the redundancy effect. As for information recognition, both cognitive load variables helped participants to recognise information after both learning and testing phases (at the significant level at $p < 0.01$), but there seems to be no direct cause of WM on recognition from the modality task. This will be further explored in the qualitative analysis.

4.2.4 Summary of cognitive load effects

These three experiments show that learners did not retain or recall listening and/or reading information significantly after learning from five different cognitive load tasks, except for the modality effect. However, they recognised information differently from different phases of experiments. As for information recognition from reading, they recognised reading information after being tested in the testing phase of integrated reading, but not after the learning phase. However, learners in the split-attention group better recognised reading information after learning and being tested. Learners' WM in both groups were found to directly affect learning, testing and recognition tasks.

In terms of listening, although both groups using integrated and split-attention tasks could not retain listening information, learners recognised the listening information to the same extent after learning from the integrated listening task and after being tested in the testing phase. However, learners in the split-attention group recognised the listening information after learning and being tested. Learners' WM resources in the split-attention listening group directly affected their learning, testing and recognition, which is similar to those in the learning and testing in the integrated group. The only mismatch is that of WM resources on the recognition of integrated listening, which could further be explained in the qualitative analysis.

As for listening-reading, the learners retained and recognised the listening+reading information after learning from the modality task and being tested in the testing phase. However, learners from the redundancy group did not retain listening+reading information any better, but they recognised the listening-reading information after learning from the redundancy task and being tested in the testing phase. Learners' WM resources in both groups directly affected learning and testing, but they did not affect the modality recognition. This will further be explored in the qualitative part.

Modified instructional materials based on cognitive load effects did not help the learners in retaining listening, reading and listening+reading information, except for modality listening-reading. However, they recognised information at the significant level after learning from materials and being tested in later phases. This means that learners processed reading, listening and listening-reading information which could be explained by WM resources, but not in the cases of integrated listening and modality listening. This will be studied in the qualitative part.

In the next section, a comparative analysis of cognitive load effects on different stages of experiment phases will be discussed.

4.3 Comparison of supportive and hindering cognitive load effects

In this section, scores of information retention through different cognitive load effects in each research stage will be presented. Modified instructional materials in terms of integrated and modality formats are discussed, followed by split-attention and redundancy formats. This is to answer research question 2 on what kind of modified materials best supports students' language learning. Tables 4.4a, 4.5a and 4.6a were compared using the ANOVA analysis to test the following hypothesis:

> H_{2a}: *In supportive cognitive load, integrated reading supports learning more than integrated listening and modality listening-reading.*

Tables 4.4b, 4.5b and 4.6b were compared using the ANOVA analysis to test the following hypothesis:

H_{2b}: In hindering cognitive load, split-attention reading supports learning more than split-attention listening and redundancy listening-reading.

4.3.1 Integrated and modality variables

As integrated and modality cognitive load effects were regarded as supportive variables in reducing cognitive load during learning, data drawn from group 1 learners' learning, testing and recognition scores were compared to measure retention results. The three-phase scores of supportive variable within group on reading, listening and listening+reading were compared by employing a one-way subjects ANOVA. In the following table, a comparison of scores from learners learning from the integrated tasks (in reading and listening) and the modality task (in listening-reading task) will be presented.

Table 4.7a. *Comparison of information retention scores among reading, listening and listening-reading in the integrated and modality groups*

Phases	***N***	***Mean***	***SD***	***F***	***df***	***Sig***	η^2
Learning	Exp1: Reading (N=41) Exp2: Listening (N=41) Exp3: L-R (N=41)	7.88 6.10 3.12	1.005 1.786 1.584	105.849	2	0.00*	0.638
Testing	Exp1: Reading (N=40) Exp2: Listening (N=41) Exp3: L-R (N=41)	5.08 3.85 3.56	1.886 1.944 2.025	6.821	2	0.002*	0.103
Recognition	Exp1: Reading (N=40) Exp2: Listening (N=41) Exp3: L-R (N=41)	7.10 6.63 7.59	1.429 1.428 1.596	4.196	2	0.017**	0.066

* Significant level at p < 0.01; ** Significant level at p < 0.05

As can be seen from the above table, there were statistically significant effects of information retention at p = 0.00 in the learning phase [$F(2, 2.24) = 105.849$, $p < 0.05$, $\eta^2 = 0.638$], the testing phase [$F(2, 3.82) = 6.821$, $p < 0.05$, $\eta^2 = 0.103$] and the recognition phase [$F(2, 2.21) = 4.196$, $p < 0.05$, $\eta^2 = 0.066$]. Learners under the integrated and modality modes of cognitive load retained information differently in different skills of the integrated tasks. A Tukey post hoc analysis was performed to compare these.

Table 4.7b. *Tukey HSD post hoc analysis of reading, listening and listening+reading scores in the integrated and modality tasks*

Dependent Variable	***(I) Experiment Group***	***(J) Experiment Groups***	***Mean Difference (I-J)***	***Std. Error***	***Sig.***
Learning	Experiment 1: Reading	Experiment 2: Listening	1.780*	.330	.000
		Experiment 3: Listening+Reading	4.756*	.330	.000
	Experiment 2: Listening	Experiment 1: Reading	-1.780*	.330	.000
		Experiment 3: Listening+Reading	2.976*	.330	.000
	Experiment 3: Listening+Reading	Experiment 1: Reading	-4.756*	.330	.000
		Experiment 2: Listening	-2.976*	.330	.000
Testing	Experiment 1: Reading	Experiment 2: Listening	1.221**	.434	.016
		Experiment 3: Listening+Reading	1.514*	.434	.002
	Experiment 2: Listening	Experiment 1: Reading	-1.221**	.434	.016
		Experiment 3: Listening+Reading	.293	.431	.776
	Experiment 3: Listening+Reading	Experiment 1: Reading	-1.514*	.434	.002
		Experiment 2: Listening	-.293	.431	.776
Recognition-Reading	Experiment 1: Reading	Experiment 2: Listening	.466	.330	.339
		Experiment 3: Listening+Reading	-.485	.330	.310
	Experiment 2: Listening	Experiment 1: Reading	-.466	.330	.339
		Experiment 3: Listening+Reading	-.951**	.328	.012
	Experiment 3: Listening+Reading	Experiment 1: Reading	.485	.330	.310
		Experiment 2: Listening	.951**	.328	.012

* Significant level at $p < 0.01$; ** Significant level at $p < 0.05$

Note: (I) Experiment Group is considered an independent variable leading to its variance in another variable, i.e. (J) Experiment Groups.

As both Tables 4.7a and 4.7b show, in the learning phase, the scores of information retention were significantly lower after integrated listening (M = 6.10, SD = 1.79, p = 0.00) and modality listening+reading (M = 3.12, SD = 1.58, p = 0.00) when compared to integrated reading (M = 7.88, SD = 1, p = 0.00). This means that, under the integrated and modality tasks, learners retained information from the reading task better than from the other two tasks. So, the hypothesis H_{2a} is accepted in the learning phase.

In the testing phase, the scores of information retention were significantly lower after integrated listening (M = 3.85, SD = 1.94, p = 0.016) and modality listening-reading (M = 3.56, SD = 2.03, p = 0.002) compared to integrated reading (M = 5.08, SD = 1.89). However, the scores were not statistically different between listening and listening+reading ($p > 0.05$) in the testing phase. This means that, under the integrated and modality tasks, learners retained information from the integrated reading task better than from the other two tasks. There was no difference in information retention when students were tested against integrated listening and modality listening-reading. Again, the hypothesis H_{2a} is accepted in the testing phase.

When it comes to the recognition phase, there was no statistically significant difference in scores in integrated listening (M = 6.63, SD = 1.43, p = 0.339) and modality listening-reading (M = 7.59, SD = 1.60, p = 0.310) when compared to integrated reading (M = 7.71, SD = 1.43). When the scores of listening and listening-reading were compared, however, the scores were significantly lower in integrated listening (M = 6.63, SD =1.43, p = 0.012) compared to modality listening-reading (M = 7.71, SD 1.43).

We can conclude that students in the learning phase who were exposed to the integrated and modality task retained information better in the reading task. A similar result in the testing phase was found when comparing reading, listening and listening+reading. However, when they were tested in the recognition phase, they recognised information from listening+reading better than listening, but performed at a similar extent to reading. The hypothesis H_{2a} concerning the supportive learning effect of reading only on reading, listening and listening+reading is accepted.

In the next section, comparisons among scores of reading, listening and listening+reading in the split-attention and redundancy effects will be presented.

4.3.2 Split-attention and redundancy effects

This section includes a comparison of scores between split-attention and redundancy effects within group 2 under the conditions of reading (split-attention), listening (split-attention) and listening-reading (redundancy). Even though hindering cognitive load variables were predicted to result in inefficient learning, reading-only was hypothesised to be more beneficial on learning than listening and listening+reading. A one-way subjects ANOVA was computed to compare scores of information retention in different stages of learning, i.e. reading, listening, and listening-reading to test the following hypothesis:

> H_{2b}*: In hindering cognitive load, split-attention reading supports learning more than split-attention listening and redundancy listening-reading.*

The results are as follows.

Table 4.8a. *Comparison of information retention scores among reading, listening and listening-reading in the split-attention and redundancy groups*

Phases	***N***	***Mean***	***SD***	***F***	***df***	***Sig***	η^2
Learning	Exp1: Reading (N=35) Exp2: Listening (N=38) Exp3: L-R (N=38)	4.80 4.16 2.55	1.795 1.994 1.606	15.183	2	0.00*	0.219
Testing	Exp1: Reading (N=35) Exp2: Listening (N=38) Exp3: L-R (N=38)	3.91 3.11 1.89	1.597 1.448 1.448	16.915	2	0.000*	0.238
Recognition	Exp1: Reading (N=35) Exp2: Listening (N=38) Exp3: L-R (N=38)	7.43 6.97 6.66	1.577 1.498 1.599	2.244	2	0.111	0.040

* Significant level at p < 0.01; ** Significant level at p < 0.05

The Table 4.8a reveals statistically significant effects of information retention at p = 0.00 between the learning phase [$F(2, 111) = 15.182$, $p < 0.05$, $\eta^2 = 0.219$ and the testing phase [$F(2, 111) = 16.915$, $p < 0.05$, $\eta^2 = 0.238$]. However, there was no statistically significant difference in the scores of recognition ($p > 0.05$) compared to the learning and testing phases. The results reveal that the learners performed differently during learning and testing while they recognised information to the same extent after reading, listening and listening-reading under the redundancy format.

Taking this into consideration, a Tukey post hoc analysis was further used to compare different scores of different skills under the split-attention and redundancy formats.

Table 4.8b. *Tukey HSD post hoc analysis of reading, listening and listening-reading scores in the split-attention and redundancy tasks*

Dependent Variable	***(I) Experiment Group***	***(J) Experiment Groups***	***Mean Difference (I-J)***	***Std. Error***	***Sig.***
Learning	Experiment 1: Reading	Experiment 2: Listening	.642	.423	.287
		Experiment 3: Listening+Reading	2.247*	.423	.000
	Experiment 2: Listening	Experiment 1: Reading	-.642	.423	.287
		Experiment 3: Listening+Reading	1.605*	.414	.001
	Experiment 3: Listening+Reading	Experiment 1: Reading	-2.247*	.423	.000
		Experiment 2: Listening	-1.605*	.414	.001
Testing	Experiment 1: Reading	Experiment 2: Listening	.809	.351	.059
		Experiment 3: Listening+Reading	2.020*	.351	.000
	Experiment 2: Listening	Experiment 1: Reading	-.809	.351	.059
		Experiment 3: Listening+Reading	1.211*	.343	.002
	Experiment 3: Listening+Reading	Experiment 1: Reading	-2.020*	.351	.000
		Experiment 2: Listening	-1.211*	.343	.002
Recognition-Reading	Experiment 1: Reading	Experiment 2: Listening	.455	.365	.429
		Experiment 3: Listening+Reading	.771	.365	.092
	Experiment 2: Listening	Experiment 1: Reading	-.455	.365	.429
		Experiment 3: Listening+Reading	.316	.357	.652
	Experiment 3: Listening+Reading	Experiment 1: Reading	-.771	.365	.092
		Experiment 2: Listening	-.316	.357	.652

* Significant level at $p < 0.01$; ** Significant level at $p < 0.05$

Note: (I) Experiment Group is considered an independent variable leading to its variance in another variable, i.e. (J) Experiment Groups.

As can be seen from both Tables 4.8a and 4.8b, the retention scores were statistically significantly higher in reading (M = 4.80, SD = 1.795, $p = 0.00$) and listening (M = 4.16, SD =

1.99, $p = 0.001$) compared to listening-reading (M = 2.55, SD = 1.61). This means that learners retained information through the split-attention reading and listening tasks better than the redundancy listening-reading task. However, the one-way subjects ANOVA revealed no statistically significant difference in the retention scores between reading and listening ($p = 0.287$ under the conditions of split-attention and redundancy effects. As for the testing phase, there were statistically significantly lower retention scores between listening (M = 3.81, SD = 1.20, $p = 0.41$) and listening-reading (M = 1.89, SD = 1.45, $p = 0.00$) compared to reading (M = 3.91, SD = 1.60). Moreover, the retention scores of redundancy listening-reading format were significantly lower than those of the split-attention listening format at $p < 0.01$. So, the hypothesis H_{2b} is rejected in the learning phase, but accepted in the testing phase.

When it comes to the recognition phase, there was no statistically significant difference in the scores of reading, listening and listening-reading. This shows that learners recognised reading, listening and listening+reading to the same extent under the split-attention and redundancy effect conditions. The students retained more information in split-attention reading and listening than that in redundancy listening+reading task. These students also retained information better in split-attention reading than both split-attention listening and redundancy listening-reading when they were tested a week after learning. However, when they were tested in the recognition task, they recognised information to the same extent.

4.3.3 Summary of cognitive load effects on EFL reading, listening and listening-reading

For research question 1, from the results of three-phase experiments on cognitive load effects, it was found that learners retained information better when they read and listened in an integrated task, i.e. an integration of questions and relevant information in the passage. These students also retained information better from reading and listening than modality listening-reading in the testing phase. This implies that an integrated task in reading and listening helps enhance learners' retention of information better than split-attention task. In listening+reading, the modality task seems to have played some role in helping learners to retain information at a later stage. All of the hypotheses H_{1a}, H_{1b} and H_{1c} are accepted in different phases as follows:

Table 4.9a. *Summary of hypotheses H_{1a}, H_{1b} and H_{1c}*

Hypotheses	Learning phase	Testing phase
H_{1a}: Integrated reading results in better retention than split-attention reading.	√	√
H_{1b}: Integrated listening results in better retention than split-attention listening.	√	X
H_{1c}: Modality listening-reading results in better retention than redundancy listening-reading.	X	√

√ = accepted, X = rejected

Note also that learners' WM verbal resources in both groups, i.e. supportive and detrimental CL, had direct effects on learning and testing results in reading, listening and listening-reading. However, in terms of recognition, WM verbal resources were significantly related to integrated and split-attention reading, split-attention listening and redundancy listening. There were no direct causations between WM verbal resources and learners' recognition on integrated listening and modality listening-reading. This can be implied that cognitive load effects directly affected learning and testing results. However, recognition results with or without the use of WM had not been directly affected from CL effects, except for the modality task. This will further be explored in the qualitative section.

When it comes to the research question 2 of which cognitive load variable was best, the integrated task of reading helped learners retain information better, followed by the integrated task of listening and the modality task of listening-reading. Learners also learned from the split-attention reading and listening and the redundancy listening-reading task, but retention diminished after the learning phase. In terms of recognising information, learners recognised information to the same extent after they learnt from the integrated task and the split-attention task. However, they recognised information more after learning from the modality task than the redundancy task. The following table summarises Hypotheses H_{2a} and H_{2b}.

Table 4.9b. *Summary of hypotheses H_{2a} and H_{2b}*

Hypotheses	Learning phase	Testing phase
H_{2a}: In supportive cognitive load, integrated reading supports learning more than integrated listening and modality listening-reading.	√	√
H_{2b}: In hindering cognitive load, split-attention reading supports learning more than split-attention listening and redundancy listening-reading.	X	√

√ = accepted, X = rejected

At this point in discussion, it can be summarised that an integrated format of individual English skills enables learners to retain information better, while a split-attention effect is detrimental to information retention. Moreover, the modality format of the integrated listening-reading task enables learners to retain information after learning and in the recognition task better than a redundancy effect task.

In the following section, information concerning learners reporting their self-perceived cognitive load used during learning will be presented.

4.4 Subjective cognitive load report

In this section, average scores of each cognitive load type as perceived by the study participants during reading, listening and listening-reading will be reported. Its aim is to find answers for research question 3 concerning how much mental effort learners perceived to use during learning. Data were drawn from subjective-rating scales in the learning phases of Experiments 1, 2 and 3. The section is divided into three reports: reading, listening and listening-reading to test the following hypotheses.

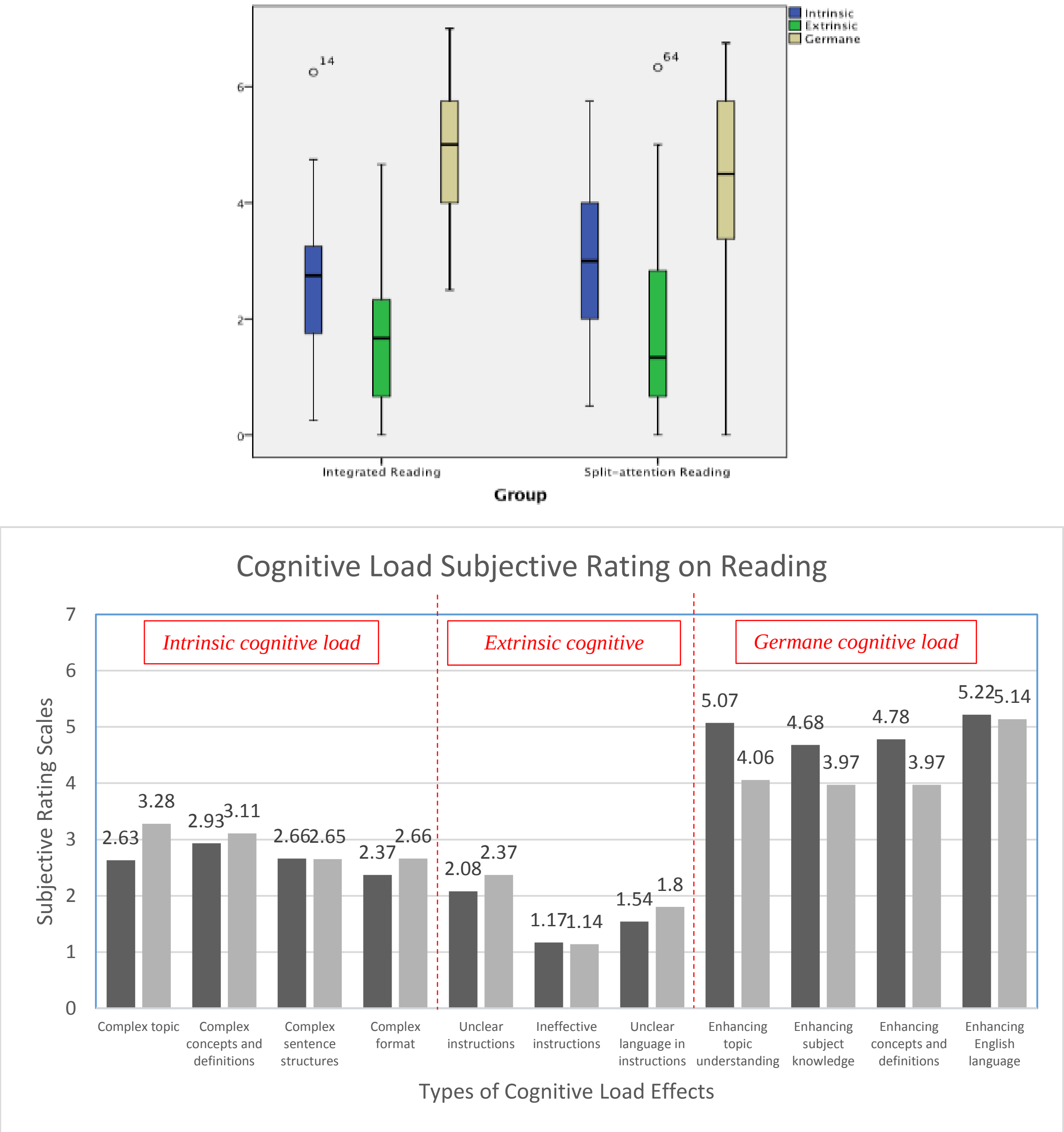
> H_{3a}*: Integrated reading is perceived by learners as less difficult than split-attention reading.*
> H_{3b}*: Integrated listening is perceived by learners as less difficult than split-attention listening.*
> H_{3c}*: Modality listening+reading is perceived by learners as less difficult than redundancy listening+reading.*

4.4.1 Cognitive load report from reading experiment

7-point-likert-scale subjective cognitive load questionnaires (see Appendix 6) were distributed to the learners in both the integrated task and split-attention task groups in the learning phase of Experiment 1 (cf. Figure 3.2a). They had to rate their perceived cognitive load based on 0-7 scales, ranging from *totally disagree* (= 0) to *totally agree* (=7), after learning from the reading texts before the other two phases. There were eleven questions on the questionnaire, which could be categorised into three groups, i.e. intrinsic cognitive load (items 1-4), extrinsic cognitive load (items 5-7) and germane cognitive load (items 8-11). Data taken from the questionnaires were executed into two ways. Firstly, average mean scores of intrinsic, extrinsic and germane cognitive load were compared between the integrated and split-attention tasks to test the following hypothesis:

> *H_{3a}: Integrated reading is perceived by learners as less difficult than split-attention reading.*

After that, mean scores of each question were compared to explore in detail the differences of cognitive load type between integrated and spit-attention effect tasks. The results are as follows.



Note: ▇ = Integrated group ☐ = Split-attention group

Range 0 = not all the case, 7 = all the case

Figure 4.2a. Subjective ratings of cognitive load on reading

As Figure 4.2a shows, overall, the average mean scores of intrinsic and extrinsic cognitive load types between the integrated reading group (M = 2.65, SD = 1.37 and M = 1.62, SD = 1.29, respectively) and split-attention effect reading group (M = 2.93, SD = 1.4 and M = 1.77, SD = 1.48) were not statistically significantly different ($F(1, 74) = 0.827$, $p > 0.05$, $\eta^2 = 0.01$ and $F(1, 74) = 0.234$, $p > 0.05$, $\eta^2 = 0.003$, respectively). However, there was a statistically significant difference in germane cognitive load between the integrated reading group (M = 4.94, SD = 1.1) and the split-attention reading group (M = 4.28, SD = 1.56, $F(1, 74) = 4.557$, $p < 0.05$, $\eta^2 = 0.06$). This means that the both integrated and split-attention reading formats imposed a similar amount of load in terms of information interactivity (i.e. intrinsic cognitive load) and the presentation of text (i.e. extraneous cognitive load). However, in terms of supporting learning (i.e. germane cognitive load), on average, the integrated reading format better supported cognitive load learning than the split-attention reading task, as rated by learners. So, the hypothesis H_{3a} is partially accepted.

In the subjective rating scales, the sub-questions *complex topic, complex concepts and definitions*, *complex sentence structures* and *complex format* were categorised as *intrinsic cognitive load*. In all four items under this category, learners in the integrated group rated three items of *complex topic, complex concepts and definitions* and *complex format* lower than those in the split-attention group (2.63 < 3.28, 2.93 < 3.11, 2.37 < 2.66, respectively), except for a similar case of complex sentence structures (2.66 ≅ 2.65). This means that, on average, although not statistically significantly different, the integrated task was perceived to be less complex in terms of element interactivity than the split-attention task. However, on average, both groups scored all four items below four, which means that they perceived the reading tasks as not too difficult to learn from.

As for the *extrinsic cognitive load*, i.e. *unclear instructions, ineffective instructions* and *unclear language in instructions*, both groups rated the three items lower than three, which means that they felt instructions in the reading texts did not hinder them to learn from the reading texts. However, students in the split-attention group scored *unclear instructions* and *unclear language in instructions* a little higher than those in the integrated group. That is they perceived instructions in the reading text to be a little less challenging than those in the split-attention group.

When it comes to *germane cognitive load*, which supports cognitive processing, on average, learners in the integrated group perceived the reading text to support their *topic understanding*, *subject knowledge*, *concepts and definitions* and *the English language* more than those in the split-attention group. They significantly rated the integrated reading text as enhancing their schema knowledge more than the split-attention group.

At this point in discussion, in EFL reading, although not statistically significantly different, learners are shown to perceive the integrated format task to involve a less complex topic, less complex concepts and definitions and less complex format than the split-attention effect format. Also, such a format was perceived to help enhance learners' schema construction more than the split-attention format.

Another statistical analysis was carried out to compare whether learners' cognitive load was in relation to their working memory before and after learning from reading instructional materials. This is to explicitly explore cognitive load from the working memory point of view. In Experiment 1 (reading), the working memory (WM) pre-test, i.e. Rey Auditory Verbal Learning Test (RAVLT), was used to measure learners' working memory prior to participating in the experiment. It was then compared with learners' cognitive load as perceived by the learners after dealing with reading materials. Reading Span test in phase 3 of the experiment was also compared with the pre-test. This explores further if participants' working memory was still in active use. Paired samples t-tests were employed to compare the WM pre-test and cognitive load types as well as the WM pre-test and WM delayed post-test within each experimental group. The following Table 4.10a reports the results.

Table 4.10a. *Comparisons between Working Memory and Cognitive load types in Reading Experiment*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Integrated reading							
Working Memory pre-test vs Cognitive load types	RAVLT (N = 41)	8.15	2.43				
	Intrinsic CL (N = 41)	2.65	1.37	13.096	40	0.00*	2.79
	Extrinsic CL (N = 41)	1.62	1.29	16.481	40	0.00*	3.36
	Germane CL (N = 41)	4.94	1.10	7.551	40	0.00*	1.70
Working memory pre-test vs delayed post-test	RAVLT (N = 40)	8.03	2.34				
	Reading span (N = 40)	2.10	1.19	16.354	39	0.00*	3.19

* Significant level at $p < 0.01$; ** Significant level at $p < 0.05$

Table 4.10a (Cont.)

Tests	*N*	*Mean*	*SD*	*t*	*df*	*Sig*	*Cohen's d*
Split-attention reading							
Working Memory vs Cognitive load types	RAVLT (N = 35)	7.20	2.59				
	Intrinsic CL (N = 35)	2.94	1.40	9.854	34	0.00*	2.05
	Extrinsic CL (N = 35)	1.77	1.48	11.661	34	0.00*	2.57
	Germane CL (N = 35)	4.28	1.56	6.42	34	0.00*	1.37
Working memory pre-test vs delayed post-test	RAVLT (N = 35)	7.20	2.59				
	Reading span (N = 35)	2.57	1.36	9.28	34	0.00*	2.34

* Significant level at $p < 0.01$; ** Significant level at $p < 0.05$

As can be seen from Table 4.10a, learners' WM prior to participating in Experiment 1 (reading) was statistically significantly different from cognitive load types, i.e. intrinsic, extrinsic and germane cognitive loads. There was also a statistically significant difference between the WM on pre-test and the WM in the delayed post-test. The magnitude of differences was large because of large effect sizes, i.e. Cohen's *d*, across all tests.

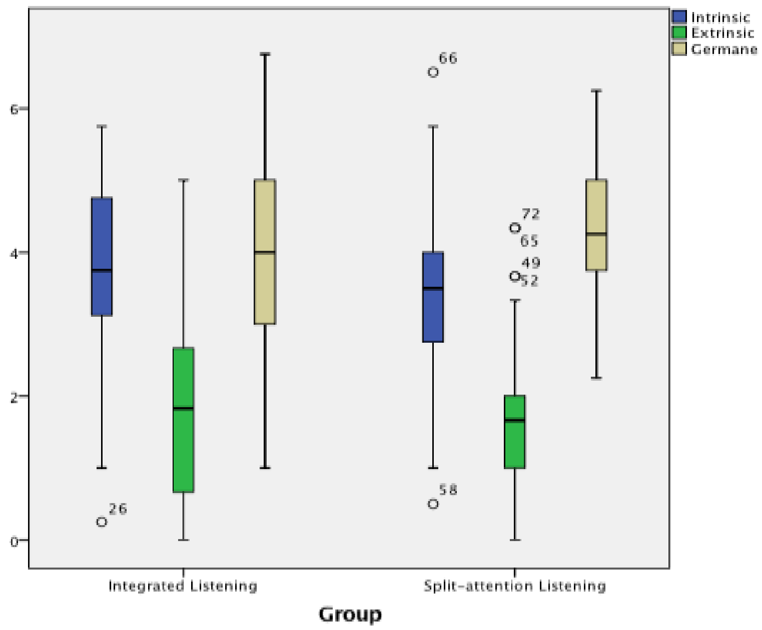
This is evidence that there is a relationship between learners' perceived cognitive load and learners' working memory in learning from both integrated and split-attention reading instructional materials. In other words, learners' cognitive load was, in a large degree, perceived to be used in activating their working memory during learning from both integrated and split-attention reading materials.

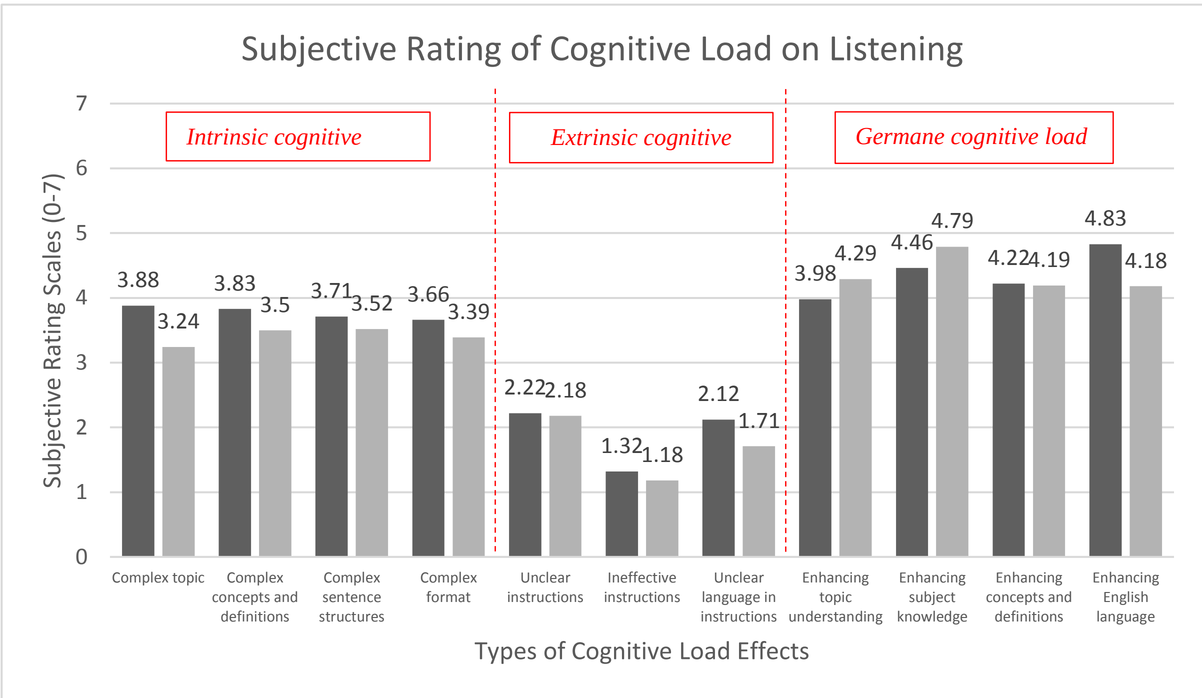
To conclude, learners' cognitive load was perceived to equally activate their working memory during learning from both integrated and split-attention reading. The scores on information interactivity nature of materials, i.e. intrinsic cognitive load, and the presentation of information, i.e. extrinsic cognitive load, were not statistically different between learners learning from integrated and split-attention reading materials. However, integrated reading materials were perceived by learners to activate their schema reconstruction, i.e. germane cognitive load, more than the split-attention reading materials. This means that, although reading materials were equally easy, learners engaged more on learning from the integrated reading with their cognitive load than the split-attention reading, partially supporting the hypothesis H_{3a}.

In the following section, the perception using subjective rating of cognitive load used during learning listening will be presented.

4.4.2 Cognitive load report from listening experiment

Participants had to rate on a 7-point-scale subjective load questionnaire after participating in the learning phase of listening from both integrated and split-attention tasks. There were eleven questions, categorised into *intrinsic cognitive load*, *extrinsic cognitive load* and *germane cognitive load*. The scales ranged from 0-7 with 0 *totally disagree* and 7 *totally agree*. Questions 1-4 were grouped as intrinsic cognitive load, 5-7 as extrinsic cognitive load and 8-11 as germane cognitive load. It was hypothesised in H_{3b} that integrated listening was perceived as less difficult than the split-attention listening. To test this hypothesis, average mean scores of intrinsic, extrinsic and germane cognitive load were compared. Then, each question on the questionnaire was explored to compare learners' perceptions between integrated and split-attention listening. The following Figure 4.2b demonstrates the results.





Note: ▇ = Integrated group ☐ = Split-attention group

Range 0 = not all the case, 7 = all the case

Figure 4.2b. Subjective ratings of cognitive load on listening

According to Figure 4.2b, overall, the average means of intrinsic, extrinsic and germane cognitive load between the integrated listening (M = 3.76, SD = 1.27, M = 1.89, SD = 1.45, and M = 3.95, SD = 1.41, respectively) and the split-attention listening (M = 3.46, SD = 1.31, M = 1.77, SD = 1.13, and M = 4.31, SD = 1.03, respectively) were not statistically significantly different ($F(1, 71) = 0.938$, $p > 0.05$, $\eta^2 = 0.01$; $F(1, 71) = 0.160$, $p > 0.05$, $\eta^2 = 0.002$ and $F(1, 71) = 1.548$, $p > 0.05$, $\eta^2 = 0.02$, respectively). Both integrated listening and split-attention listening formats were perceived similarly by learners. So, the hypothesis H_{3b} is rejected.

Regarding the subjective rating scales, the first four items rated by learners in the integrated group scored a little bit higher than those in the split-attention group, although no statistical difference was found between the two groups. The participants perceived the listening text in the integrated task no more challenging to learn from than the split-attention task. On average, both groups of students rated the listening texts in both formats more than three, which could suggest that the listening text contained a relatively high element of interactivity (i.e. intrinsic cognitive load).

As for the *extrinsic cognitive load*, both groups perceived instructions in the listening text not to be unclear (2.22:2.18), not to be ineffective (1.32:1.18) and not containing unclear language (2.12:1.71). On average, learners learning from the listening text in the integrated format rated learning instructions to be more challenging than those learning in the split-attention group. This means that split-attention listening text tended to be less challenging to learn.

As Figure 4.2b shows, learners in the split-attention group perceived the listening text to support their *topic understanding* and *subject knowledge* more than those in the integrated group (4.29 > 3.98, 4.79 > 4.46, respectively). However, the integrated listening group perceived the integrated listening text to support them in terms of *concepts and definitions* and *the English language* more than the split-attention group (4.22 > 4.19, 4.83 > 4.18, respectively). This could mean that the integrated format of listening text was perceived to help support learning the English language rather than the subject matter.

It can be summarised from the results that split-attention listening was perceived to contain fewer elements of interactivity and unclear instructions than the integrated listening task, but the support of language learning from split-attention listening was perceived to be less effective than the integrated format.

To explore further whether there was a relationship between learners' cognitive load and their working memory during learning from integrated and split-attention listening materials, another statistical test was employed. Table 4.10b displays the results.

Table 4.10b. *Comparisons between Working Memory and Cognitive load types in Listening Experiment*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Integrated listening							
Working Memory pre-test vs Cognitive load types	RAVLT (N = 40)	8.08	2.42				
	Intrinsic CL (N = 40)	3.76	1.27	11.034	39	0.00*	2.23
	Extrinsic CL (N = 40)	1.89	1.45	14.341	39	0.00*	3.10
	Germane CL (N = 40)	3.95	1.41	9.044	39	0.00*	2.08
Working memory pre-test vs delayed post-test	RAVLT (N = 39)	7.95	2.32				
	Reading span (N = 39)	2.51	1.60	13.811	38	0.00*	2.58
Split-attention listening							
Working Memory vs Cognitive load types	RAVLT (N = 33)	7.61	2.18				
	Intrinsic CL (N = 33)	3.46	1.31	9.203	32	0.00*	2.31
	Extrinsic CL (N = 33)	1.77	1.13	14.193	32	0.00*	3.36
	Germane CL (N = 33)	4.32	1.03	8.694	32	0.00*	1.93
Working memory pre-test vs delayed post-test	RAVLT (N = 32)	7.47	2.06				
	Reading span (N = 32)	2.28	1.42	12.149	31	0.00*	2.93

* Significant level at $p < 0.01$; ** Significant level at $p < 0.05$

As Table 4.10b demonstrates, learners' working memory prior to participating in Experiment 2 (listening) was statistically significantly different from cognitive load types, i.e. intrinsic, extrinsic and germane cognitive loads. There was also a statistically significant difference between the WM on pre-test and the WM in the delayed post-test. The magnitude of differences was large because of large effect sizes, i.e. Cohen's *d*, across all tests.

This means that there is a relationship between learners' perceived cognitive load and their working memory in learning from integrated and split-attention listening. In other words, learners' cognitive load was, in a large degree, perceived as activating their working memory during learning from both integrated and split-attention listening materials. Moreover, evidence from subjective cognitive load rating showed these two groups of participants perceived integrated and split-attention listening as equally difficult to the same degree, in terms of intrinsic, extrinsic and germane cognitive load. The hypothesis H_{3b} is, therefore, rejected.

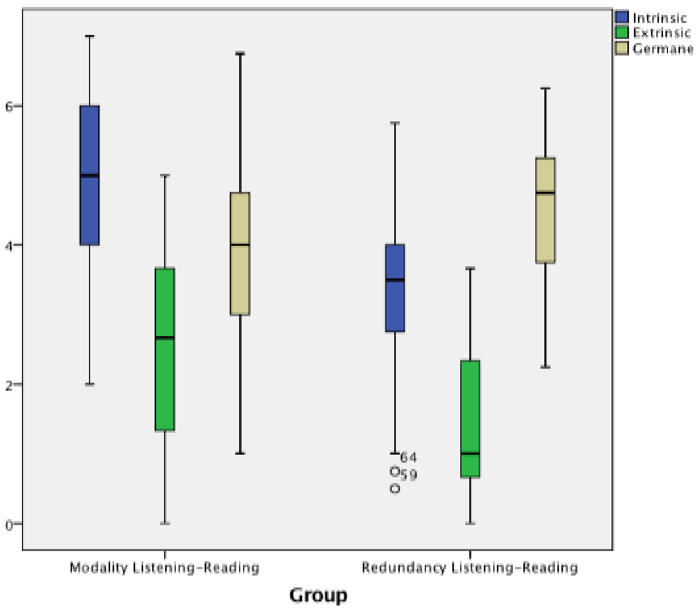
In the next section, learners' self-reports on cognitive load used during learning listening-reading will be discussed.

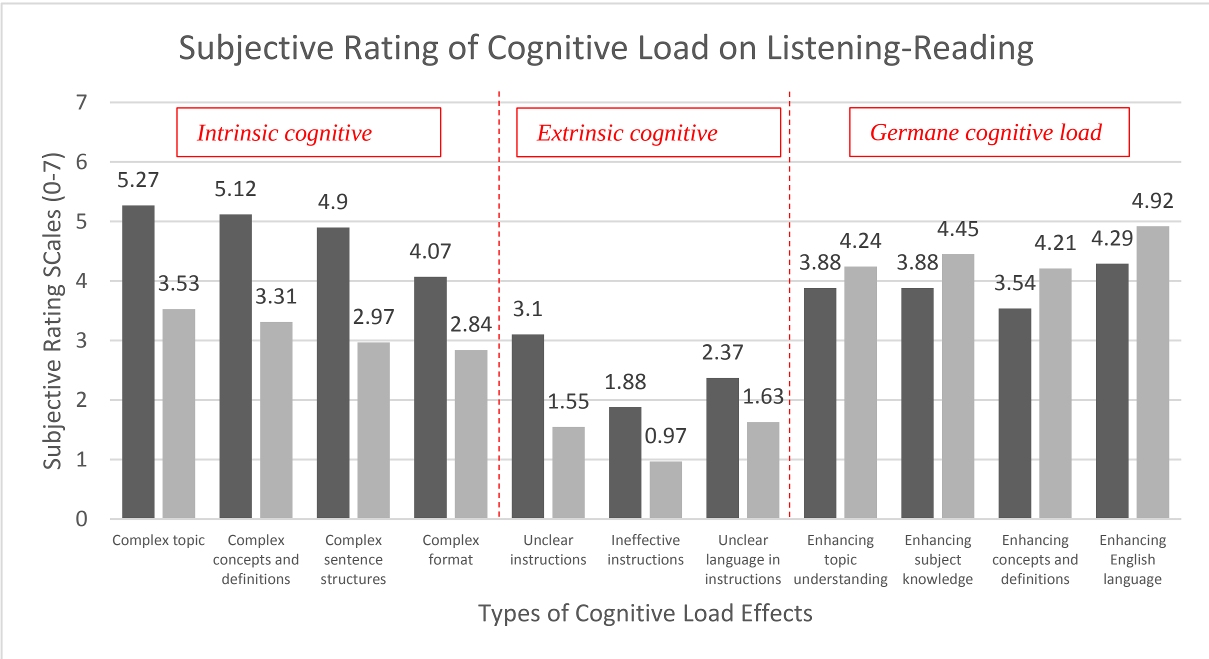
4.4.3 Cognitive load report from listening-reading experiment

After dealing with the listening-reading texts on both types of cognitive load variables, i.e. modality and redundancy effect modes, learners were required to complete the 7-point-scale subjective load questionnaire, which consisted of eleven questions. The eleven questions were categorised into *intrinsic, extrinsic* and *germane cognitive loads*. Average mean scores of intrinsic, extrinsic and germane cognitive load were compared to test the following hypothesis:

> *H_{3c}: Modality listening+reading is perceived by learners as less difficult than redundancy listening+reading.*

Following the analysis, detail of each question was explored to compare perception differences between modality and redundancy effects. Figure 4.2c below shows the results.





Note: = Modality group = Redundancy group

Range 0 = not all the case, 7 = all the case

Figure 4.2c. Subjective ratings of cognitive load on listening-reading

As Figure 4.2c shows, there were statistically significant differences on the mean scores of intrinsic and extrinsic cognitive load types between the modality (M = 4.84, SD = 1.32 and M = 2.44, SD = 1.42, respectively) and the redundancy (M = 3.16, SD = 1.29 and M = 1.38, SD = 1.10, respectively) ($F(1, 77) = 32.352$, $p < 0.01$, $\eta^2 = 0.30$ and $F(1, 77) = 13.641$, $p < 0.01$, $\eta^2 = 0.15$, respectively). This means that, on average the redundancy effect group perceived that they demanded less cognitive load in terms of element interactivity and the presentation of text than the modality format, as rated by learners. However, there were no statistically significant differences in the mean scores of germane cognitive load between the modality (M = 3.9, SD = 1.36) and the redundancy formats (M = 4.45 and SD = 1.112, conditions; $F(1, 77) = 3.919$, $p > 0.05$, $\eta^2 = 0.05$). The hypothesis H_{3c} concerning a less difficult perception on the modality task is rejected.

Regarding the subjective rating scales, on average, those who learnt from the modality listening+reading task, i.e. listening and picture description, rated the first four questions, i.e. *intrinsic cognitive load*, higher than those in the redundancy format (i.e. listening and reading text) (i.e. 5.27 > 3.53, 5.12 > 3.31, 4.9 > 2.97, and 4.07 > 2.84, respectively). This means that they perceived the modality listening+reading texts to contain a higher element of interactivity to learn from than the redundancy format. When it comes to *extrinsic cognitive load*, the learners rated the modality text to contain more unclear instructions than the redundancy one (i.e. 3.1 > 1.55). However, on average, the ratings of the instructions for both cognitive load types were below three, which could be regarded as containing less unclear language and ineffective instructions. The modality format of listening-reading texts was perceived to contain more unclear instructions for language learning than the redundancy text at a significant level ($p = 0.00$). *Germane cognitive load* was not statistically significant different.

In summary, for the three types of cognitive load, learners perceived the redundancy text to support their learning better than the modality one. In fact, the redundancy text was perceived to help the participants to learn the subject matter through the English language more than the modality text.

To explore further if learners' cognitive load used during learning from both modality and redundancy listening-reading texts was in relation with their working memory, another statistical test was employed. Table 4.10c shows the results

Table 4.10c. *Comparisons between Working Memory and Cognitive load types in Listening-Reading Experiment*

Tests	***N***	***Mean***	***SD***	***t***	***df***	***Sig***	***Cohen's d***
Modality listening-reading							
Working Memory pre-test vs Cognitive load types	RAVLT (N = 41)	8.15	2.43				
	Intrinsic CL (N = 41)	4.84	1.32	8.035	40	0.00*	1.69
	Extrinsic CL (N = 41)	2.45	1.42	13.855	40	0.00*	2.86
	Germane CL (N = 41)	3.89	1.36	9.688	40	0.00*	2.16
Working memory pre-test vs delayed post-test	RAVLT (N = 38)	8.16	2.30				
	Reading span (N = 38)	2.51	1.60	11.634	37	0.00*	2.85
Redundancy listening-reading							
Working Memory vs Cognitive load types	RAVLT (N = 38)	7.24	2.51				
	Intrinsic CL (N = 38)	3.16	1.29	10.649	37	0.00*	2.04
	Extrinsic CL (N = 38)	1.38	1.10	13.798	37	0.00*	3.02
	Germane CL (N = 38)	4.45	1.12	6.250	37	0.00*	1.43
Working memory pre-test vs delayed post-test	RAVLT (N = 33)	7.18	2.16				
	Reading span (N = 33)	4.73	2.67	4.250	32	0.00*	1.01

* Significant level at $p < 0.01$; ** Significant level at $p < 0.05$

Although redundancy listening-reading was perceived to be less difficult than the modality listening-reading, both types of cognitive load variables were perceived by both groups of learners to activate their use of working memory at a significant level ($p < 0.01$). The degree of magnitude of difference was large because of the large effect sizes across all tests. Evidence from working memory tests and cognitive load types revealed that the learners from both modality and redundancy listening-reading perceived that their working memory was activated by cognitive load when learning from modality and redundancy listening-reading. However, their subjective rating of cognitive load showed that the redundancy was significantly less difficult than the modality in terms of information interactivity, i.e. intrinsic cognitive load, and the presentation of information, i.e. extrinsic cognitive load. The hypothesis H_{3c} is, therefore, rejected.

The next section summarises all results from subjective cognitive load rating and working memory measurement.

4.4.4 Summary of Subjective Rating Scales

As reported in the previous sections (Sections 4.4.1-4.4.2), learners perceived the integrated formats of English reading and listening to help support their learning more than the split-attention effect format. In other words, the participants perceived the reading text to contain fewer complex structures of text presentation and to support their schema construction. As for the listening text, the participants perceived the integrated format to support their language learning more than the split-attention effect format, even though the split-attention listening text was viewed as containing fewer complex structures.

When it comes to the integrated skills of listening-reading, the learners perceived the redundancy format, i.e. presenting both listening and reading at the same time, to support EFL reading-listening more than the modality format, and this format was perceived to contain fewer complex structures in the text presentation and to help support learners' schema construction more than the modality mode. Results of testing hypotheses H_{3a}, H_{3b} and H_{3c} are summarised below.

Table 4.11. *Summary of hypotheses H_{3a}, H_{3b} and H_{3c}*

Hypotheses	**Learning phase**
H_{3a}: Integrated reading is perceived by learners as less difficult than split-attention reading.	√ (partial)
H_{3b}: Integrated listening is perceived by learners as less difficult than split-attention listening.	X
H_{3c}: Modality listening+reading is perceived by learners as less difficult than redundancy listening+reading.	X

√ = accepted, X = rejected

Evidence from working memory pre-tests and cognitive load types as well as delayed post-test of working memory demonstrated that learners' working memory had direct effects on cognitive load when they learnt from all cognitive load variables. Their working memory after learning was also significantly different from their working memory prior to participating in all experiments. This means that in dealing with reading, listening and listening-reading instructional materials, learners' working memory was activated by cognitive load, especially during learning and delayed post-tests.

In the following section, an integration of results from sections 4.2, 4.3 and 4.4 will be presented.

4.5 Summary of Quantitative Data

With regard to the experimental results, we found that there was a relationship between modified instructional materials and learners' information retention (RQ1). Integrated reading and integrated listening resulted in better retention than split-attention reading and listening in the learning phase (accepting H_{1a} and H_{1b}), whereas the modality listening+reading resulted in better retention than the redundancy effect in the testing phase (accepting H_{1c}). WM plays a role in learning and testing from integrated and split-attention reading, split-attention listening and redundancy listening-reading, but not in integrated listening and modality listening-reading.

In terms of the best candidate for instructional design and cognitive load effects (RQ2), it was confirmed that reading-only, especially in an integrated task, helped support learning more than listening and reading+listening in the learning and testing phases (accepting H_{2a}). Evidence of reading-only in the detrimental effects, i.e. split-attention and redundancy effects, was confirmed only in the testing phase (accepting H_{2b}).

When learners rated how difficult instructional materials was in terms of their mental effort perspectives (RQ3), integrated listening and modality listening+reading were not perceived as less difficult than split-attention listening and redundancy listening+reading (rejecting H_{3b} and H_{3c}). It was only integrated reading which was perceived as helping learners to engage with the text (partially accepting H_{3a}), although the nature of text and text presentations were perceived as difficult equally with the split-attention reading. However, all cognitive load variables were in association with learners' WM verbal resources, meaning that CL variables were perceived to activate learner's WM resources to process.

To answer the main research question whether learners could process information efficiently from modified instructional materials, the quantative results pointed to contradictory results from experiments and learners' perceptions in that there was efficient learning, but perceived difficulty in integrated reading and integrated listening. Also, the rejection of H_{1c} in the learning phase was still unclear. This needs qualitative analysis to illuminate the process of learning and to report learners' perception in terms of instructional materials and their mental efforts used in learning from the materials. The following part reports the results.

Part 2: Qualitative Data

4.6 Semi-structured interview results

This section illuminates the process of the present study. Information from the semi-structured interviews were coded into three themes of *cognitive load types*, i.e. characteristics of materials; text presentation; and self-perception toward instructional learning, using the thematic analysis as follows.

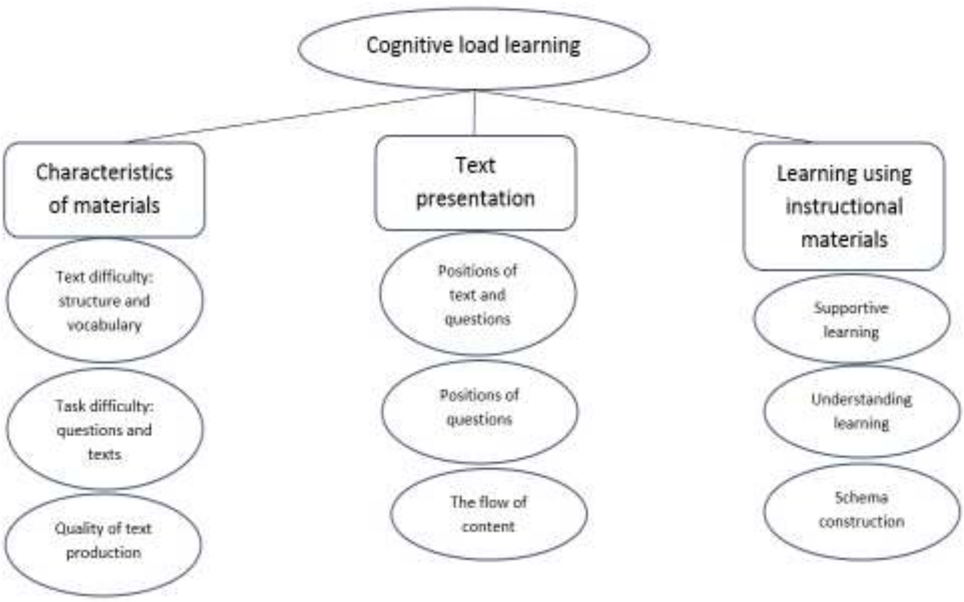


Figure 4.3. Thematic development of semi-structured interviews

As noted in Chapter 3, the analysis of the semi-structured interview data was drawn from concept-driven coding (Gibb, 2009), in that learning is in relation to human cognitive architecture. Learners' interactions with instructional materials in the present research was also accessed through semi-structured interviews where they reported their perceived overall cognitive load during learning reading, listening and listening-reading. The results of different cognitive load types, i.e. intrinsic, extrinsic and germane cognitive loads, were reported through the same three themes as in the subjective-rating questionnaire: characteristics of text (i.e. intrinsic), the presentation of text (i.e. extrinsic), and learning using instructional materials (i.e.

germane). In the analysis, the discourse analytic approach was also employed so as to include context-dependent differences on learners' perceptions toward instructional materials when some participants provided some deviated ideas from the theme. This is illuminated by two frameworks of *Information Processing Principles* under the evolutionary knowledge (Sweller *et al.*, 2011, Sweller, 2017) and the *Dual-coding approach* by Paivio (1990).

In quoting, this present research employed numerical denomination so that participants' personal information was in confidential according to ethical considerations. The denomination was GxSx, signifying that G represents an experimental group, i.e. Group 1 (G1) and Group 2 (G2), and S means an individual number of participants who participated in the interviews. Group 1 refers to participants from the supportive cognitive load group, i.e. who used integrated and modality tasks, whereas Group 2 refers to participants from the hindering cognitive load group, i.e. who used split-attention and redundancy tasks.

4.6.1 Interview results of reading experiment

In the semi-structured interviews, ten volunteers from the integrated experimental group and nine from the split-attention group were recruited to reveal their perceptions toward instructional materials and their learning with the materials. Reading in different presentation modes (i.e. cognitive load variables) was predicted to result in different perceptions toward characteristics of reading text, text presentation and instructional learning results. The integrated format was predicted to help support learning reading with less cognitive load in memory capacity, whereas interacting with the split-attention format was predicted to increase cognitive load, thereby hindering effective language learning. Each treatment group answered 7-8 interview questions. The following are the results.

Theme 1: Linguistic characteristics of materials

After semi-structured interviews with nineteen students, it was found there were two major factors perceived to be influencing the effect of texts on participants' learning: sentence structure and vocabulary. Participants in the integrated group regarded sentence structure in the text difficult. They said this was the syntax in sentences that was complicated as shown below:

> *'It's confusing. I can't remember. It seems sentences are a bit complicated.' (G1S2)*

> *'Some patterns of sentence are hard to understand, such as sentences after commas.' (G1S10)*

In addition to the text, some participants in the integrated group perceived the language used in questions difficult as follows:

> *'I found some questions and paragraphs a bit too difficult…' (G1S3)*
> *'I think some of the questions is very hard to understand…' (G1S6)*

According to Sweller *et al.* (2011), task difficulty is related to a high level of elements, i.e. vocabulary and sentence structure, interacting on instructions and materials. In the case of language difficulty, the learners perceived task difficulty in terms of vocabulary, too, resulting in a high level of intrinsic cognitive load for the integrated reading task.

As for the split-attention effect group, vocabulary in context was sometimes perceived by participants as a challenge in tackling the text. This includes ambiguity.

> *'And if a word that I don't know, I will read pass them and I will reread that and I will read all the structures and it mean the one meaning thing to understand.' (G2S4)*
>
> *'Just read and try to understand it [word in sentence] at that time.' (G2S7)*

Patterns of sentence structure were also factors determining how difficult the reading text was. On the split-attention reading task, participants in this treatment needed to exert intrinsically mental effort to make sense of the words and sentences in the task.

In terms of learners' perception toward text characteristics, sentence patterns and vocabulary in both the reading text and the questions were major factors in adding intrinsic cognitive load to working memory capacity of both participant groups. However, when it comes to an application of cognitive load, participants from both groups reported their perceptions differently.

Theme 2: Text presentation

When it comes to the presentation of text in different patterns (as cognitive load variables in the experiments), participants in the integrated group, i.e. questions embedded in text, reported their perceptions as follows:

'The text was not difficult at all. The story was arranged according to the questions in the text.' (G1S4)

'I think that questions make me understand the passage better. I think the questions support me.' (G1S5)

'Questions were arranged according to the story, so I can concentrate on one point for one question at a time. …I think it [question] helped my reading because I only read one paragraph for one question and understand it.' (G1S8)

'I think the question helped me realise if I did understand the story.' (G1S9)

As can be seen from the above remarks, when questions were embedded into the reading text, i.e. integrated reading, participants perceived the questions as helping them to understand and process the text in a logical way. However, in some respects, embedding questions in the reading text was perceived as annoying.

'I think the question posted within the text help me understand what the paragraph is about, but I think it wastes time to think when I stop at each paragraph.' (G1S10)

At this point in discussion, for the integrated reading group, embedding questions in the reading text was perceived as helping learners understand the text in a logical way with questions arranged according to the story. However, sometimes, it annoyed them when they had to stop to read.

When it comes to an arrangement of text as questions at the end with explanation boxes, participants in the split-attention group reported conflicting perceptions toward the explanation boxes. That is boxes were both positive and negative for their learning. As for a negative side, participants perceived the explanation boxes to be confusing and difficult.

'The boxes are a bit challenging because some words are hard…' (G2S2)

'I think all the boxes make me confused.' (G2S3)

'The box can be more description, something I can understand.' (G2S7)

When participants perceived the boxes to be positive, their attention was shifted to the boxes.

'I read the box first and the passage later, maybe the box is so obvious. It pop up in my eyes, and I read it because I think it's important, because it's the frame and detail in it.' (G2S8)

In terms of questions posted after the text, participants in the split-attention group reported their perceptions as follows:

'The questions are not difficult, but I cannot remember the text to answer…' (G2S2)

'The question is not difficult to answer. Not that I can remember everything for the questions. I just remember what I can understand.' (G2S7)

The results show that participants in the split-attention group did not perceive questions to be difficult. It is, in fact, the location of questions at the end of the reading text that seems to have been a problem for them to remember text and process information. These responses further support this.

'Questions make me more difficult because I can only read the passage one time, and the passage confused me to answer the questions.' (G2S3)

'I think it's okay, not difficult at all, but I think when someone tried to remember the answer of the questions, it's so difficult.' (G2S8)

The location of questions seems to hinder students' learning while reading. In the integrated group, when questions were embedded within the reading text, participants perceived the presentation to support their learning, except for one case where the learner said stopping reading in the text could be annoying. However, when questions were posted at the end of the text with explanation boxes, participants in the split-attention group perceived the location of questions to be challenging in remembering all information in the reading text to answer.

In the next section, students' perception toward instructional learning will be presented.

Theme 3: Self-report toward learning using instructional materials

Participants in the integrated reading group reported positive perceptions as follows:

'I think reading some paragraphs and answer the questions helped me... I like the way the text and questions were organised. If I have to read the whole passage and answer all the questions, it will be a lot more difficult for me. Reading one paragraph will help me understand and answer the questions better.' (G1S9)

'I think reading and stopping to answer questions helped me read because I can concentrate on the whole story.' (G1S10)

However, the integrated format also hindered understanding the flow of story, as reported by a participant below:

'I feel the task is easy, but I could not practice reading the whole thought of the passage.' (G1S8)

However, reading in the integrated format resulted in some learners forgetting the reading information, as can be seen from a participant below:

'…but in the test you can only read the paragraph and answer the question, and then the next paragraph. And that makes it harder to remember what you learn of that paragraph.' (G1S6)

When it comes to learning results of the integrated format, participants in the integrated group perceived that they could process more information after learning, as can be seen from the following examples:

'Sometimes the story was interesting, but I had some conflicts with the story.' (G1S4)

'I think it seemed useful, but for me, I think it doesn't answer how to manage the time.' (G1S5)

As demonstrated in the above samples, it seems that after using the integrated reading, participants could process information and think further from the available information in the text. This could mean that learners' memory capacity might not be filled up during learning. Another piece of evidence below shows that when the integrated format included information relevant to learners' background knowledge, learning from reading could be interesting. This also shows that the choice of content was possible in the text.

> *'It was not too difficult, and the story is interesting. Like story about time, it's not difficult to read because I know about the story before. This story gives me more information about the thing I know. The story is related to my everyday practice, so it's not boring at all.' (G1S7)*

It can be concluded from the results that the integrated reading format helps learners to concentrate on and process written information effectively, except for some cases where the information might overload the readers or be too easy to read. Evidence from further engagement of learners' thinking and background knowledge demonstrated that their memory capacity might not be filled up and this could be a good candidate for the presentation of text. When it comes to split-attention reading, participants reported their learning differently as follows:

> *'…it's hard if you don't know the questions before and then it makes you forget about something important in the text.' (G2S4)*
>
> *'I was not too stressful to read. … if I read all of them and answer at the back, I sometimes forget.' (G2S7)*
>
> *'So difficult to remember it [the text] all.' (G2S6)*

Evidence above demonstrates that reading the entire story prior to answering all answers resulted in learners forgetting information although reading in this format did not result in stress. A problem further arose for participants in that they perceived reading the entire story as containing too much information and the box to be confusing, as can be seen below:

> *'…information is too long. …I think there were too many topics. I think the detail on the topic is not related because it contained no reasons.' (G2S1)*
>
> *'I think it didn't explain anything or make anything clearer. The box… I don't know why it's here.' (G2S3)*

As presented in the above scenario, learning from split-attention format results in information overload during reading, and at the same time, learners' attention shifted toward many different paragraphs and boxes, which caused confusion. However, reading under split-attention was possible as perceived by the following participants:

> *'I think this text is good too because it gives me how to manage time.' (G2S2)*

> *'I don't have any problem about this one [the split-attention format] I think. I think I love it to be challenging' (G2S4)*
>
> *'I like it so because it makes me practice English. The skills in English, I can practice better.' (G2S9)*

The third remark suggests that split-attention reading format enhanced English learning, although it might have increased information load in the participants' memory capacity.

Here we can conclude that participants' learning from both integrated and split-attention formats supports English reading for these learners in different ways. For the integrated reading format, learners reported to concentrate and understand reading information when learning with the format. In terms of split-attention formation, learners perceived the format to be a positive challenge in helping them learn and read, but long information with explanation boxes in the split-attention reading format caused learners to forget information and get confused.

In the following section, a summary of results on semi-structured interview on reading will be discussed.

4.6.2 Summary of interview results on reading experiment

With regard to the results of semi-structured interviews, the structure of sentences and vocabulary in the reading text and the questions, i.e. intrinsic nature of element interactivity, were perceived as difficult for learners to learn and process information either from integrated or split-attention format. However, when information was presented in different formats, i.e. integrated and split-attention, the volunteer participants perceived their learning differently. For the integrated format, i.e. embedding questions in the reading text, the questions were perceived to be effective for processing information logically, with some learners' perceptions that it stopped the flow of reading. In terms of split-attention, i.e. embedding description boxes into the text and listing questions at the end of text, the description boxes were perceived either as confusing, explaining more information for the text, or turning learners' attention from the text.

Formats of integrated and split-attention showed different perceptions of support learners' language learning and reading. Participants in the integrated group reported that they concentrated on reading and included information from the reading text in their cognitive processes. As for the perception of split-attention format, participants reported the effective use of the reading text in helping them improve their English and processing information, but lengthy information was perceived to cause confusion and information overload during reading.

At this point in discussion, we can conclude that the integrated reading format was perceived to help learners to concentrate on and process reading information effectively. It logically helped learners concentrate on reading and left some memory capacity for them to process information further. As for the split-attention format, information overload and the deviation of attention during reading was perceived to occur when learners read lengthy text with explanation boxes, but the participants perceived it positively as it helped them learn more English and engage with the topic.

In the next section, the results of semi-structured interviews on listening will be presented.

4.6.3 Interview results of listening experiment

There were another ten volunteers from the integrated group and nine students from the split-attention group. In listening, including questions in the listening text, i.e. integrated listening, was predicted to yield a productive understanding of the text, resulting in effective cognitive capacity for learning. However, the split-attention format where the listening text and questions were placed in different locations, was predicted to increase information overload in cognitive capacity. In the following, volunteers' perceptions toward instructional materials will be presented.

Theme 1: Linguistic characteristics of materials

In listening, internal elements of listening, i.e. speed, accent and language, were perceived by learners to affect their comprehension. In terms of language, sentence structure and vocabulary could be detrimental to effective listening. In addition, speed and accent might have made the text difficult for learners to process. In the following, learners' perception toward characteristics of listening materials will be discussed.

For the integrated listening group, speed and accent were not perceived as problematic but rather as positive, as can be seen from the following remarks.

> *'I'm quite used to the accent because I listen to the accent in everyday life, so it's not a problem to follow the story in English.' (G1S4)*
>
> *'I think the speed is okay for the test. In everyday life, the listening will be a lot faster than this.' (G1S5)*
>
> *'It's normal, not too easy or too difficult. There's no problem with the accent and speed.' (G1S6)*

Interestingly, some participants in the integrated listening group reported using their learning experience to engage with the listening text, such as ‘in everyday life’ (*G1S4* and *G1S5*). This could be evidence that the biologically primary knowledge of listening skills was transferred to learn the biologically secondary knowledge, i.e. EFL listening (Sweller, 2017). However, the language used, the vocabulary and sentence structure, in the listening text was also a factor hindering their understanding.

> *‘I think the text is quite difficult because it has many unseen vocab I haven’t heard before and I don’t know what I said.’ (G1S1)*
>
> *‘Accent is okay. Some sentences were so difficult. Some were simple so it’s easy to listen to.’ (G1S3)*
>
> *‘The speed is okay, and the accent is okay. Just I don’t know some words.’ (G1S8, 18)*

In the integrated group, sentence and structure were perceived to be more difficult than speed and accent. However, in the split-attention group, learners’ perceptions were different with accent mentioned as follows:

> *‘I don’t think it’s difficult. It’s just words that I don’t know, so it’s not fair to blame the listening to be difficult. … the accent is different from what I know.’ (G2S6)*
>
> *‘There are so many difficult words that I don’t know so I’m not sure if the text is difficult or the accent makes me not understand the text. The speed is normal.’ (G2S7)*
>
> *‘I don’t think the speed is a problem, but the accent is difficult to catch.’ (G2S8)*

It seems that vocabulary was a factor in hindering learners’ understanding, similar to the integrated group. However, there were some participants in the split-attention group who reported speed and accent difficulties as follows.

> *‘The text is so fast that I cannot follow. … I am not used to the accent in the listening.’ (G2S1)*
>
> *‘… so, there are some words in the text that are not familiar. The speed in the text is also fast.’ (G2S4).*

It can be concluded from the remarks that both integrated listening and split-attention listening groups perceived the language, i.e. sentence structure, vocabulary, speed and accent, used in the listening text difficult, thereby hindering effective learning. To obtain a clearer picture of how the presentation of listening text resulted in effective or ineffective listening for learners in integrated and split-attention groups, the following section will yield more evidence of learners' perception toward instructional materials.

Theme 2: Text presentation

When it comes to the different presentations of listening materials, participants in the integrated group differed from the split-attention group. For this group, embedding questions in the listening text resulted in both positive and negative perceptions of their listening. Evidence of the positive perceptions is as follows.

> *'I think it's good because I can stop to think and summarise what I have listened. This could make me link ideas in the listening better.' (G1S6)*
>
> *'I think it's better to stop to answer the questions because I can have more time to answer questions. If the listening isn't stop, I might not be able to follow the listening.' (G1S7)*
>
> *'I think it's easier for me to remember the whole story if the text is separate in parts.' (G1S8)*

The time for them to 'think and summarise' the listening text before moving on to listen to the rest of the text can be regarded less demand on their memory capacity to free them to process more information, satisfying the top-down process (Field, 2004, 2008, Khunziakhmetov and Porchesku, 2016). However, the integration of questions in the listening text also resulted in negative perceptions as reported by the following participants.

> *'Listening and stopping to answer questions may be good, but it doesn't help me remember the whole story. … the information is not linked.' (G1S2)*
>
> *'I'm still concentrating on the listening, but the question stops me to concentrate.' (G1S4)*
>
> *'It's easy, but I don't think it's smooth. I feel I was stopped all the time and the flow of idea is stopped too.' (G1S5)*

As can be seen from these remarks, the attention of learners while concentrating on listening was disrupted because of the questions, which might result in a split-attention effect, rather than supporting listening. When being asked about what happened, those who reported negative perspectives revealed their feelings as follows:

> *'I'm not quite sure if the listening will continue after the questions.' (G1S4)*
>
> *'I'm feel reluctant because I'm not sure when the next question will come up. If I have never practised this type of listening before, it will be so difficult.' (G1S9)*

The quotes also show that an unfamiliarity of the format causes participants to feel 'not sure' or 'reluctant' toward the arrangement of questions. This might be a detrimental factor causing more demands on working memory capacity for these participants.

When the listening text was rearranged into a whole listening story and all questions attached at the end of the text, participants in the split-attention group reported the following feelings:

> *'It's difficult because I don't remember the story … there's so much information'. (G2S2)*
>
> *'It's difficult because I need to remember key words and events in the story and try to rearrange the story to answer the questions.' (G2S6)*

The overload information in the listening text was perceived to be a factor filling up the memory capacity of learners in the split-attention group. The deviation of attention from listening to questions at the end also required a lot of information to be processed, and the participants in the split-attention 'forgot' the listening information before answering the questions, as follows:

> *'It's difficult because I don't remember the story. I also don't know what to answer because there's so much information.' (G2S2)*
>
> *'…keywords in the listening did not exist in questions, I couldn't answer the questions.' (G2S3)*
>
> *'When I try to answer questions, I just forget what I was listening.' (G2S4)*

To summarise, for the integrated listening format, i.e. embedding questions in the listening text, there was more time for learners to process the listening information during listening. However, this format disrupted listening when learners were not familiar with the format. In terms of split-attention format, listening to the text seemed to just result in information overload in cognitive capacity prior answering questions. Given the remarks regarding text presentation about learners' perceptions, it is important to find out more. In the following section, further remarks on learning results as perceived by the learners will be presented.

<u>Theme 3: Self-report toward learning using instructional materials</u>

In terms of learning the listening text from different presentations, the majority of participants in the integrated group reported their information processing as follows:

> *'I listen and try to understand and imagine… like create the picture.' (G1S1)*
>
> *'I listen and think. Maybe just follow by the listening. I imagine.' (G1S2)*
>
> *'I always imagine when listening because I can remember information in pictures rather than in words.' (G1S4)*
>
> *'I try to listen to all of the sentence and guess the meaning of the word. I also imagine in pictures.' (G1S7)*

Processing information in 'pictures' could be regarded as visual information which does not compete with cognitive capacity for listening, satisfying *the Dual Coding Approach* (Paivio, 1990, 2014a, 2014b; Sadoski and Paivio, 2001). In addition, some participants in this group processed the listening text in their native language, as reported below:

> *'If the sentences were too long, I would translate them to Thai first, but if the sentences were arranged logically, I just understand them.' (G1S3)*
>
> *'I listen for keywords and remember them to construct my understanding in Thai.' (G1S9)*
>
> *'I translate into Thai when I understand the listening text. If I don't understand the text, I just remembered what I have listened.' (G1S10)*

Regarding the remarks above, this is evidence of the transfer of skills from biologically primary knowledge to biologically secondary knowledge (Sweller, 2017). This also satisfies what Paivio (2014a, 2014b) postulated as *Bilingual Dual Coding Theory*, where both L1 and L2 are interrelated in terms of cross-representation. The integrated format helped the learners process listening information using dual coding and not putting demands on cognitive capacity. This is confirmed by a participant as followed:

> *'I think it's better to listen bit by bit and answer the following questions because I can concentrate on only one question. If listening to the whole story, I might not understand the listening at all.' (G1S3)*

Although the integrated format was perceived to help learners process the listening text effectively, some participants in this group reported that the listening text and the integration of questions detrimentally split their attention (as already presented in Theme 2).

> *'Listening and stopping to answer questions makes me confused and cannot concentrate on listening.' (G1S4)*
>
> *'It's [the integrated format] easy, but I don't think it's smooth. I like it better if I listen to the whole story because I can process the whole story easily. In the listening, I feel I was stopped all the time and the flow of idea is stopped too.' (G1S5)*

In the integrated format, learners could process more information in the listening text when they listened and stopped to answer questions. However, some participants perceived such a format as diverting attention from the listening text.

When it comes to split-attention format learning, some participants in this group reported that they processed the listening text in pictures, similar to those in the integrated group, as follows:

> *'I listen and try to see pictures in my mind…' (G2S2)*
>
> *'I think during listening, and I did this in English because I didn't want waste my time to switch from English to Thai. Translating from English to Thai could cause confusion to me because sentence patterns in two languages are a lot different. I also think in pictures when the story was related to everyday events that I know, but I didn't create a new picture for the story.' (G2S6)*

Given the remarks above, it could be regarded that during listening, participants in the split-attention group processed the listening text in pictures, but the processing could be completed only when the listening text was familiar to them. Additional information during listening was perceived to place demands on the cognitive capacity as described by *G2S6*.

During listening, the majority of participants in the split-attention group reported a holistic approach to listening and applications of various strategies as follows:

> *'I try to find main ideas of the listening. Also, I try to link all of the ideas into a story. I did this in Thai.' (G2S1)*
>
> *'If it's in passage, I will listen to the first and last sentences to link the whole idea of paragraph. I will listen to linking words and try to understand the text logically. I use keywords to understand the listening text because if I use pictures, I cannot follow the listening text.' (G2S3)*
>
> *'I try to guess what the story is about based on keywords. I didn't translate the text in Thai because the listening keeps on in English, so I understand the text in English.' (G2S4)*
>
> *'I understand the text in English without translating into Thai. If I don't understand the text, I could just skip it.' (G2S8)*

When learners were listening, they had to process the entire text. This was predicted to overload information in their cognitive capacity and it did, as reported by some participants below:

> *'During listening, when I concentrated on difficult words, I couldn't follow the listening and I become blank.' (G2S1)*
>
> *'I sometimes could not follow the listening because I was worried about the idea and then I couldn't follow the ongoing listening. I find myself blank during listening.' (G2S2)*
>
> *'I use a lot of brain because I have tried very hard to guess words I don't know. When answering questions, I tried so hard to remember words, but I couldn't do it, anyway.' (G2S7)*
>
> *'I couldn't concentrate on listening all the time. When I tried to concentrate a lot, I just simply forgot and lost concentration.' (G2S9)*

These remarks demonstrate that for some participants when they concentrated on listening, the ability to answer questions decreased because the participants 'forgot' or 'became blank' after listening. This means that the split-attention format led for some to information overload in cognitive capacity, and their ability to process listening information further in answering questions became lost because of the information overload. This is analogous to the *Narrow limit of change principle* in information processing (Sweller *et al.*, 2011), where only limited pieces of information are stored due to limited working memory capacity. Additional information will automatically be excluded when the storage is filled up.

In processing information in either integrated or split-attention listening format, participants processed the listening information differently. Participants in the integrated format benefited from more cognitive capacity when they listened and stopped to process the information. However, some learners perceived such a format as deviating their concentration from the listening text. When it came to the split-attention format where participants concentrated on listening to the entire text and then answering questions, they perceived information to overload in their cognitive capacity.

In the next section, the summary of remarks from the semi-structured interviews on listening experiment will be presented.

4.6.4 Summary of interview results on listening experiment

Remarks by learners in the integrated listening format pointed out to language used in the listening text to hinder their learning, but the arrangement of listening text into separate paragraphs embedded with questions helped them to process listening information. When participants listened and stopped to answer questions, they felt they could take their time to think and learn, which means that more cognitive capacity was available. Although language is difficult, integrated listening was perceived by learners to support their learning – thus effective processing in cognitive capacity was enhanced. Although the majority of participants in the integrated group liked this format, there were some participants who negatively perceived such a format to ‘interrupt’ their concentration.

When it comes to the split-attention format, where learners listen to the text and answer all questions at the end, it was found that the majority of participants perceived the text to be difficult in terms of linguistic aspects of the text. This suggests that language difficulty might be a major factor in hindering participants’ learning in the integrated format, but the split-attention format increased the demands on learners’ cognitive capacity. They perceived this to be because in the split-attention format, the group listened to the entire text, whereas those in the integrated group listened bit by bit which resulted in less cognitive capacity for information processing, but their perceptions toward speed and accent were not negative.

In addition to speed and accent, the presentation of listening with all questions at the end seemed to cause more cognitive load in the split-attention group, in that participants’ minds became ‘blank’ when answering questions. Learners might not take in all the listening information. This means that the cognitive capacity of learners in processing the listening text was filled up in attending to the listening text only, and the availability of cognitive capacity for answering questions was less likely available.

In summary, the integrated listening format increased demands on cognitive capacity in learners to process the listening information, i.e. germane cognitive load (Sweller *et al.*, 2011) more than for the split-attention format, even though language used in the listening text was perceived as difficult by both groups. The perception of split-attention group toward information overload in the listening text could have been also corresponded by linguistic difficulty of the text. This results in a less cognitive capacity available for the split-attention group.

In the next section, the results of semi-structured interviews in the listening-reading experiment will be reported.

4.6.5 Interview results of listening-reading experiment

In listening and reading, the two presentation formats resulted in different learning and demands on cognitive capacity. Given the fact that a listening text is difficult in terms of its language, a different presentation of written form (or reading) support or hinder comprehension. When a graphic summary of information was given to learners, i.e. a modality task, learners could have supplemented listening with a visual memory and used the given picture to guide their listening efficiently. However, when the transcript of listening was given to language learners, i.e. a redundancy task, additional information could have hindered or supported learning. In the following sections, semi-structured interview results of another ten volunteers from the modality task (within the integrated group) and another eight volunteers from the redundancy task (within the spit-attention group) will be revealed. As in the sections above, this is categorised into characteristics of materials, text presentations and self-perception toward instructional learning.

Theme 1: Characteristics of materials

With regard to the listening text, language was perceived to be a major challenge by participants from both modality and redundancy groups. The perception of language difficulty could be categorised into two major factors: vocabulary, and speed and accent.

In terms of vocabulary, both groups reported that vocabulary used in the listening text was beyond their background knowledge and perceived as difficult as follows:

> *'I could say the listening is difficult because there are a lot of technical words in the listening.' (G1S4)*
>
> *'Vocabulary in the last part of the story, something like 'innovation', is difficult.' (G1S5)*

'I didn't understand contents in the listening, something like IT.' (G1S6)

'The text is difficult for me because there are so many business words, which I don't know.' (G2S7)

'I think it's a bit difficult for me because the text is all about business…' (G2S8)

In addition to the difficulty of vocabulary, accent and speed were also perceived as difficult, i.e. it was too fast and not clear, as reported by participants from both groups below.

'The speed is a bit fast and when I can't focus on a point in listening, I couldn't concentrate on the next listening bit.' (G1S8)

'The accent in the listening and the speed makes the listening difficult for me.' (G1S9)

'In the listening, some words are not quite clear – maybe because of the clip. The listening is also too fast.' (G2S4)

'In the listening text, the speed is a bit too fast.' (G2S6)

It is possible that participants from both modality and redundancy groups perceived linguistic characteristics in the listening text as difficult because the topics of content were on 'business' and 'IT', which were beyond participants' knowledge. Although participants from both group shared similar perceptions, when both groups interacted with different written forms of the listening text, they reported different perceptions.

For the modality group, participants listened to the text and saw a graphic summary as a diagram. They reported their perception toward the diagram positively as follows:

'The diagram contains pictures and linking story, and this help me remember information better from the listening' (G1S2)

'The diagram is clearer. I can see the overall picture of the story from the diagram.' (G1S3)

'The diagram is easy to understand because information is linked through flowchart. The diagram contains keywords and the flow of information. This makes me understand the whole story better.' (G1S5)

The diagram was perceived to help participants in the modality group to see a clear picture and understand the whole story better from listening. Keywords and the flow of information illustrated in the diagram could help alleviate language difficulty in the listening as perceived by the participants.

When it came to reading in the redundancy group, the majority of participants reported that the reading script was too long and difficult, as follows:

> *'I think the content in the text is too much too.' (G2S1)*
>
> *'But there are a lot of words I don't understand in the reading text, and I think the reading is difficult too.' (G2S4)*
>
> *'The text is difficult for me because there are so many business words, which I don't know.' (G2S7)*

As demonstrated, participants in the redundancy group perceived the reading text to be difficult. This means that the reading information, although it is similar to the listening text, made more demands on cognitive capacity of participants. Despite difficulty factor, however, there are some participants favouring the reading script as follows:

> *'I think it's a little difficult but I could see from the text, so it's not too difficult.' (G2S1)*
>
> *'I don't think language in the text is too difficult; I can make sense of the story.' (G2S8)*

The above evidence shows that some participants in the redundancy group regarded the reading text to supplement their understanding of the listening text. The difficulty of listening was lowered when participants could 'see' the text.

We can conclude that when participants interacted with listening and reading at the same time, both groups of modality and redundancy perceived the listening to be difficult in terms of language. However, reading information in different presentations resulted in different perceptions. For the modality group, a graphic summary in a diagram provided learners with an overall picture of listening, keywords and the flow of information (see Appendix 4a). When it comes to the redundancy group, the majority of participants perceived the reading script to be difficult with too much information, although some participants perceived it to help them see the listening text and to make sense of the story.

In the next section, learners' perceptions toward text presentations will be reported.

Theme 2: Text presentation

In the previous section, it was found that listening information was difficult for participants in both modality and redundancy groups. Also, reading information to supplement the listening was perceived differently in terms of material characteristics. In this section, information regarding different text presentations of reading information as perceived by participants in both groups will be presented.

Participants in the modality group saw a summary graphic of listening information in a diagram. They reported positive perceptions toward the presentation of text as follows:

> *'I think this is good enough because the diagram contains main ideas and pictures to guide listening, and the listening gives more information to the diagram.' (G1S1)*
>
> *'… I could grasp the main ideas more because I used the diagram. For example, I learned how 'R&D' is linked to 'business innovation' because I used the diagram to guide my understanding from the listening' (G1S2)*
>
> *'I focused on words in the diagram and used those words to guide me to listening for detail.' (G1S5)*
>
> *'I followed the story based on the diagram. I could use the diagram to organise information in my mind during listening.' (G1S7)*

As can be seen from the above remarks, the listening text and summary diagram were successfully presented in parallel to guide listening for some. However, some participants in this group reported the presentation in this format negatively and this may have overloaded their cognitive capacity as follows:

> *'The diagram contained only rough information of the flow of overall story, but I still don't understand the diagram because of difficult vocabulary.' (G1S7)*
>
> *'I think the diagram and the listening are not similar. When I read the diagram I thought of another picture, but when I listened to the story, additional information from the listening broke my picture and this didn't make me remember the story. (G1S10)*

When it comes to listening and reading a transcript of the listening, i.e. a redundancy effect, participants reported mixed feelings. Some participants regarded additional information as difficult as follows:

'I focused on the listening, but when I didn't understand something I would look at the script. Still, I couldn't understand because I don't know the meaning of words.' (G2S2)

''I think the text is difficult because there are so many words that I didn't know and I can't translate. I think the text is too long.' (G2S5)

The above remarks indicate if participants do not have the vocabulary to understand listening, reading from the script is not helpful. That could be why some participants perceived the reading text to be 'too long' (*G2S5*).

Where the reading script might add more information and overload cognitive capacity, some participants supported the use of listening script in listening, as reported below:

'In the listening text, I couldn't understand some words, but I could guess meanings of the word by looking at the context of the unknown words in the reading text. During listening, I sometimes got stuck with unknown words and tried to guess meaning of the words in the reading text, although the listening has continued.' (G2S6)

'The reading text helped me too because I could see words I don't know and guessed the meaning of the words in Thai.' (G2S7)

As shown in the above remarks, some participants used the listening script in supporting their listening, guessing meanings of unknown words from context. This means that participants perceived the use of the script as helpful.

At this point in discussion, we can say that the presentation of the summary diagram for the integrated group helped guide participants to listen to the text, except for some cases where the diagram seemed to be a problem in listening. Some participants in the redundancy group regarded the listening script as helping them guess words from context except for some cases where the script did not help listening. These interviews show individual differences in use of strategies.

In the next section, learning results from both modality and redundancy groups as perceived by the participants will be presented.

Theme 3: Self-report toward learning using instructional materials

When it comes to learning with the two presentations, participants from both modality and redundancy groups reported their perceptions differently. In the modality group, the majority of participants focused on the diagram more than the listening. However, information in the diagram helped participants concentrate and remember listening information, as reported below:

> *'I think listening and reading the diagram at the same time makes me remember the story more because, in the listening, when I hear the word 'sustaining innovation', I could see a picture from the diagram. This helps me understand and remember where the word is in the whole story and the context around the word.' (G1S1)*
>
> *'I couldn't remember some information from the listening, but the pictures in the diagram helped me recognise information. I remember pictures in the diagram to help me understand listening. When there are difficult words, I don't need to create my own pictures in my mind because the pictures are already available for me to understand the text.' (G1S4)*

During listening, participants processed in a dual mode in their cognitive capacity because pictures in the diagram were used to co-construct listening information when participants were listening to the text, i.e. *Dual Coding Approach* (Paivio, 1990, 2014a, 2014b; Sadoski and Paivio, 2001).

Overall that participants perceived learning from modality format to support cognitive processing, there was a case where the participant could not process in the dual mode of learning from listening and the diagram, as follows:

> *'I could understand the diagram, but when I listened to the story, information in the listening makes the flow in my mind distorted. This is because of adding information from listening to the pictures.' (G1S10)*

These remarks show that when listening and reading a diagram, some participants might be confused by incoming information in the listening.

With regard to another dual mode of learning, i.e. listening and reading the listening transcript, some participants focused on reading more than listening.

'I focus on the reading more because I could see words and understand the text. This is because when I don't understand the listening, I can look for words and sentences in the reading text.' (G2S4)

'I think the text helps me understand the content, but my concentration was only on the reading text.' (G2S5)

'I think the reading script helped me a lot because I could see words that I don't know.' (G2S7)

This means that the transcript can play a role in adding and supplementing information which is not as easily available from listening. However, in some cases when participants concentrated on reading more than listening, this led to a lack of focus as follows:

'I just skipped difficult words in the reading text and continued reading because if I stopped to read, I couldn't follow the listening.' (G2S5)

''I needed to concentrate a lot because, during listening, I needed to follow contents in the reading text. Sometimes, my mind got blank during reading and I needed to refocus where the listening was. I focused more on reading rather than listening.' (G2S6)

Participants learnt from a dual mode of listening and reading the listening transcript in different ways: information was supplemented or ignored, depending on how much participants concentrated on the reading text.

Participants in the redundancy group reported their perceptions toward the dual mode of learning with respect to taking in information as follows:

'I could remember the information in chunks. I remembered information through linking information in my mind.' (G2S2)

'I remember keywords from the listening. I could answer questions because I could remember keywords, such as 'factors' and this keyword is in the question.' (G2S3)

The above examples show that participants in the redundancy group could remember words or chunks of information from listening and reading, but the majority of participants in this group could only remember the overall picture with no detailed information, as follows:

'I summarised a big picture of the text in my mind. For example, I remember how many groups of businesses there are and what description of

each group is. I remembered the content in English, organised the information in my mind according to the reading text.' (G2S4)

'I can't exactly remember the three ways of business because the words are difficult, but I did understand an overall concept of each type of business. I did this in Thai. For example, when the listening is about the three types of business, I could picture the three types in my mind.' (G2S7)

The two examples above demonstrated that when participants did not rely on the reading transcript too often, they felt they could spare some capacity to process listening information and remembered the gist of information. Participants' reaction to the reading text in the redundancy condition resulted in more cognitive capacity to process information effectively.

At this point in discussion, we can conclude that in working with instructional materials of listening and reading, participants from both modality and redundancy groups benefit from the dual mode of learning. For the modality group, learners was predicted to use a dual mode of learning in processing both pictures and listening information, whereas, in the redundancy group, an average-to-minimal focus on reading transcript decreased the cognitive capacity of learners. However, the shift of attention to reading was reported to result in information missed due to information overload.

In the following section, a summary of findings in the dual mode of learning listening and reading will be presented.

4.6.6 Summary of interview results on listening-reading experiment

From the learners' remarks, it appears that that when learning in a dual mode of listening and reading, the majority of participants perceived the listening text to be difficult. Characteristics of listening which were perceived by all were linguistic aspects of the text. However, when learning from different modes of presentation, i.e. modality and redundancy, participants from each group perceived each format differently.

In the modality group, a diagram with a graphic summary was perceived to contain clear pictures and flow of information. It contained keywords which were perceived to help guide listening. When learning from the dual mode of learning, participants in the modality group perceived the diagram to provide an overall picture of listening text, except for some cases where both diagram and listening were problematic for participants' learning due to language difficulty in both listening and diagram reading.

When it comes to the redundancy group, both listening and reading the transcript were perceived to be difficult because of unknown words and too long information. This means that there was information overload, yet some participants in this group perceived the transcript to help guide their learning.

The results of perceptions of obtaining information from both types of text presentation were different. In the modality group, listening while seeing a diagram could have resulted in available cognitive capacity for processing by filling in information from listening with keywords and pictures. When it comes to the redundancy format, participants said they could not remember detailed information from either listening or reading because their attention was on reading more than listening, and both were negatively affected. However, when participants concentrated less on reading the script, they freed their cognitive capacity to process the information while listening. This can be summarised as following: intake of information in the redundancy format led to overload, but when participants were able to use reading to supplement listening, they said they processed listening information better.

4.7 Summary of quantitative and qualitative data

In this section, both quantitative and qualitative results will be used to co-constructively answer the three research questions (see Table 4.12).

From the three experiments on reading, listening and listening-reading, different statistical tests revealed different pictures for research question 1. It was hypothesised that integrated reading resulted in better retention than split-attention reading (H_{1a}); integrated listening led to better retention than split-attention listening (H_{1b}); and listening-speaking modality resulted in better retention than redundancy listening (H_{1c}). Mean difference comparisons between predicted supportive and hindering cognitive loads revealed that, in the learning phases of reading and listening, integrated variables led to better information retention than the split-attention variables. Although there was no statistical mean difference in the learning phase of listening-reading, the results of modality variable in the testing phase were significantly higher than for the redundancy variable. This means that, in general, the different cognitive load variables supported the learning results, i.e. information retention, when Thai EFL learners learnt from the integrated reading and integrated listening, and when they were tested after learning from the modality listening-reading. However, in each cognitive load variable, paired t-test results pointed out no statistically significant differences, except for the modality condition. Each condition led to the recognition of information after reading, listening and listening-reading and/or being tested, and cognitive capacity was filled up. This means that the learners did not retain reading, listening and listening-reading information significantly when they learnt from modified instructional materials in both supportive and hindering cognitive loads, except for the modality condition.

Regarding the partial acceptance of the hypotheses in research question 1, both quantitative and qualitative data were used to co-constructively answer research question 2. Statistically, integrated and modality variables, when being tested against ANOVA analysis, supported the hypothesis H_{2a} that integrated reading supports learning more than integrated listening and modality listening-reading. Learners reported that they were able to remember reading and listening information in the integrated tasks since the incoming information from instructional materials was bit by bit. This allowed them to stop to process information more effectively with fewer demands on cognitive capacity. The split-attention also helped them to retain information, partially accepted the hypothesis H_{2b} in that split-attention reading supports learning more than split-attention listening and redundancy listening-reading, but because of language difficulty and information overload, the overflow of information resulted in less effective retention.

In the dual mode of listening-reading learning, the task played a role in supporting them to retain information in a later stage afterwards, according to an ANOVA analysis. This is because the graphic summary of modality task provided a big picture to see the clear process of listening content. This allowed learners to use spare cognitive capacity for difficult listening information. However, the redundancy task also helped support learners to retain information in the learning phase (as there was no statistical difference in the learning phase of listening-reading). This was because learners attended to the listening script to guide their listening minimally as their attention was on listening mainly. This means that the cognitive capacity was not filled up, and this allows it to be free for additional listening information.

The conclusion for the best candidate for reading, listening and listening+reading comprehension could be the supportive load variables, especially on the integrated reading. This is because learners stopped to process reading information before reading the entire text. However, it is important to also note that stopping to read and process additional information could lead to deviating attention from concentration on the main text, according to some reports from participants.

In interacting with instructional materials with different cognitive load variables, the learners reported their perceptions differently. As the results of subjective rating scales revealed, integrated reading was perceived to be less complicated than split-attention reading, accepting the hypothesis H_{3a} in that integrated reading is perceived by learners as less difficult than split-attention reading. This is because stopping and thinking for reading information bit by bit decreased extraneous cognitive load and increased germane cognitive load. Learners also reported their perception toward their instructional learning in that learning from use of the integrated reading was easier than split-attention reading because they could stop to process information one set at a time, and they said they could remember information in the reading better. The split-attention reading was less effective since description boxes embedded in the text led to the deviation of attention, which resulted in cognitive overload and forgetting the reading information.

In listening, the integrated group perceived the listening text to be more difficult than the split-attention group, rejecting the hypothesis H_{3b} in that integrated listening is perceived by learners as less difficult than split-attention listening, according to the subjective rating scales. Intrinsic and extraneous cognitive loads were rated higher in the integrated listening than in the split-attention listening. The integrated listening text was perceived to contain more difficult language and instructions than the split-attention listening. However, the interview results revealed that participants from both the integrated and split-attention groups perceived the listening text to be difficult, but the presentation of text was perceived to result in less cognitive capacity used in the integrated listening. The learners using the integrated listening reported that the integrated listening task allowed time for them to process the listening information after each question one at a time. This is confirmed by a higher germane cognitive load perceived in the integrated listening, which means that the integrated listening allows more cognitive capacity available for learners to process listening information and think further in the listening task. An opposite result in the split-attention revealed less germane cognitive load in the subjective rating scales. This means that the cognitive capacity of split-attention was filled up to process more information since the interview data pointed to linguistic difficulty and too much information to process.

As for the dual mode of listening-reading, subjective rating scales revealed that the modality of listening-reading was more difficult than the redundancy listening-reading, rejecting the hypothesis H_{3c} in that modality listening+reading is perceived by learners as less difficult than redundancy listening+reading. Learners reported that the listening text was more difficult resulting in more demands for processing than the redundancy listening-reading. However, the interview data showed that participants from both groups regarded the listening text to be difficult because the topic was beyond their background knowledge. Since learners in the redundancy group could see the listening script during listening, they might have rated the subjective rating scales as not too difficult in terms of language and instructions compared to the modality task. In interacting with the listening-reading materials, the modality listening-reading was perceived to provide learners with a big picture, but this big picture might not be enough for processing all the listening information, as participants reported in the subjective rating scales.

The interview data revealed a different point of view on text presentation of listening-reading materials. Learners in the modality group had more positive perceptions of the use of graphic summary compared to reading the listening script for participants in the redundancy group, although some learners in the redundancy group supported the use of listening script to guide their listening. Revealing how much cognitive capacity was perceived to be used during listening-reading, learners thought the listening text was more difficult in the modality group on the subjective rating, but the reading presentation of the modality listening-reading was perceived to enhance cognitive capacity to process listening information, based on the interview results. When learners paid less attention to the listening script, the redundancy condition did not negatively affect cognitive capacity.

4.8 Conclusion

In this chapter, the results of experimental studies, subjective-rating scales and semi-structured interviews were reported in conjunction with answering research questions. It was found that instructional materials with the presentation of integrated reading, integrated listening and modality listening-reading under the framework of Cognitive Load Theory resulted in better learning and retention than split-attention reading, split-attention listening and redundancy listening-reading tasks. However, subjective-rating scales in Experiments 1 and 2 were not statistically significantly different between integrated tasks and split-attention tasks. A reversed result of subjective-rating scales on modality and redundancy effects were found, which is in contrast to the learning result in Experiment 3. The qualitative interview information also supplied different results on learning using integrated, split-attention, modality and redundancy tasks. Participants who favoured the integrated reading and the integrated listening reported to learn and process reading and listening information gradually, resulting in better processing, but some participants learning from the integrated tasks reported that the reading and listening tasks were confusing because of disconnected parts of information. Those learning from the modality listening-reading task reported to process EFL listening better when they followed the diagram, but some were confused with both listening and diagram because the diagram and listening were pictured differently in ones' imaginations. Those learning from the redundancy reading-listening task reported the task to be too challenging, but some participants favoured the redundancy tasks because they could see the passage while listening. The only possible support of redundancy task is that, during listening, learners who paid a particular attention to listening rather than reading could gain more understanding. These results mean that modified instructional materials under supportive cognitive load effects could help learners learn EFL reading and listening better than hindering cognitive load effects.

In the next chapter, significant points of findings from the mixed-methods approach will be discussed against existing literature and combined to answer research questions.

Table 4.12 Answering research questions from quantitative and qualitative results

Main RQ: Can learners process information in their working memory better from modified instructional materials?		
<u>ANSWER</u>: Learners' WM resources affected learning and testing scores in all CL variables, but supportive CL variables supported short-term retentions in the learning and/or testing phases. No CL variables were found to support recognition, or long-term retention in long-term memory, except for the modality task.		
RQ1: Is there an association between learners' information retention and English listening, reading and reading-listening materials?		
Hypotheses	**Independent-samples t-tests**	**Paired t-tests** *(learning and testing phases)*
H_{1a} *Integrated reading results in better retention than split-attention reading.*	Accepted *(integrated reading >retention> split-attention reading)*	Rejected *Integrated reading: no retention from the learning to testing phases*
H_{1b} *Integrated listening results in better retention than split-attention reading.*	Accepted *(integrated listening >retention> split-attention listening)*	Rejected *Integrated listening: no retention from the learning to the testing phases*
H_{1c} *Modality listening-reading results in better retention than redundancy listening-reading.*	Accepted *(modality >retention> redundancy)*	Accepted *Modality listening-reading: retention from the learning to the testing phases*
RQ2: What kind of modified materials best supports learners' language learning?		
Hypotheses H_{2a} *In supportive cognitive load, integrated reading supports learning more than integrated listening and modality listening-reading.*	**ANOVA analysis** Accepted *(integrated reading > integrated listening and modality listening-reading)*	**Interview data** *Stopping to read and listen allows time to process information bit by bit.*
H_{2b} *In hindering cognitive load, split-attention reading supports learning more than split-attention listening and redundancy listening-reading.*	Partially accepted *(split-attention reading > split-attention listening and redundancy listening-reading)*	*Text was perceived as too long to remember. Listening was perceived to be more difficult because of accent.*
RQ3: How much mental effort do learners perceive to use in working with instructional materials?		
Hypotheses	**ANOVA analysis on subjective-rating scales**	**Interview data**
H_{3a} *Integrated reading is perceived by learners as less difficult than split-attention reading.*	Accepted *(integrated reading less complicated than split-attention reading)*	*In integrated reading, stopping to read allows time to process information bit by bit. In split-attention reading, deviation of attention occurred.*
H_{3b} *Integrated listening is perceived by learners as less difficult than split-attention listening.*	Rejected *(integrated listening more difficult than split-attention listening)*	*Listening was perceived as difficult for both tasks but stopping to answer questions during listening one at a time (i.e. integrated listening) was perceived to use less demands on cognitive capacity.*
H_{3c} *Modality listening+reading is perceived by learners as less difficult than redundancy listening+reading.*	Rejected *(modality more difficult than redundancy)*	*Listening was perceived as difficult for both tasks because of the unfamiliar topic. A graphic summary provided a big picture but might not be enough to process all the listening information. Less attention to listening script was perceived to help guiding listening.*

Chapter 5. Discussion

In the this chapter, key issues from the findings (as in Table 4.12) will be discussed against related literature to yield more understanding and research contribution to Cognitive Load Theory in language education.

5.1 EFL instructional materials and information retention

In this section, the results of three experiments on information retention and recognition will be discussed in connection with research questions as follows

5.1.1 EFL instructional materials and information retention

This section discusses the findings of this research study to reveal answers for the sub-questions 1 and 2. The results of learning from EFL instructional materials and efficient information retention will be reported.

RQ1: *Is there an association between learners' information retention and English listening, reading and reading-listening materials?*

RQ2: *What kind of modified materials best supports students' language learning?*

The independent-samples t-tests from the three experiments revealed that Thai EFL learners who used the integrated reading (Experiment 1) and the integrated listening (Experiment 2) tasks resulted in better scores in the learning phases than the split-attention reading and the split-attention listening tasks. This means that the supportive cognitive load, i.e. integrated tasks, in both reading and listening resulted in better learning than the split-attention reading and listening tasks. However, effective retention from the learning and the testing phases were found only in the integrated reading and modality tasks, not the integrated listening. These results were in line with Cognitive Load Theory (Sweller *et al.*, 2011) in that when the presentation of information was integrated from different sources for learning, the result of cognitive load was less than that of the split-attention effect, i.e. it was a hindering cognitive load effect.

These findings are also similar to research from Cierniak *et al.* (2009), Hung (2009), and Al-Shehri and Gitsaki (2010) in that the integrated tasks on EFL learning led to more comprehension scores and learning than the split-attention effect. However, the present research study yielded different findings from Hung (2009) in that the Thai EFL learners studied showed better retention in the testing phases of reading and listening-reading than the split-attention and redundancy effect groups. This means that, in terms of learning with cognitive load, the learners could process the integrated reading information from the integrated task and integrated information from the modality listening-reading task better than the split-attention and redundancy tasks, and this helped them retain EFL reading and listening-reading information better than the split-attention and redundancy tasks. This was also shown in the subjective-rating task where the germane cognitive load of integrated reading (Experiment 1) was viewed as significantly better than the split-attention reading. In addition, learners' WM resources were activated during learning, testing and recognition as found in both WM resources and experimental studies as well as WM resources and subjective rating scales. As claimed by Cowan (1988, 2005, 2014), Sweller (2011, 2016) and Jiang (2017), when the information entered long-term memory, the result of working memory capacity to process the information is unlimited because of the result of germane cognitive load in reconstructing schema, i.e. semantic meaning at a discourse level.

When it comes to the integrated listening task, the results of perception of germane cognitive load for subjective-rating scale were not statistically significantly different from the split-attention effect. This means that, even though the integrated listening task resulted in better learning from quantitative analysis, this task and the split-attention listening task were perceived as similarly difficult. When we examined the results of retention of listening in the testing phase more closely, scores of both integrated listening and split-attention listening tasks were low, at the averages of 3.85 and 3.08, respectively. In addition, the subjective-rating of integrated and split-attention listening tasks was not significantly different in terms of intrinsic and extrinsic cognitive load types. This means that neither listening groups retained information efficiently regardless of supportive or hindering cognitive loads. Both groups of listening significantly demonstrated to use their WM resources during learning and being tested as evidence found in WM resources and experimental studies. According to Call (1985) and Ohata (2006), auditory information was found to be challenging for second language processing since working memory span for L2 input processing is more limited than that used in processing one's native language. Call further pointed out that auditory information in working memory is difficult to process because learners needed to hold as much information as possible prior to interpreting meaning from the input. Evidence of semi-structured interviews shows that vocabulary and linguistic structures challenged the participants from both groups to process. This finding resonates what Vandergrift and Baker (2015) advocated in terms of a strong correlation between L2 vocabulary and L2 listening comprehension. This means that, in L2 listening processes, participants from both groups tended to overuse the bottom-up processes to deal with linguistic challenges, thereby trading off the top-up listening process, resulting in no memory resources left for processing listening, as found in Ligeza *et al.* (2017).

Listening was found to create more difficulties for retention, and this is reflected in listening-reading learning in Experiment 3 (listening-reading). But, modality (listening + picture) and redundancy (listening + reading) tasks were not significantly different in the learning phase, and results from the two tasks were low. However, the modality listening-reading task resulted in better retention in the testing phase than the redundancy phase. This is partly in line with findings of Sydorenko (2010), Sombatteera and Kalyuga (2012), Mayer *et al.* (2014) and Lee and Mayer (2015) in that the modality of listening with a graphic were better than listening with reading with a transcript or captions to read on the comprehension tests. However, the modality task was only more efficient than the redundancy task when learners were tested in the testing phase.

There are two possible reasons why the present study's results were partly different from those of Sydorenko (2010), Sombatteera and Kalyuga (2012), Mayer *et al.* (2014) and Lee and Mayer (2015). Firstly, listening information in the learning phase was intrinsically difficult from learners' point of view. When learners looked at the graphic summary in the modality task, the listening information was perceived to impose a greater cognitive load than the redundancy effect. These learners in the modality effect did not see the transcript. The availability of a graphic summary during listening means using two different modes of sensory processing, i.e. the phonological loop and the visuospatial sketchpad (Baddeley, 1992, 2006, 2007). When the auditory information entered the phonological loop, the learners' ability to hold the auditory information long enough to process it efficiently was challenged (Call, 1985, Ohata, 2006). This leaves the memory capacity in the visuospatial sketchpad to process the visual information, i.e. the graphic summary, alongside the listening text, resulting in an overload of listening information in the phonological loop. This is different from the perception of the redundancy task in that learners saw the transcript, which they, then, perceived as guiding their listening, unlike the graphic summary. This is explained in Chen *et al.* (2012) and Mayer *et al.* (2014) in the reversed redundancy effect studies that redundant materials, i.e. listening and reading texts, basically support cognitive processing when EFL learners are not yet able to process the auditory information automatically.

Another reason for the different findings of the present study from Sydorenko (2010), Sombatteera and Kalyuga (2012), Mayer *et al.* (2014) and Lee and Mayer (2015) is that learners retained the listening information from the modality and the redundancy tasks differently. In the modality task, learners reported in the interviews that they remembered the graphic summary in the testing phase, whereas learners in the redundancy group did not remember listening information, even though they could see the transcript during listening. This could be explained by the Levels of Processing framework by Craik and Lockhart (1972) in that when EFL learners read a text, the surface level of text is lost in memory, but the deep level of semantic processing remains. Given the fact that the graphic summary was still remembered by learners in the modality task, the trace of listening retention was triggered from learners' long-term memory (Cowan, 1988, 2005, 2014), i.e. non-linguistic cognitive knowledge (Craik and Lockhart, 1972). According to Verhoeven and Perfetti (2008), the presence of graphic memory in some learners' memory means that there existed mental images for processing listening. This supports what Field (2004, 2008) and Henderson (2017) suggested as balancing the top-down and bottom-up processes. However, in views of WM resources, evidence of WM resources from both groups of learners on listening-reading showed that listening processing was affected by learners' WM resources. This means that WM plays a role in learners' processing of redundancy and modality listening-reading, but the WM resources in the redundancy group was overflowed by both listening and reading the script. Instead of supporting listening by means of reading script by means of visualising pictures from the script (Lee and Mayer, 2015), participants in the redundancy group who concentrated too much on the listening script employed bottom-up processes too much – this trades off the top-down listening processes (Ligeza *et al.*, 2017).

At this point in discussion, we can conclude that the best candidate for cognitive load effects for efficient EFL learning is integrated reading (Research Question 2). As for the listening information, integrated listening better supported EFL learning than the split-attention listening. For the dual mode of listening-reading learning, the availability of a graphic summary in the modality task resulted in better retention, but not in efficient learning, compared to the redundancy task. This supports hypotheses of the Research Question 1 concerning the association between modified instructional materials and EFL reading, listening and listening-reading.

In the next section, a closer look at how instructional materials supported EFL learning through recognition tests will be discussed in the context of working memory models.

5.1.2 EFL instructional materials and recognition

With regard to the discussions in 5.1.1, it was found that, in terms of learning, integrated reading and integrated listening were better for cognitive processing than split-attention reading and split-attention listening. Regarding information retention, integrated reading and modality listening-reading were better for information recall than split-attention reading and redundancy listening-reading. This means that, from experimental studies, Cognitive Load Theory was suitable for the design of instructional materials for language learning and processing. However, a discrepancy of findings within Experiment 2 listening, and the mismatch of learning and information retention in Experiment 3 need a further discussion from Working Memory point of view as follows.

According to Postman *et al.* (1974) and Baddeley (1992, 2006, 2007), working memory (WM) can be assessed from *recall* (direct evidence of information retention) and *recognition* processes (trace of information retention). The results from three experiments confirmed that *recall* could be tested directly through information retention as discussed in the previous section. In terms of *recognition*, this study employed three measurements to test the access to working memory and cognitive load, i.e. Ray Auditory Verbal Learning Test (RAVLT) in the pre-test, subjective load rating scales (perceptions on cognitive load), and Reading Span Task in the delayed post-test, as well as interviews. The following explains how recognition was in relation to cognitive load and working memory.

These Thai EFL learners' working memory prior to participating in learning from the three experimental tasks seemed to be activated in learning (as there were statistically significant differences in the WM pre-tests). This means that the traces of learning from reading, listening and listening-reading entered learners' long-term memory as shown by the results of recognition tests. This could be explained by Geary (2002), Geary and Berch (2016), and Sweller *et al.* (2011) under the *environmental organising and linking principle* of the five natural language processing principles in that, for learners, cognitive load variables, i.e. presentation modes, were used to activate their long-term memory as they learnt reading, listening and listening-reading information in the learning phase. Participants uptaking information through language forms, i.e. reading or listening, could store information in their long-term memory and recruit long-term memory information to their working memory during the recognition test. This means that, although supportive cognitive load could play a role in efficient learning, learners' processing still registered learnt information in their long-term memory, resulting in no statistically significantly differences between integrated and split-attention tasks in the recognition phases of Experiments 1 and 2. Learners' WM verbal resources were also found to be in a direct association with learners' perceived cognitive load in both groups of learners on supportive CL and detrimental CL interventions. This can be implied that, in the recognition task, learnt information was brought from learners' long-term memory to engage with the external stimuli, i.e. the recognition tasks, in WM. This supports Cognitive Load Theory, especially in terms of delayed test effect (Sweller, 2019), where tests which are used to measure learners' processing of information in later stage could yield more evidence of registered information in learners' long-term memory. However, the evidence of no significant differences between supportive and detrimental CL on recognition resonate what Hung (2009) concluded in his study that cognitive load effects supported learning only, but there was no different effect found in later stage.

The above notion could be explained through *encoding-specificity principle* (Tulving and Thomson, 1973), in that information is remembered better if the encoding and retrieval contexts are similar. In the Experiment 1 reading, the learners were asked to read and answer the true/false recognition statements, whose words and phrases were taken from the reading texts. Also, the words and sentences used in listening were used to design the true/false recognition statements in Experiment 2 listening. The similar contexts of encoding and retrieving could have been one of the factors leading to in the higher scores in the recognition phases of experiments in both reading and listening, as also supported by Budiu *et al.* (2009) and Budiu, (2014). The results of reading span task tested right after the recognition task also demonstrated that there is an immediate test effect when WM measurement is tested immediately after the recognition task. As postulated by Sweller (2019), during engaging with a task, learners tend to employ almost all WM resources in their capacity. This causes WM depletion to later process an immediate test, i.e. the reading span task in the present study.

Another idea which could explain why reading and listening information was recognised similarly between integrated tasks and split-attention tasks is the Working Memory model of Cowan (1988, 2005, 2014). As explained through the Tulving and Thomson's encoding-specificity principle, information in the recognition task, i.e. true/false statements, could have been a factor in triggering the *focus of attention* in participants' long-term memory during the learning phases. Participants could then automatically judge the recognition statements in their working memory in connection to the triggered area of long-term memory as explained in the Cowan's WM model, satisfying the *principle of randomness as genesis* (one of the five natural language processing principles, Geary, 2002, Geary and Berch, 2016, Sweller, 2011, 2015, 2016).

We can conclude that during processing reading and listening information, the learners used their cognitive load and working memory efficiently in learning from supportive cognitive load variables (i.e. *recall* WM). However, in delayed post-tests, reading and listening information stored in participants' long-term memory was triggered similarly from familiar stimuli, i.e. recognition true/false statements, given that participants learnt under different cognitive load variables. This means that Cognitive Load Theory was only suitable for the design of instructional materials and efficient learning, but it did not yield an understanding of how learners recognise stored information.

Another point of consideration are the results of the recognition phase of Experiment 3. It was found that participants who learnt from the modality task recalled and recognised the listening information better than those in the redundancy task. As discussed in previous section, the *recall* information of modality was supported by Baddeley's Working Memory model (1992, 2006, 2007) in information retention from visual and auditory information through the visuospatial sketchpad and phonological loop, and Cognitive Load Theory of modality effect (Sweller *et al.*, 2011, 2017). In terms of recognition participants in the modality task could recognise listening information better than the redundancy effect and the integrated listening task. This evidence demonstrates recognition memory as a result of semantic memory through visual image input at the presence of listening-reading learning (Rotello and Heit, 2000, Medina, 2008). The availability of graphic summary visually during listening stored this sort of representation in participants' long-term memory through the visuospatial sketchpad (Baddeley, 1996). In addition, participants in the modality task reported their perceptions in semi-structured interviews that information in the graphic summary was linked to the listening information, aiding them in better understanding the listening information. This means that the result of better recognition in listening-reading modality was due to the two channels of working memory in Baddeley's Working Memory model as well as the dual-coding representation of information for deeper semantic understanding as described in the *dual-coding approach* by Paivio (1990, 2014a, 2014b) and Sadoski and Paivio (2001). In addition to this, evidence from WM resources yielded no significant differences in WM verbal resources on integrated listening and modality listening-reading. This can be implied that, in processing listening with the support of images, learners processed the familiarity of language, activated by recognition tasks, by associating it with mental image representation, similar to studies by Verhoeven and Perfetti (2008) and Jared *et al.* (2013). This may be a reason why WM verbal resources had no direct relationship with image processing, supporting the independent systems for processing, according to Baddeley (2006, 2007) and Paivio (2014a, 2014b).

To conclude, it could be argued that in learning a foreign language, the ability of recognising foreign language information is also important since it leads to an understanding of whether information is and is not stored in EFL learners' long-term memory. To facilitate learners' taking in reading and listening information efficiently, a teacher could design a task to activate learnt information through similar contexts (as in *encoding-specificity principle* by Tulving and Thomson, 1973). As for the listening-reading information, the presence of visual images could lead to a deeper understanding of listening information as explained by the *dual-coding approach* (Paivio 1990, 2014a, 2014b, Sadoski and Paivio, 2001).

5.1.3 Summary of EFL instructional materials and information retention and recognition

In EFL learning, providing EFL learners with familiar contexts of reading and listening information activates their memory to access to information from reading and listening, given no differences in learning from different text presentations (integrated or split-attention task). Also, to aid the integrated skills of language, i.e. listening-reading, providing learners with the modality task could lead to more efficient retention and recognition of information.

The implications from the findings in terms of SLA is that supportive CL variables, i.e. integrated and modality tasks, helped EFL learners to process reading and listening from the top-down perspective where their semantic meaning was brought into processing information step-by-step in their WM during learning from instructional materials. Selective attention on linguistic complexity, as found in the redundancy task, helped reduce learners' WM resources from the bottom-up point of view. However, in terms of long-term retention, i.e. recognition, the use of picture significantly supported the visuospatial sketchpad in WM to associate it with language processing. This process resonates the balance between top-down and bottom-up processes as suggested in Field (2004, 2008).

In the next section, answers to research question 3, concerning the amount of cognitive load the learners perceived to use in using the instructional materials, will be discussed.

5.2 Learners' perceived difficulty of tasks under cognitive load effects

RQ3: *How much mental effort do students perceive to use in working with instructional materials?*

Data drawn from the results to answer this research question are subjective ratings and semi-structured interviews. According to Clark *et al.* (2006) and Sweller *et al.* (2011), intrinsic and extrinsic cognitive load should be low and germane cognitive load should be high for efficient learning. In terms of subjective ratings of reading experiment, participants rated the intrinsic nature of reading information, i.e. intrinsic cognitive load, and the manner of text presentation, i.e. extrinsic cognitive load, similarly for the integrated reading task and the split-attention reading task. On average, the intrinsic and extrinsic cognitive load of both integrated and split-attention reading tasks scored low. That is the reading tasks from two experimental groups were not very challenging. This echoes the findings in the study by Cierniak *et al.* (2009), in that there was no difference in secondary tasks for integrated L1 reading and split-attention L1 reading. However, in the present study, integrated reading resulted in perception of more germane (or supportive) cognitive load than split-attention reading, so, although reading tasks were perceived as easy in both integrated and split-attention reading, the integrated reading task was felt to enhance processing than the split-attention task. This is supported by participants' interview data. Participants in this group reported that the integrated reading enhanced their comprehension because they could process reading information one section at a time. This supports the top-down process for reading processing (Edin *et al.*, 2009), thereby decreasing the trade-off of memory to concentrate on the bottom-up process, i.e. linguistic complexity (Ligeza *et al.*, 2017). The split-attention task, however, imposed more load on their memory capacity because they needed to remember a large amount of information all together and search for information for the comprehension questions at the end of text. This account can be explained by Cognitive Load Theory (Sweller *et al.*, 2011, Sweller, 2017) in that, when learners need to search for information at different places and hold information (i.e. *split-attention effect*), their cognitive load increases. The overflowing brain with too much bottom-up processes to spare attention to different sources of information in the split-attention effect increases more demand on WM (Ligeza *et al.*, 2017).

Given the fact that the integrated reading task increases germane cognitive load more for EFL learners than the split-attention task, it is interesting why the intrinsic and extrinsic cognitive load in both integrated and split-attention tasks were not different. Results from the interview data revealed that in both integrated and split-attention tasks sentence structures and vocabulary were challenging factors for them to make sense of reading. This is supported by Sweller *et al.* (2011) in terms of task difficulty, in that when the number of interactivities with information is high, a task can be regarded as difficult. In this respect, difficult sentence structures and vocabulary require more mental effort for the reading information. This is why participants in the integrated and split-attention tasks perceived the intrinsic nature of cognitive load in reading texts similarly in terms of these challenges. Evidence from the WM verbal resources on learners' perceived cognitive load also demonstrated that all types of cognitive load, i.e. supportive and detrimental CL, were in a significant relationship with their WM. This means that cognitive load, in terms of intrinsic and extrinsic CL, is affected by WM resources.

Another possible reason for similar results of extrinsic cognitive load is that of text presentation and learners' level of expertise. In an account by Mikk (2008), optimal number of characters for text comprehension (i.e. relevant to intrinsic cognitive load) is between 130-150 characters. This is in line with the integrated reading task, when learners had to stop after reading a paragraph of 100-120 words (i.e. relevant to extrinsic cognitive load), so the amount of information interactivity for integrated reading means a lower cognitive load. However, learners in the split-attention group reported similar perceptions to that of the integrated group. A possible explanation for this is that there was one participant from the split-attention task reporting to love the challenge of the task. According to Yeung *et al.* (1998), Yeung (1999), Genç and Gülözer (2013), when learner's level of expertise increases, perceptions of a split-attention task can reverse, where it is as not too difficult. However, in the quantitative data, that is the actual reading scores of learning phase, the average learning results of split-attention for comprehension and retention (at 4.80) were significantly lower than the integrated task (7.88) at 3.48. Split-attention group perceived the split-attention task as not too challenging, so learners' performance does not support this. The possible of reason for this discrepancy could be what Ismail *et al.* (2013) discussed in terms of motivational resources of the level of expertise. They argue that learners' perception of a task as difficult or easy is explained by increasing germane cognitive load, which is possible for the increase of working memory capacity for including more intrinsic and extrinsic cognitive load. However, given this notion, performance relating to a germane cognitive load of split-attention was also significantly lower than that of the integrated task. This means that neither level of expertise nor motivation in germane cognitive load can be used in explaining the similar perceptions for the split-attention and integrated tasks on intrinsic and extrinsic cognitive load. This, however, needs further study of Cognitive Load Theory.

At this point, we can conclude that in the reading experiment intrinsic and extrinsic cognitive load of integrated and split-attention reading tasks were perceived similarly as not containing too much information (for the integrated task) and not too challenging (for the split-attention task). However, in terms of learning, germane cognitive load of the integrated reading task enhanced reading more than the split-attention reading. This is explained by the interview results where participants in the integrated task reported that they interacted with the reading text pieces one at a time, i.e. low extrinsic cognitive load, but high germane cognitive load. The results were also in line with the quantitative results in favouring the integrated reading task over the split-attention task. This means that the design of integrated reading task, which imposes higher germane cognitive load than the split-attention reading task, supports the top-down processes (Edin *et al.*, 2009) and the theoretical framework of Cognitive Load Theory.

When it comes to the listening experiment, both integrated and split-attention listening were not different in terms of intrinsic, extrinsic and germane cognitive load, even though the learning phase of the listening experiment supports retention from the integrated listening. Evidence from WM resources also showed a significant relationship between listening CL effects and WM verbal resources. This is in line with Ohata (2006) in reporting constraints on listening in short-term working memory. Participants in the interviews reported that both intrinsic and extrinsic cognitive load in the integrated listening task and the split-attention listening task were difficult because of language structures and vocabulary (for both integrated and spit-attention tasks) and speaker's accent (for the split-attention task). This can be explained in terms of Cognitive Load Theory (Sweller *et al.*, 2011) in that an increase in interactivity of intrinsic elements, i.e. structures, vocabulary and accent, in a task indicates an increase in task difficulty. Unseen vocabulary and difficult sentence structures in the listening text in both tasks relates to Call (1985) in terms of the 'knowledge of target language syntax' (p.769) and Vandergrift and Baker (2015) in terms of L2 vocabulary and listening comprehension. Call found and later Ohata (2006) found that when EFL learners possess better knowledge of L2 syntax, their ability to process listening input increases. In this study, learners reported to find vocabulary and sentence structures difficult and unclear. This increased their intrinsic cognitive load to process the listening information because of less syntactic background knowledge in their long-term memory. Also, learners' report of vocabulary challenges showed that they focused too much on the bottom-up listening processes, thereby trading off their WM capacity to balance the top-down and bottom-up processes (Field, 2008, Ligeza *et al.*, 2017). When it comes to the extrinsic cognitive load, some participants in the interviews reported that in the integrated listening task they could think in pictures and sometimes in their L1 after the listening text was stopped. T*he Bilingual dual coding approach* (Paivio, 1990, 2014a, 2014b) notes that when learners process information in both visual and aural information in terms of close association between L1 and L2, their working memory capacity expands and is able to process both visual and aural information efficiently. This is supported by the studies of Cooper *et al.* (2011) where expert learners processed information in imaginations and their cognitive capacity increased to engage in schema construction, i.e. semantic meaning, in long-term memory. The present study, even though learners have not yet reached a high proficiency level (as found in low listening scores in both integrated and split-attention tasks), the integrated task of listening was reported by the learners to allow them some time for listening and information processing, i.e. increased germane cognitive load, which led to a better retention result, i.e. enhanced listening top-down processes, than the split-attention listening task in the listening learning phase.

The results of subjective ratings in listening were in contradictory to ones in the listening-reading task. That is the intrinsic and extrinsic cognitive loads in the modality listening-reading task are significantly higher than those in the redundancy listening-reading task, although the learning results of the two tasks were not significantly different and both cognitive load effects were significantly affected by learners' WM. An explanation for the ratings of difficulty in the modality task might be explained by Moussa-Inaty *et al.* (2011) and Jiang *et al.* (2017) in that in EFL listening, reading only resulted in better learning and subjective ratings when it comes to listening comprehension. A possible reason is from the participants' interviews in which they could 'see' the listening text, which guides them to listen following to listening text. This notion is explained in Chang *et al.* (2011), Chen *et al*. (2012), Studente and Garivaldis (2015) who found that listening to and reading a listening script (or text label in Ari *et al.*, 2014) helped enhance listening comprehension. As participants reported to 'see' the listening text in the interview in the present study, the redundancy effect task was perceived as less difficult in terms of intrinsic and extrinsic cognitive load than the modality task.

However, the perception of task difficulty of modality task over the redundancy task did not lead to less germane cognitive load in the modality task. As reported in the subjective ratings, germane cognitive load was not found to be statistically significantly different between the modality task and the redundancy task. This is also in line with the learning results of Experiment 3. This means that in learning both tasks of listening-reading resulted in a similar extent of retention, even though participants could 'see' the listening script. In further investigating cognitive load of participants in the modality and redundancy task, it was found that the modality task resulted in long-term memory retention and recognition than the redundancy task (see Section 5.1.2 mentioned above). So, in learning from both modality and redundancy tasks, the perceived difficulty of modality seems to be less favourable than the redundancy task, but it helped support information retention because of the available trace of recognition memory in long-term memory. So, the application of Cognitive Load Theory is suitable for the design of modality listening-reading from the recognition point of view.

We can summarise here that the integrated reading task resulted in less cognitive demand than the split attention task. In terms of listening and listening-reading, the listening text imposed high cognitive load in both Experiments 2 and 3. A curious case of listening and reading in learners favouring the redundancy task does not affect the supportive cognitive load in retention and recognition. In fact, both modality and redundancy tasks were challenging for cognitive load learning at the same extent.

In the next section, a conclusive summary of the three research questions will be used to answer the main research question of the present study.

5.3 Summary discussion

Following discussions from the above two sections, the integrated task of reading enhanced retention better than the split-attention reading. In terms of listening, learning from the integrated task was significantly better than the split-attention listening task. As for the listening-reading task, both modality and split-attention tasks resulted in no statistically significantly difference, but the retention result was more favourable in the modality listening-reading task. This concludes the main research question as follows:

Main research question: *Can learners process information in their working memory better from modified listening and reading materials?*

Modified instructional materials based on both Cognitive Load Theory and Working Memory frameworks helped learners learn and retain listening and reading information efficiently. The retention can be achieved when participants engaged in processing reading or listening information little by little through the integrated tasks or stored a graphic summary of listening in their long-term memory through the modality task. Learners' WM had direct effects on learning results in the learning and testing tasks, and these findings supported the top-down processing to balance the trade-off of bottom-up processing. Both product and process results of the present study confirmed that Cognitive Load Theory can be an instructional material framework for EFL instructional design, which includes Working Memory and cognitive processing in illuminating cognitive processing and learning.

In the next chapter, a brief summary of the thesis, research implications for both theory and pedagogy as well as further research recommendations will be presented.

Chapter 6. Conclusion

This study has investigated the relationship between EFL reading-listening instructional materials and Thai EFL learners' information retention. Chapter 1 introduced the topic and research problems for this present study. Chapter 2 discussed related literature in terms of human cognitive architecture, Cognitive Load Theory and instructional materials, followed by Chapter 3 in outlining research design and tools based on the gap of related literature in Chapter 2. Chapter 4 presented detailed findings of experiments, subjective ratings and semi-structured interviews. These were further discussed in detail in Chapter 5. Possible implications on theory and pedagogy, and recommendations for further research will be presented in this chapter.

6.1 Research questions and main argument

The present study aims to investigate whether modified instructional materials help support or hinder learners' information retention, and to what extent learners' mental effort are used to engage with reading, listening and listening-reading materials. It aims to answer the following research questions.

Main research question: *Can learners process information in their working memory better from modified listening and reading materials?*

Sub research questions

1. Is there an association between learners' information retention and English listening, reading and reading-listening materials?

2. What kind of modified materials best supports learners' language learning?

3. How much mental effort do learners perceive to use in working with instructional materials?

It can be argued in the present study that assessing EFL learning through experiments, according to Cognitive Load Theory, yielded only the product results of EFL reading-listening learning and learners' EFL reading-listening information retention from learning. However, in this study, I argued that a mixed-methods approach, including experiments, subjective-rating scales, working memory tests, and semi-structured interviews, could reach an understanding of

EFL cognitive load learning from both product and process perspectives. Thai EFL learners revealed deeper understanding and difficulties of their EFL instructional material learning (mental efforts) as well as their EFL cognitive processing through subjective-rating scales and interviews. This mixed-methods approach disseminated both EFL learning results (product) and learners' self-reports of EFL cognitive load learning (process) to bolster Cognitive Load Theory.

6.2 Contributions of the study

In this section, I discuss how the present study contributed in two major ways – to the existing knowledge and to the methodology in investigating cognitive load learning.

6.2.1 Contributions to the existing knowledge

With regard to the related literature, there is a gap in studies which explore use of Cognitive Load Theory in designing EFL instruction and instructional materials through a mixed-methods approach. In the present study, the existing knowledge of Cognitive Load Theory from the research in designing EFL reading, listening and listening-reading instructional materials was added to through experimental study. However, to try to understand what happened in learners' cognitive processing, the use of subjective rating and semi-structured interviews revealed possible underlying reasons why the integrated tasks and the modality tasks, i.e. supportive cognitive load, resulted in better learning and/or retention than hindering cognitive load, i.e. split-attention and redundancy tasks. Moreover, these interviews showed that when the learners stopped to read or to listen, some of them reported they imagined the reading or listening text as pictures. Two theories might explain this as follows. Firstly, when the learners engaged with reading or listening information, they increased their germane cognitive load, which enhanced long-term memory schema construction (Sweller *et al.*, 2011). Learners reported to understand and think in pictures when they processed reading and listening information one piece at a time. This explains how cognitive capacity was free for processing, i.e. an increase in germane cognitive capacity, which resulted in better retention in the Experiments 1 and 2, supporting Cognitive Load Theory. Another explanation for stopping to read or to listen in integrated tasks is Baddeley's (1992, 2006, 2007) working memory model relevant to the integrated tasks, and *dual coding approach* (Paivio, 1990, 2014a, 2014b) for the modality task. In terms of working memory, learners reported understanding and thinking in pictures when learning from the integrated reading and integrated listening. This means that both the *visual sketchpad* and *phonological loop* of Baddeley's working memory were employed to engage with language information, i.e. reading or listening, which extracted visual information from their long-term memory to link with the reading or the listening information. In terms of listening-reading information, the results of the experiment and the semi-structured interviews supported the *dual coding approach* (Paivio, 1990, 2014a, 2014b), in that both listening and a graphic summary engaged the learners in processing through both visual and aural stores. The coding of visual information in their long-term memory resulted in better retention in the testing phase of Experiment 3. Both the *dual coding theory* and *Baddeley's working memory* explain cognitive processing through a qualitative lens (Kvale, 1996, 1999, 2003), satisfying the mixed-methods approach of the present study.

Another research gap is the lack of a combined construct of Cognitive Load Theory and Working Memory. The findings confirm that the integrated reading resulted in better learning and retention than the split-attention reading, the integrated listening resulted in better learning than the split-attention listening, and the modality listening-reading task resulted in better retention than the redundancy listening-reading. This indicates that supportive cognitive load helped learning and/or retention. Learners' WM resources directly affected their learning and/or retention at no expense of cognitive load effects, meaning that learners' cognitive demand was used in processing information with any cognitive load effects. However, in the recognition phase (i.e. WM measurements) of the three experiments, integrated vs split-attention reading and integrated vs split-attention listening resulted in no statistically significantly differences. Although learning from the integrated reading or integrated listening helped learners with the reading and the listening information, they were able to recognise the reading and the listening information in their working memory at no expense to different cognitive load types, according to paired t-tests between WM tests and the subjective ratings of cognitive load types. This is further explained by *encoding-specificity principle* (Tulving and Thomson, 1973) in recognising similar language used in reading and listening recognition statements and reading and listening information in either integrated and split-attention tasks. In terms of better recognition of the modality listening-reading task over the redundancy listening-reading task, the *recognition memory* of Rotello and Heit (2000) Medina (2008) explains semantic memory through visual information, which resulted in a deeper registration of information in learners' long-term memory. Evidence from WM verbal resources also indicated no processing of images in the phonological loops, but supported the top-down processes (Field, 2004, 2008) and dual-coding theory where a direct association between images and language enhanced listening processing (Paivio, 1990, 2014a, 2014b).

The above two cases of mixing WM theories with Cognitive Load Theory contribute to an understanding of a new combined construct. This satisfies an overall understanding of human cognitive architecture in EFL learning through a cognitive constructivism lens.

6.2.2 Contributions to methodology

As discussed in the above section, a mixed-methods approach explained how different EFL instructional materials have an impact. In terms of practicality of methodology in classroom research, the present study revealed that semi-structured interviews have the potential to explain deeply what happens during learning.

Regarding the use of subjective ratings of cognitive load types, the rating scales revealed only positive support for Experiment 1 (reading). However, no statistically significantly differences were found in different cognitive load variables in Experiment 2 and an opposite result of self-report on cognitive load variables in Experiment 3. The subjective ratings used in Cognitive Load Theory did not correlate with the results of experiments. Rather, semi-structured interviews revealed a better understanding of more efficient step-by-step learning of integrated reading and integrated listening through the lens of germane cognitive load in Cognitive Load Theory. What might underlie the better results for retention and recognition in the modality task was also revealed through semi-structured interviews in that participants said a graphic summary helped support remembering; this is relevant to *dual coding approach* (Paivio, 1990, 2014a, 2014b) and top-down processes (Field, 2004, 2008). These semi-structured interviews are therefore a powerful tool for a teacher researcher to find out more about EFL cognitive processing, which is in line with recommendations by Kvale (1996, 1999, 2003) in using semi-structured interviews to extract and establish psychological understandings.

6.3 Implications of the study

In this section, how findings in this study shed light on the design of EFL reading-listening instructional materials for efficient learning.

6.3.1 Theoretical implications

Under Cognitive Load Theory integrated tasks support learning and imply the design of certain instructional materials. In the present study, it was confirmed that the integrated tasks supported

EFL learning from reading and listening. Evidence from the experimental studies was revealed by statistically significantly learning results sharing that the integrated reading and listening tasks worked better than the split-attention reading and listening tasks. In line with Cognitive Load Theory, integrated tasks are applicable to EFL reading and listening instructional materials. To understand this efficient learning in the use of Cognitive Load Theory, semi-structured interviews revealed that participants dealt with the reading and listening text in the integrated tasks one piece at a time, which is explained by Working Memory models in terms of top-down processing in SLA, supporting Cognitive Load Theory.

Information retention as a result of interaction with texts can only be explained in Experiments 1 and 3 when Cognitive Load Theory is used in the analysis; integrated reading and modality listening-reading tasks resulted in information retention, supporting Cognitive Load Theory. However, in the recognition phase, which employed working memory measurements, the trace of information recognition from reading and listening explains if reading and listening information is or is not stored in learners' long-term memory, supplying the understanding of working memory in Cognitive Load Theory.

Task difficulty, which is relevant to intrinsic cognitive load, was revealed by subjective ratings in conjunction with WM measurements. The intrinsic nature of listening in the integrated and split-attention tasks and listening-reading in modality and redundancy tasks for the subjective ratings used in measuring cognitive load and task difficulty were sometimes inconsistent, especially when they were used in the classroom context of the present study. Semi-structured interviews, used in the present study, offered a clearer understanding of underlying strategies in describing individual cognitive load that participants perceived they used in learning from instructional materials.

6.3.2 Pedagogical implications

The findings of this present study yield three practical implications for the classroom as follows. Firstly, in teaching EFL reading, it advocates the use of integrated reading for information retention in tertiary EFL learning. This is from evidence of experiments, subjective ratings and semi-structured interviews in better scores and favourable comments on the integrated reading task over the split-attention reading task. In terms of listening, the presentation of the text affects EFL learners' learning. When an instructor designs a listening task, presenting the listening text in chunks one at a time helps learners process the information better as evidence shown in the experiments and semi-structured interviews. Alternatively, an instructor could provide EFL learners with a listening script or a graphic summary, but she or he needs to make sure that learners attend to the listening script minimally during listening, or that they study the graphic summary prior to listening. Either way helps EFL learners to listen and process the listening information, especially in long listening texts, as supported by Shipstead *et al.* (2012) in training bottom-up strategies, such as visual stimuli, to enhance listening by means of raising-awareness.

Secondly, in terms of language testing, the use of different tests lead to different results. In testing subject and language knowledge directly, the use of short-answer comprehension questions could be used by an instructor to directly test retention (and possibly comprehension). This is shown in the comprehension test results of learning and testing phases on accessing learning and retention. However, if the tests were designed in terms of true/false questions, the score results might have only revealed what these learners recognised from reading, listening, listening-reading, not in retention and comprehension, as explained by the working memory recognition tests. Evidence from reading span tasks after the recognition tests also pointed to the immediate test effect (Sweller, 2019), where WM resources tend to deplete immediately after processing. So, teachers who design tests to capture reading and listening processes should also be aware of this effect.

The last implication of this study for pedagogy is that of teachers' classroom research. EFL teachers who would like to measure learners' cognitive load during learning can use practical tools, such as subjective ratings and semi-structured interviews, in addition to experimental tests. Findings from semi-structured interviews and subjective ratings were used concurrently in the present study to reveal learners' perceptions when they were learning from instructional materials, which can be regarded as practical ways for cognitive load studies.

6.4 Reflections on the research process

This research project yielded an overall result of product and process investigation of EFL listening-reading materials and learners' information retention. However, it is believed that the research process could have been made more possible to access cognitive processing in the following. Firstly, in the learning phase, the use of subjective rating scales was found to be applicable only in Experiment 1. In this case, it would have been better to use another working memory test, possibly the Reading Span task, to immediately measure that working memory capacity so that cognitive load could be accessed at the time of learning in addition to subjective rating scales. However, whether or not to immediately or delayed test should be taken into consideration because of the immediate test effects (Sweller, 2019). Alternatively, the subjective rating scales might be used in later phases because of the test effect. Secondly, in each experiment, two variables of cognitive load, i.e. supportive and hindering cognitive load, were investigated. It would have been better to include all supportive and all hindering cognitive load in each experiment so that findings of cognitive load effects could be compared at the same experimental situation. Finally, in the recognition phase, it is interesting if a psychological semi-structured interview has been used to access the recognition memory, which is beyond the scope of the present study. This way, the role Working Memory (WM) could be understood from the recognition point of view, fulfilling WM measurements from the recall and recognition perspectives.

6.5 Recommendations for further study

EFL learning not only includes passive skills of reading and listening, but also productive skills, i.e. speaking and writing. The new construct of Cognitive Load Theory plus Working Memory in the design of EFL speaking and writing instructional materials could be added from the present study. Secondly, in terms of Cognitive Load Theory, there are many other cognitive load types that go beyond what the present study looked at, i.e. integrated tasks, split-attention tasks, modality tasks and redundancy tasks. It would be interesting to explore if other cognitive load types, such as worked example, transient information effect could be combined with WM theories in the design of EFL instructional materials. This way, more of Cognitive Load Theory could be applied to the design of EFL instructional materials. Last, but not least, in the present day of information technology, online learning has become more popular in all kinds of learning. Although there exist some studies on Cognitive Load Theory on online learning, it would be interesting to include the new construct of CLT plus WM in explaining EFL online learning. This way, not only CLT is understood in online learning, but an underlying understanding of cognitive load online learning can be explained through WM theories.

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Appendix 1: Research information and students' consent form

Newcastle University ECLS

Information sheet and consent form: PhD research project
English reading-listening instructional materials and students' information retention

Information Sheet for a PhD Research Project:
English reading-listening instructional materials and students' information retention

You are invited to participate in a PhD research project from August 2016 to January 2017. For this project, you will participate in and take tests on reading and listening instructional materials, complete a series of questionnaires, and be interviewed so as to measure the use of English instructional materials to help support your language learning. Before you decide to take part in the project, it is important for you to understand what the project will cover. Please take time to read the following information carefully.

Project description

This project builds on the fact that, in the world of global communication, Asian students, especially Thai learners, find it challenging in obtaining a huge amount of information available. One of the arguments is that students need to learn so many subjects in a day, and this might impede the capacity of working memory required to obtain and retain new knowledge. When learning a foreign language, i.e. English, students might need to allocate their limited memory capacity to learn from the subject's materials, even though some of the capacity has already been dedicated to learning other subjects. Taking this scenario into consideration, it is important to design English instructional materials to help support language learning in receptive skills, and at the same time, to help students maintain knowledge gained through learning from the materials.

Project aims

The main objective of this project is to design English instructional materials which are suitable for undergraduate students to learn from and maintain information. It also aims at finding out what kind of instructional materials best supports students in learning English reading and listening skills as well as in retaining information learnt from the materials, through the lens of students' views and perspectives.

The results of findings in this project carried out by the researcher will be used in PhD thesis, research articles and presentations concerning English instructional materials.

Data gathering and organisation

Quasi-experiments, subjective rating scales and semi-structured interviews

The researcher would like to conduct 3 quasi-experiments, concerning English reading materials, English listening materials and English reading-listening materials, by having students do pre-tests, immediate post-tests and delayed post-tests. The pre-tests aim to measure students' background knowledge concerning language learning, the immediate post-tests will be used to measure students' information learnt from the materials, and the delayed post-tests will be administered to measure students' information learnt from the materials in a longer period.

After learning from the materials at the immediate post-test phase, you will be asked to complete 3 questionnaires in order to know about your learning based on the materials, your memory capacity during learning from the materials and your opinions toward the materials. When you have already done the delayed post-tests, you will be asked to volunteer in participating in semi-structured interviews, which will be sound recorded, asking you about your overall perception toward yourself as a learner learning from the materials and the effectiveness of materials in support your language learning.

Prepared by Monthon Kanokpermpoon (21/01/16)

Prior joining this project, you will have already been assigned into English classrooms, based on your national admission exam results, administered by Thammasat University, and the researcher will be your teacher of the course. The results from quasi-experiments, subjective rating scales and semi-structured interviews will be in confidential and will not affect your grade in the course.

The data you provide to the project will securely be stored in a handy drive and a secured storage capacity at Newcastle University (internal drive), and used for research purposes only. The data gathering process will happen in August 2016.

The findings from quasi-experiments, subjective rating scales and semi-structured interviews will be used for two purposes:

- **They would be shared with the researcher's supervisors so that they can measure the reliability of results**
- **Test results and data from the questionnaires and semi-structured interviews will be used in writing up PhD thesis, research articles and/or presentations concerning the project**

Withdrawal

Involvement in this project is voluntary and participants can withdraw at any time without providing reasons. If you would like your test results to be withdrawn during your participation in the project, please inform the researcher so that the results will be deleted permanently from the project records.

After reading this information, if you would like to take part, please complete the consent form. You will be provided with a copy of the form for your own records and one copy will be kept by the researcher.

If you have any further enquiries regarding your participation in this project or if you would like a copy of the research results, please do not hesitate to contact:

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Informed Consent for Students for a PhD Research Project:
English reading-listening instructional materials and students' information retention

I have read and understood the information sheet, and have had the opportunity to ask questions. I understand that my involvement is voluntary and that I have the right to withdraw at any time without providing reasons. Also, I have learned that participating in this project does not affect my grade results of the course. Please tick [✓] in the box to indicate your level of agreement to participate in the PhD research project activities:

I agree to be involved in this project and:

- ☐ I **understand and agree** to learn and do pre-tests, immediate post-tests and delayed post-tests on reading materials, listening materials and reading-listening materials at my best abilities.
- ☐ I **understand and agree** to complete post learning questionnaires.
- ☐ I **understand and agree** to participate in semi-structured interviews after the delayed post-test phase, which will be sound recorded.
- ☐ I **understand** that the test results and data from both questionnaires and semi-structured interviews will be shared with the researcher's supervisors.
- ☐ I **understand and agree** that the test results and data from both questionnaires and semi-structured interviews will be used in writing up PhD thesis, research articles and/or presentations.

I understand that the copyright of any recordings which are generated as a result of participation in this project shall be assigned to the PhD research project.

This consent form covers any use of tests, questionnaires and audio recordings by the research project starting from the date you sign this form.

UK Data Protection Act 1998: The PhD research project will not use the **personal details or full name** (first name and surname) of any individual in any tests, questionnaires, audio recordings or in any of our other printed material without consent.

Name ______________________________ Signed ______________________

Date ____________________

Prepared by Monthon Kanokpermpoon (21/01/16)

Appendix 2a: Integrated reading task

<u>Directions</u>: Read the following passage (once only) and answer the questions that follow.

Do we have enough time for everything? Probably not! We all know that time is always limited, but we may want more time when we are doing something. To manage time is even more difficult, although there are tools to do so, such as to-do lists or calendars. A possible reason for this challenge is that time is a perishable resource, or a resource which loses its value and cannot be stored (there is no bank for time!). In the 21st century, however, there are deeper reasons for the challenge in managing time.

Q1: What is the reason why time is difficult to manage?
A: ______________________________

1. What is important is not obvious. It is not always clear what our preferences are. How do you trade off reading for exams with going to Japan with your family, for example? In most cases, you may not know what you really want. How do you decide if your choices are not always clear? When we do not know our preferences, we can use the *decision theory*, where we have to identify values, uncertainties and other possible issues in a given decision. This means that we might have different options to choose from in a given situation.

Q2: Why is it difficult for us to decide our preferences in managing time?
A: ______________________________

2. Too many things to consider. In some cases, you may realise that all of your choices are clear, but you may find there are too many things going on. Even worse, all of the activities will catch your attention, but you may find it difficult to allocate your time to every activity. You would have what computer experts call an *intractable computational problem*, which means there is no algorithm that can swiftly decide how best to allocate your time.

Q3: When everything is clear for you, why is it still difficult for you to manage time?
A: ______________________________

3. Things happen. Life is always dynamic, i.e. many things happening at the same time, and many things accidentally happen all the time. You need to re-adjust your plans owing to this change.

Q4: Why do we need to re-adjust our plans?
A: ______________________________

4. Your time is in need. When you look at your calendar, you will find that most of your time is booked for other people and businesses. The challenge is that our social identity makes it hard for us to say no. *Social identity* determines your roles in any given situations. For example, at school, you may be a student in class, or a classmate among your friends.

Q5: Why is it difficult for us to say no to other people or businesses?

A: ____

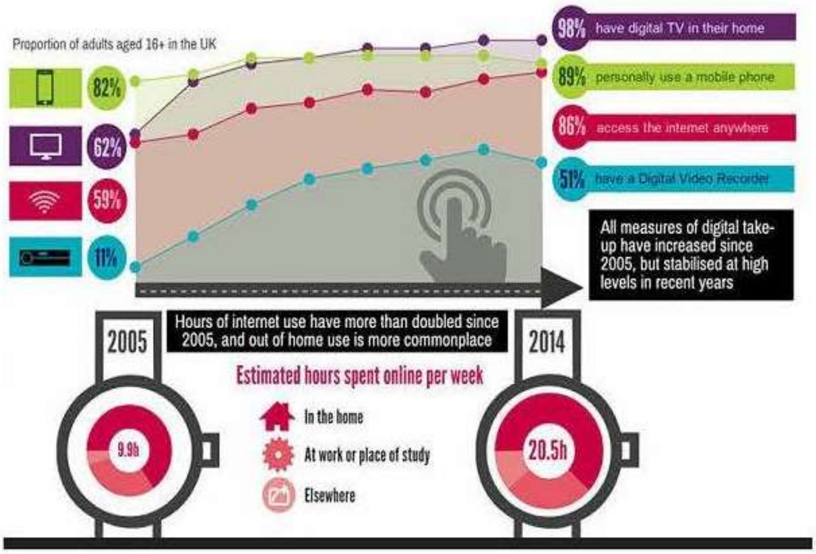
5. We are only human. As humans, we usually choose to do an easier task over a more difficult one. We always mismanage our time and make mistakes. Since we are humans, *procrastination*, or the tendency to unreasonably postpone a task, always makes us mismanage time to a greater or lesser extent.

Q6: Why do we as humans always procrastinate?

A: ____

6. Technology has made things worse. Ironically, technology creates more activities for us to spend our limited time. Even worse, because of technology, we are put into social pressure since other people can reach us at almost any time or place.

In the UK, teenagers spent about 27 hours online!



Source: Telegraph, 15 May 2015
http://www.telegraph.co.uk/finance/newsbysector/mediatechnologyandtelecoms/digital-media/11597743/Teenagers-spend-27-hours-a-week-online-how-internet-use-has-ballooned-in-the-last-decade.html

Q7: Why does technology put social pressure on our time?

A: ____

So, how can we solve the above problems and what can we do to manage our time? Well, there is no silver bullet. The underlying causes will always be there – the pressure on our time will likely not to diminish soon. Also, the traditional calendar is not always the solution. It is just a record of how much time we have spent, but it does not tell us how to spend what is left! Despite this challenge, however, the calendar is still a great device for us to coordinate among people. It is also a good reminder of what we did or intend to do. But, we need much more.

Q8: Why is there no perfect solution to manage time?

A: ____

Q9: Why is a calendar NOT a good tool to manage time?

A: ____

We might need tools that present to us in one place the various things. Tools should help us realise what our preferences about how to spend our time. They should be flexible enough for our dynamic life. Tools should also allow us to be 'responsibly social', and they should nudge us to do the right thing. If they do all this, technology will once again be our ally in our most important quest in life — spending time on what really matters to us.

Q10: What kind of tool can we adapt to solve time management problems?

A: ____

Adapted from: http://www.huffingtonpost.com/yoav-shoham-/6-reasons-why-time-management-is-hard_b_5078758.html

Appendix 2b: Split-attention reading task

Directions: Read the following passage (once only) and answer the questions that follow.

Do we have enough time for everything? Probably not! We all know that time is always limited, but we may want more time when we are doing something. To manage time is even more difficult, although there are tools to do so, such as to-do lists or calendars. A possible reason for this challenge is that time is a perishable resource (there is no bank for time!). In the 21st century, however, there are deeper reasons for the challenge in managing time.

> *When a resource becomes **perishable**, it loses its value and cannot be stored.*

1. What is important is not obvious. It is not always clear what our preferences are. How do you trade off reading for exams with going to Japan with your family, for example? In most cases, you may not know what you really want. How do you decide if your choices are not always clear?

> *When we do not know our preferences, we can use the **decision theory**, where we have to identify values, uncertainties and other possible issues in a given decision. This means that we might have different options to choose from in a given situation.*

2. Too many things to consider. In some cases, you may realise that all of your choices are clear, but you may find there are too many things going on. Even worse, all of the activities will catch your attention, but you may find it difficult to allocate your time to every activity.

> *You would have what computer experts call an **intractable computational problem**, which means there is no algorithm that can swiftly decide how best to allocate your time.*

3. Things happen. Life is always dynamic, and many things accidentally happen all the time. You need to re-adjust your plans owing to this change.

> *A **dynamic situation**, i.e. many things happening at the same time, always happen in today's society. Choosing one over another is so difficult, indeed.*

4. Your time is in need. When you look at your calendar, you will find that most of your time is booked for other people and businesses. The challenge is that our social identity makes it hard for us to say no.

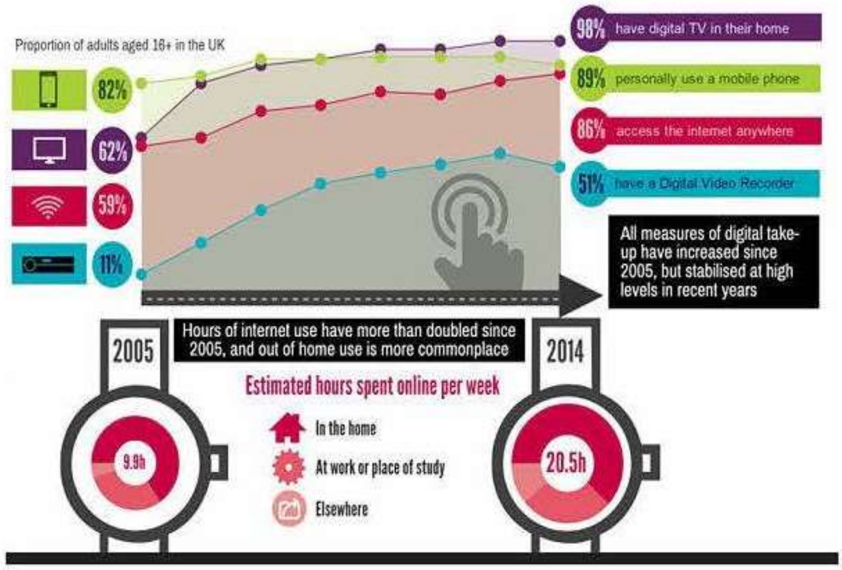
> ***Social identity** determines your roles in any given situations. For example, at school, you may be a student in class, or a classmate among your friends.*

5. We are only human. As humans, we usually choose to do an easier task over a more difficult one. We always mismanage our time and make mistakes. This is just human.

> *Since we are humans, **procrastination**, or the tendency to unreasonably postpone a task, always makes us mismanage time to a greater or lesser extent.*

6. Technology has made things worse. Ironically, technology creates more activities for us to spend our limited time. Even worse, because of technology, we are put into social pressure since other people can reach us at almost any time or place.

In the UK, teenagers spent about 27 hours online!



Source: Telegraph, 15 May 2015
http://www.telegraph.co.uk/finance/newsbysector/mediatechnologyandtelecoms/digital-media/11597743/Teenagers-spend-27-hours-a-week-online-how-internet-use-has-ballooned-in-the-last-decade.html

So, how can we solve the above problems and what can we do to manage our time? Well, there is no silver bullet. The underlying causes will always be there – the pressure on our time will likely not to diminish soon. Also, the traditional calendar is not always the solution. It is just a record of how much time we have spent, but it does not tell us how to spend what is left! Despite this challenge, however, the calendar is still a great device for us to coordinate among people. It is also a good reminder of what we did or intend to do. But, we need much more.

We might need tools that present to us in one place the various things. Tools should help us realise what our preferences about how to spend our time. They should be flexible enough for our dynamic life. Tools should also allow us to be 'responsibly social', and they should nudge us to do the right thing. If they do all this, technology will once again be our ally in our most important quest in life — spending time on what really matters to us.

Adapted from: http://www.huffingtonpost.com/yoav-shoham-/6-reasons-why-time-management-is-hard_b_5078758.html

***<u>Directions</u>*: After reading the passage, answer the following questions.**

Q1: What is the reason why time is difficult to manage?

A: ____

Q2: Why is it difficult for us to decide our preferences in managing time?

A: ____

Q3: When everything is clear for you, why is it still difficult for you to manage time?

A: ____

Q4: Why do we need to re-adjust our plans?

A: ____

Q5: Why is it difficult for us to say no to other people or businesses?

A: ____

Q6: Why do we as humans always procrastinate?

A: ____

Q7: Why does technology put social pressure on our time?

A: ____

Q8: Why is there no perfect solution to manage time?

A: ____

Q9: Why is a calendar NOT a good tool to manage time?

A: ____

Q10: What kind of tool can we adapt to solve time management problems?

A: ____

Appendix 3a: Integrated listening task

<u>Directions</u>: Listen to the following passage (once only) and answer the following questions.

In English, the idiom, "Birds of a feather flock together" means a group of people with similar characteristics, such as being in the same school. When a different kind of person would like to join the group, they might not be happy with the newcomer. This can be called discrimination or racism.

Q1: What is an English idiom meaning people of similar characteristics?

You can find many different kinds of racism in the society. For example, in school, sports talents might not want nerdy students in their group. At work in Asia, women might find it hard to become senior managers. In peer groups, friends with a brighter skin colour might look down upon people of colour, especially in Asia. Well… a main question remains, "Why does racism still exist in human society?". We will look at many reasons as follows.

Q2: What example of racism was made in terms of relationship or friendship?

The first cause for racism can be found in history. We always find that history contains both happy and shameful records of our actions. Of course, history is a guidance for our future practice, but the record of mistreat to coloured people has always haunted us.

Q3: In history, what was an example of racism?

The second reason of racism is that people sometimes ignore that there exists racism. When we read news about racism with emigrants around the world, we might not care about them since it is just news in the papers.

Q4: What do people do when they hear of mistreat to emigrants around the world?

The next cause of racism can be found in mass and social media. When you turn on the television, you will always find many advertisements. The products advertised on TV mostly promote your skin being brighter, rejuvenate your natural beauty and even make you look like a model.

Q5: In mass media, what influences people to look down upon other people?

Another reason for racism is that of society. A classic belief for a society is that classlessness in society will result in social disorder, but the class itself can be a problem. European and Asian people are different geographically and socially, and this can be a cause of racism to stop outsiders from entering the country.

Q6: What happens when a society becomes classless?

In politics, there are two levels of discrimination. At a micro level, a group of people may have higher power in passing law. For example, there was a classic belief of 'white is better', and other ethnic groups could find it hard to be leaders in society.

Q7: At a micro political level, which group of people were believed to have higher power?

At a macro level, foreigners may not be accepted in a city or a country because they are aliens or outsiders, and this is called 'Xenophobia'.

Q8: What is 'Xenophobia'?

The last cause of racism is from within a person. In our inner voices, different skin colours, habits and practices are known as 'the other'. And believe it or not, we always practise our sadistic pleasure in our mind in looking down at 'the other'. This is known as 'inferiority complex' in scientific studies.

Q9: In our inner voice, what is 'the other'?

From several causes we have mentioned, we can find that racisms can be found everywhere. It is our job to deal with racism strategically. At a personal level, we can avoid direct racism. If it is difficult to avoid it, you can deal with words, rather than a person. You can say, 'the phrase is really offensive,' for example. At an interpersonal level, you can practise with superiors, or join a group to respond to racism. Finally, you should know your own right and understand racist actions, not racist people.

Q10: When you cannot avoid direct racism at you, what should you do?

Appendix 3b: Split-attention listening task

<u>Directions</u>: Listen to the following passage (once only) and answer the following questions.

In English, the idiom, "Birds of a feather flock together" means a group of people with similar characteristics, such as being in the same school. When a different kind of person would like to join the group, they might not be happy with the newcomer. This can be called discrimination or racism.

You can find many different kinds of racism in the society. For example, in school, sports talents might not want nerdy students in their group. At work in Asia, women might find it hard to become senior managers. In peer groups, friends with a brighter skin colour might look down upon people of colour, especially in Asia. Well… a main question remains, "Why does racism still exist in human society?". We will look at many reasons as follows.

The first cause for racism can be found in history. We always find that history contains both happy and shameful records of our actions. Of course, history is a guidance for our future practice, but the record of mistreat to coloured people has always haunted us.

The second reason of racism is that people sometimes ignore that there exists racism. When we read news about racism with emigrants around the world, we might not care about them since it is just news in the papers.

The next cause of racism can be found in mass and social media. When you turn on the television, you will always find many advertisements. The products advertised on TV mostly promote your skin being brighter, rejuvenate your natural beauty and even make you look like a model.

Another reason for racism is that of society. A classic belief for a society is that classlessness in society will result in social disorder, but the class itself can be a problem. European and Asian people are different geographically and socially, and this can be a cause of racism to stop outsiders from entering the country.

In politics, there are two levels of discrimination. At a micro level, a group of people may have higher power in passing law. For example, there was a classic belief of 'white is better', and other ethnic groups could find it hard to be leaders in society. At a macro level, foreigners may not be accepted in a city or a country because they are aliens or outsiders, and this is called 'Xenophobia'.

The last cause of racism is from within a person. In our inner voices, different skin colours, habits and practices are known as 'the other'. And believe it or not, we always practise our sadistic pleasure in our mind in looking down at 'the other'. This is known as 'inferiority complex' in scientific studies.

From several causes we have mentioned, we can find that racisms can be found everywhere. It is our job to deal with racism strategically. At a personal level, we can avoid direct racism. If it is difficult to avoid it, you can deal with words, rather than a person. You can say, 'the phrase is really offensive,' for example. At an interpersonal level, you can practise with superiors, or join a group to respond to racism. Finally, you should know your own right and understand racist actions, not racist people.

Directions: *Answer the following questions from the listening.*

Q1: What is an English idiom meaning people of similar characteristics?

A: ______________________________

Q2: What example of racism was made in terms of relationship or friendship?

A: ______________________________

Q3: In history, what was an example of racism?

A: ______________________________

Q4: What do people do when they hear of mistreat to emigrants around the world?

A: ______________________________

Q5: In mass media, what influences people to look down upon other people?

A: ______________________________

Q6: What happens when a society becomes classless?

A: ______________________________

Q7: At a micro political level, which group of people were believed to have higher power?

A: ______________________________

Q8: What is 'Xenophobia'?

A: ______________________________

Q9: In our inner voice, what is 'the other'?

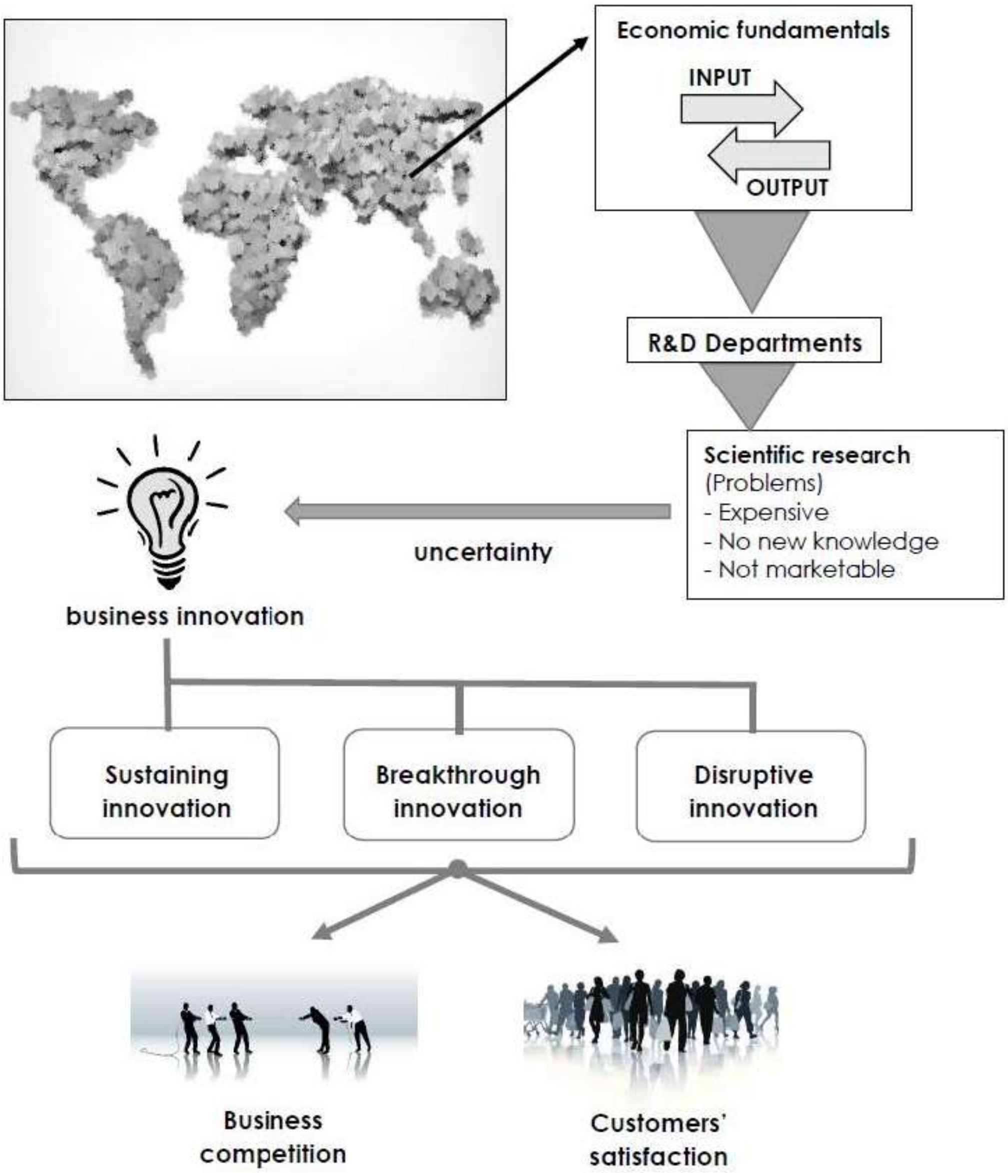
A: ______________________________

Q10: When you cannot avoid direct racism at you, what should you do?

A: ______________________________

Appendix 4a: Modality listening-reading task

<u>Directions</u>: Listen to the following text and study the diagram below. Then, answer the questions that follow.



Directions: After listening to the text and studying from the diagram, answer the following questions.

Q1: According to the passage, what is a determining factor for the growth of economic output?

A: ____

Q2: Why do many companies establish an R&D department?

A: ____

Q3: Besides high costs, what is another major problem of scientific research?

A: ____

Q4: For the past 100 years, what happened when an innovation was produced?

A: ____

Q5: According to the passage, what are the results of business innovations?

A: ____

Q6: What is the easiest way for an organisation to compete in the innovative market?

A: ____

Q7: How can a company produce breakthrough offerings?

A: ____

Q8: What happens when a company launches a completely new product to the market?

A: ____

Q9: Among the three types of innovation, which one mostly occurs first?

A: ____

Q10: Why does a company choose a type of innovation to compete in the market?

A: ____

Appendix 4b: Redundancy listening-reading task

<u>Directions</u>: Read and listen to the passage below, and then answer the questions that follow.

(Reading text and listening script)

Do you know how well a country runs in an economic world? Basically, economists look at basic fundamentals of economics, which are inputs and outputs. Inputs mean basic resources a country has, and outputs means products a country produces. You can increase more inputs to produce more products. Alternatively, you can use innovative technology to increase products from the limited number of resources. In the industrialised world, innovative technology is a factor for the growth of outputs in many countries.

In many industrialised world, uncertainties in business situations may arise, and organisations need to respond to the uncertainties. Most of the time, these companies established a Research and Development department, or R&D, to cope up with uncertainties. However, research within the department may have two different problems. Firstly, the research itself is very expensive and this can cause financial problems for a company. Secondly, new scientific findings may not produce products that sell well. Whatever challenges found in R&D, we can say that an uncertainty is a major drive for a company to discover innovative activities.

For the past century, many innovations have influenced the ways people live. We can see that almost everyone in the society has a smartphone. There are also many gadgets found in our everyday lives. These gadgets are the results of business innovations. We have to note also that these upgrades are not static; they are changing in every second of life. In the following, we will see how a company innovates in three different ways.

The first and safest way to innovate is to stay in the game sustainably. Sustainability means that a company may produce an innovation, and then add more variations to the products. Tablet technology may develop into generations 2, 3, 4, 5 and so on, for example. Most often, this type of innovation involves adding or fixing more features, reducing cost of production and expansions of product line.

The second type of innovation is breakthrough offerings. This means that a company aims to achieve the next best thing. Most of the time, a company combines all different products' functionality into one final product. A good example is the production of iPhone in Steve Jobs' era. When it was first available into the market, people were amazed and really wanted to get the product. This is because of the product's simplicity and full functions, such as touch screen, media players, and smart apps. This type of innovation represents a huge, discrete step change in performance, technology and customers' value.

The last type of business innovation is disruptive innovation. When people think of innovation, they may want something totally new. Some organisations produce a new gadget which disruptively changes the way people live. An example is the first model of the iPod. Even though there existed MP3 players, the new iPod changed the way people listened to music. Starbucks is another example of disruptive innovation, where people change their coffee consumption into something worth paying a lot more for.

All in all, these types of innovation are interrelated. For example, when disruptive innovations are introduced, they are often maintained through incremental innovations. This might be interspersed with sporadic breakout. Finally, another innovation might disrupt the market and a new cycle will start again.

In conclusion, economic growth and technological advancement may be struggling to survive because of its internal uncertainty and external market competition. At the same time, a company can choose either type of business innovation, whether it be sustainability, breakthrough offerings, or disruptive innovation. Eventually, both uncertainty and the availability of innovative choices might go hand-in-hand for organisations to strive and survive in business competition and to satisfy their customers who thrust for new development.

Adapted from:
Rosenberg, N. (2004) 'Innovation and economic growth', retrieved 13 May 2016, from http://www.oecd.org/cfe/tourism/34267902.pdf
http://bgr.com/2016/01/08/best-of-ces-2016-innovation/
http://www.fastcodesign.com/1665186/there-are-three-types-of-innovation-heres-how-to-manage-them
http://www.theinnovativemanager.com/the-four-types-of-innovation-and-the-strategic-choices-each-one-represents/

<u>Directions</u>: After reading and listening to the text, answer the following questions.

Q1: According to the passage, what is a determining factor for the growth of economic output?

A: ____________________

Q2: Why do many companies establish an R&D department?

A: ____________________

Q3: Besides high costs, what is another major problem of scientific research?

A: ____________________

Q4: For the past 100 years, what happened when an innovation was produced?

A: ____________________

Q5: According to the passage, what are the results of business innovations?

A: ____________________

Q6: What is the easiest way for an organisation to compete in the innovative market?

A: ____________________

Q7: How can a company produce breakthrough offerings?

A: ____________________

Q8: What happens when a company launches a completely new product to the market?

A: ____________________

Q9: Among the three types of innovation, which one mostly occurs first?

A: ____________________

Q10: Why does a company choose a type of innovation to compete in the market?

A: ____________________

Appendix 5a: Recognition test – Reading

Comprehension check – reading

<u>Directions</u>: Based on the reading passage that you have read, decide if the following statements are true or false.

1. Time is a limited resource, but it is not perishable.

2. The decision theory deals with how you decide for choices.

3. Under the decision theory, you can always be certain of your preferences.

4. Deciding how to allocate several things in a day needs more time to do so.

5. Your life can be static and you can allocate your time for every activity.

6. People always spend their time for other people.

7. We always mismanage our time.

8. Technology makes us deal with social pressure more easily.

9. The pressure on our time will not likely to diminish in a short period.

10. We can still use calendars to coordinate with people and to remind us of what we did.

Appendix 5b: Recognition test – Listening

Comprehension check – listening

Directions: Based on the listening text that you have listened, decide if the following statements are true or false.

1. People are like birds that always flock together.

2. Friends can sometimes be against each other because of racism.

3. We cannot believe in history to guide our future deed.

4. People are always alert when there is discrimination.

5. Many kinds of rejuvenating products are part of our racist behaviours.

6 .When a society is classless, social disorder can be solved easily.

7. Different races are factors challenging law predominance in the society.

8. Xenophobic people are against people of different colours, habits and practices.

9. The inferiority complex in our mind makes us a person of justice.

10. We cannot use words or expressions to directly deal with racist actions.

Appendix 5c: Recognition test – Listening-reading

Comprehension checks – reading-listening

Directions: Based on the reading-listening text that you have studied, decide if the following statements are true or false.

1. Economic fundamentals consist of inputs and processes.

2. Most companies establish an R&D department to deal with uncertainties.

3. Research in business innovation can be too costly to carry out.

4. Scientific research always produce new knowledge, which is marketable.

5. Business innovations have affected customers' everyday practices for the past century.

6. Incremental innovations can help a company boost the market with new and bold products.

7. A combination of all functionality of products can offer breakthrough innovations.

8. A product line can be obsolete when another company disruptively innovates a product.

9. Many companies shift from one innovation to another, depending on their market situation.

10. Customers are not a major factor for a business to invest in technological innovations.

Appendix 6: Subjective rating scales (Sample)

Subjective-rating scales (Reading)

The following questions refer to the tasks you have done during reading. Please respond to each of the questions on the scales of 0 to 7 (0 means *not at all the case* and 7 meaning *completely the case*).

1. The topic covered in the reading text was very complex. หัวข้อในบทอ่านมีความซับซ้อนมาก	0	1	2	3	4	5	6	7
2. The reading text covered concepts and definitions that I perceived as very complex. ฉันรู้สึกว่าแนวความคิดและคำอธิบายความหมายในบทอ่านมี ความซับซ้อนมาก	0	1	2	3	4	5	6	7
3. The reading text covered sentences and structures that I perceived as very complex. ฉันรู้สึกว่าประโยคและโครงสร้างภาษาที่ใช้ในบทอ่านมี ความซับซ้อนมาก	0	1	2	3	4	5	6	7
4. The reading text covered a format that I perceived as very complex. ฉันรู้สึกว่ารูปแบบการจัดเรียงข้อความในบทอ่านมีความซับซ้อนมาก	0	1	2	3	4	5	6	7
5. The instructions and/or explanations during reading were very unclear. คำสั่ง และ/หรือคำอธิบายในระหว่างการอ่านมีความคลุมเครือ มาก	0	1	2	3	4	5	6	7
6. The instructions and/or explanations were very ineffective for learning. คำสั่ง และ/หรือคำอธิบายไม่มีประสิทธิภาพในการส่งเสริม การเรียน	0	1	2	3	4	5	6	7
7. The instructions and/or explanations contained many unclear language. คำสั่ง และ/หรือคำอธิบายมีภาษาที่ไม่ชัดเจนอยู่มาก	0	1	2	3	4	5	6	7
8. The reading text enhanced my understanding of the topic covered. บทอ่านช่วยส่งเสริมความเข้าใจในหัวข้อที่อ่านให้แก่ฉัน	0	1	2	3	4	5	6	7
9. The reading text really enhanced my knowledge and understanding of time management. บทอ่านส่งเสริมความรู้และความเข้าใจเรื่องการจัดการเวลา ให้แก่ฉันมาก	0	1	2	3	4	5	6	7
10. The reading text really enhanced my understanding of the concepts and definitions. บทอ่านช่วยส่งเสริมความเข้าใจในแนวความคิดและคำอธิบายความหมายให้แก่ฉันมาก	0	1	2	3	4	5	6	7
11. The reading text really enhanced my knowledge of the English language. บทอ่านช่วยส่งเสริมความรู้ด้านภาษาอังกฤษให้แก่ฉัน	0	1	2	3	4	5	6	7

Comments on the reading text:

Appendix 7: Interview questions

Interview questions…

Objectives:

1. To gather information on cognitive load when learning from instructional materials
2. To learn from learners whether they use domain-specific or domain-general knowledge during learning from instructional materials (cf. Tricot and Sweller, 2014)
3. To learn how students learn form instructional materials

Reading:

1. When you were reading, did you read the questions first or later? Why?
2. When reading the text, how did you understand some unknown words?
3. How did you read the text?

4.1 How did you find the questions posted in the last part of the text?

4.2 How did you find the questions posted within the text?

5. During reading the text, how did you feel about the text?
6. If you could show your brain's capacity during reading, how much percentage could you say you used during reading?
7. How much did you enjoy reading and answering questions?
8. If possible, how would you redesign the reading text?

Listening:

1. When you were listening, did you read the questions first or later? Why?
2. When listening to the text, how did you understand some unknown words?
3. How did you listen to the text?

4.1 How did you find the listening questions when the listening text was stopped?

4.2 How did you find all of the questions presented to you during listening?

5. During listening to the text, how did you feel about the text?
6. If you could show your brain's capacity during listening, how much percentage could you say you used during listening?
7. How much did you enjoy listening and answering questions?
8. If possible, how would you redesign the listening text?

Reading-listening (redundancy):

1. During reading, did you read the questions first or later? Why?
2. During listening, did you read the questions first or later? Why?
3. How did you read and listen to the text?
4. How did you find the questions when reading and listening to the text?
5. During reading and listening at the same time, how did you feel about the text?
6. How did you learn from both reading and listening texts?
7. How much did you enjoy reading and listening?
8. Which text seems more difficult to understand? Reading or listening text?
9. If possible, how would you redesign the whole text?

Listening-Reading diagram (modality):

1. During reading the diagram, did you read the questions first or later? Why?
2. During listening, did you read the questions first or later? Why?
3. How did you read the diagram and listen to the text?
4. How did you find the questions when reading the diagram and listening to the text?
5. During reading the diagram and listening at the same time, how did you feel about the text?
6. How did you learn from both the diagram and the listening text?
7. How much did you enjoy reading the diagram and listening at the same time?
8. Which text seems more difficult to understand? Reading the diagram or listening to the text?
9. If possible, how would you redesign the whole text?

Appendix 8: Thematic development from interviews

Integrated Reading

Theme 1 Characteristics of materials	
1 Difficult structures	complicated sentences (S2) sentence patterns – not clear (S10)
2 Difficult vocabulary	Difficult items (words) (S2) Some words – don't know (S8)
3 Text and questions (Difficult)	Not sure (S1), difficult questions and paragraphs (S3), hard to understand – some questions (S6), some questions – difficult (S7), text – too long (S8), some questions – not clear (S10)
4: Text and questions (Supportive)	Story arranged according to questions (S4), questions make me understand passage (S5)

Theme 2 Text presentation (format)	
1 Supportive	Good – not flip back and forth to read (S2), Questions – realise what the passage means (S3), logical (S4), questions – understand passage (S5), questions – arranged in order - one point for one question (S8), questions – realise understanding (S9)
2 Distractive	Read and answer – hard to remember (S6), too easy – not practice reading the whole text (S8), think more- waste time to stop at each paragraph (S10)

Theme 3 Self-perception on learning from the text	
1 Supportive	Good for learning – read, understand – sentence (S1), some questions – realise what the passage means (S3), seems useful (S5), help me – understand and answer questions (S9)
2 Distractive	Read and answer questions, then next paragraph – hard to remember (S6), too easy-not practicing reading the whole thought (S8), waste time to think – stop to read (S10)
3 Reflecting	Boring – conflicts with story (S4), doesn't answer how to manage time (S5), not difficult-know about the story before (S7)

Split-attention Reading

Theme 1 Characteristics of materials	
1 Text and questions (Supportive)	Text –good (S2), don't have problem with (S24), makes me practice English (S9)
2 Text and questions (Difficult)	Too long – information / a lot of topics / not relate (S1), passage – confused me / questions – more difficult (S3), no question before – difficult (S4), difficult to remember (S6)
3 Vocabulary in context (Challenging)	Reread, read all structures (S4), try to understand (S7)

Theme 2 Text presentation (format)	
1 Description box (Supportive)	more description / understand (S7), obvious / pop up in eyes/ important (S8)
2 Description box (Difficult)	Challenging – words hard (S2), make me confused / don't know why it's here (S3)
3 Position of questions (Remembering)	Not difficult – can't remember text (S2), reread it and back it to questions (S4), so difficult to remember it all (S7), not difficult – not remember everything (S7), remember to answer – difficult / answer from understanding – not difficult (S8), can't remember them all (S9)

Theme 3 Self-perception on learning from the text	
1 Forgetting	Hard – don't know questions before – miss something important (S4), so difficult to remember it all (S6), read all of them – sometimes forget (S7), can't remember them all (S9)
2 Reflecting	Not tell me – reasons – why to make topic (S1), give me – how to manage time (S2), I love it to be challenging (S4), help me practice English (S9)

Integrated listening

Theme 1 Characteristics of materials	
1 Sound productions (Not difficult)	Accent – familiar (S4), speed – okay (S5), no problem – accent/speed (S6)
2 Sound productions (Difficult)	Too fast – first question (S5), Fast text, unfamiliar accent (S7)
3 Language structures (Challenging)	Don't' understand – hear – don't know / many unseen vocab (S1), sentence – difficult and easy (S3), complex text - don't know some words (S8)

Theme 2 Text presentation (format)	
1 Supportive	Question – direct info – listening / better – listen bit by bit (S3), good – stop to think and summarise (S6), better – more time to answer questions (S7), better – remember first question and answer (S8),
2 Challenging	information – not linked (S2), concentrating – question stops me (S4), easy – not smooth / flow of idea stop (S5), difficult – reluctant – not sure when next question comes (S9)
3 Mixed feeling	Good – want more time to think (S1), good – want more time to answer questions (S10)

Theme 3 Self-perception on learning from the text	
1 Thinking in pictures	Understand and imagine – create the picture (S1), follow listening – imagine (S2), sometimes imagine the story in picture – not often (S3), always imagine – remember in picture (S4), imagine in pictures (S7), imagine and remember difficult words (S8)
2 Using native language	Translate English in to Thai / answer – write in English (S5), listen for keywords – understand in Thai (S9), translate into Thai (S10)
3 Thinking time	Can concentrate on one question (S3), listen – think story before and after (S5), can stop to think and summarise – listened (S6), more time to answer questions / gain new knowledge from listening (S7)
4 Splitting attention	Question – stop me to concentrate (S4), not sure – when next question comes (S9), sleepy (S10)

Split-attention listening

Theme 1 Characteristics of materials	
1 Sound productions (Not difficult)	Okay – accent – understandable (S5)
2 Sound productions (Difficult)	listening – so fast – can't follow (S1), speed – so fast (S4), accent – different from what I know (S6), accent – difficult to catch (S8)
3 Language structures (Challenging)	words – don't know (S1), so much information (S2), text – not difficult / my words – limited (S3), many difficult words I don't know (S7), some unknown words / no background knowledge (S9)

Theme 2 Text presentation (format)	
1 Information overloaded	couldn't follow – become blank (S1), don't remember - so much info (S2), keywords – not found in listening (S3), listening – keep on – forget (S4), attention lost – listening – focus on some questions (S5), remember keywords and events (S6), challenging – remember and guess – words (S7), couldn't remember story (S8), remember idea – listen – forget (S9)
2 Questions (Difficult)	Difficult – so much info – don't know what to answer (S2), difficult – 5 keywords – can't find in listening (S3), answer question – forget to concentrate on listening (S4), some understandable, some difficult (S5), remember words to answer – couldn't do it (S7), couldn't answer – couldn't remember story (S9)
3 Questions (Easy)	easy to follow (S6), not difficult – but couldn't remember story (S8)

Theme 3 Self-perception on learning from the text	
1 Processing language in listening	Find main ideas – link all ideas (S1), listen – first and last sentences – keywords / something phobia – difficult to understand (S3), guess – keywords – no Thai (S4), guess – understand in English, not Thai (S8)
2 Think in pictures	Listen and see pictures in my mind (S2), think in picture / familiar – no new picture (S6), think in picture – link to listening (S7)
3 Manipulating learning	blank head – idea flow in – guess in English and Thai (S5), keep quiet and concentrate – think in Thai, if known, think in English , new idea (S9)
4 Not remembering / forgetting	Blank during listening (S2), can't think of keywords (S3), forget – listening (S4), attention lost in listening (S5), totally forgot words (S7), couldn't remember the story (S8), forgot all the time (S9)

Modality (Listening-Reading)

Theme 1 Characteristics of materials	
1 Language in listening	Difficult – don't know a lot of vocabulary (S2), difficult – technical words (S4), last part – difficult (something like innovation) (S5), difficult - content, something like IT (S6), too detailed information (S7), difficult words (S8), content – too long, too much detail, difficult words (S10)
2 Sound productions in listening	speed – cannot follow (S3), speed - fast (S8), difficult – accent and speed (S9)
2 Pictures in diagram	Many words and pictures – easy to understand (S1), contains pictures and linking story (S2), contain main points (S3), keywords and pictures (S4), info – linked through flowchart (S5), pictures of story (S6), main points (S7), pictures and flow of information (S9), overall pictures (S10)

Theme 2 Text presentation (format)	
1 Supportive pictures in diagram	Diagram – main ideas and pictures – guide listening / listening gives more information (S1), diagram – guide understand – listening (S2), use diagram – don't understand listening (S3), diagram – help understand listening (S4), pictures – guide understand – whole listening story (S5), organise info – listening (S6), guide – to listen (S8), guide me to follow the listening (S9), understand overall picture (S10)
2 Challenging listening	Very detailed information – hard to remember (S7), information – flow – distorted (S10)

Theme 3 Self-perception on learning from the text	
1 Focus on diagram (supportive)	Addition on diagram – remember pictures (S1), remember pictures to link all info (S2), pictures – pop up in my mind (S3), pictures – recognise info – no need to create my own pictures (S4), understand whole story – info – linked through flowchart (S5), remember pictures, flow of information (S9)
2 Focus on diagram (difficult)	Don't understand – difficult vocabulary (S7)
3 Focus on listening	Remember info – sentences similar to questions (S6), remember voices in the listening (S8), picture from diagram broke – additional info from listening – distorted (S10)

Redundancy (Listening-Reading)

Theme 1 Characteristics of materials	
1 Language in listening and text	Some grammar and words – difficult (S1), difficult words (see but don't know meaning) (S2), words – not clear, difficult (on reading too) (S4), text – too long / words – don't know (S5)
2 Content	Topic – not familiar (S2), story – not familiar (S3), difficult – so many business words (S7), text – business (S8)
3 Sound productions in listening	Accent – not familiar (S1), too fast (S4), too fast (S6), accent – challenging (S7)

Theme 2 Text presentation (format)	
1 Information overload	Content – text – too much (S1), confused, couldn't remember anything (S2), text – too long (S5), can't remember some info (S8)
2 Supportive	See words in text – control reading during listening – understand (S4), see words in reading – help guess meaning (S7)
3 Challenging	Listen – don't understand words – read – don't understand – got stuck (S6)

Theme 3 Self-perception on learning from the text	
1 Focus on reading	Understand from reading / remember info in Thai (S1), see words / summarised a big picture from seen words (S4), remember words (S5), remember words in text – conclude in mind – mind got blank during reading (S6), remember words – forget – got blank (S8)
2 Focus on listening	Make sense of listening from reading – remember keywords (S3), remember info in chunks – link in my mind / look at script when don't understand (S2), remember in concepts, not words (S7)
3 Not understanding, blank, confused	Couldn't follow listening – don't understand (S1), confused and couldn't remember anything at all (S2), See words - don't understand – couldn't remember (S5), got stuck in listening – guessing words in script (S6), confused – which words are in which context (S8)