The Effectiveness of Worked Examples Associated with Presentation Format and
Prior Knowledge: A Web-based Experiment

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This dissertation titled

The Effectiveness of Worked Examples Associated with Presentation Format and

Prior Knowledge: A Web-based Experiment

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ABSTRACT

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The Effectiveness of Worked Examples Associated with Presentation Form and Prior Knowledge: A Web-based Experiment (231 pp.)

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The aim of this study is to explore whether presentation format and prior knowledge affect the effectiveness of worked examples. The experiment was conducted through a specially designed online instrument. A 2X2X3 factorial before-and-after design was conducted. Three-way ANOVA was employed for data analysis. The result showed first, that prior knowledge, gender and class year had some impacts on the effectiveness of worked examples, so individual differences needs to be considered while designing worked example instruction. Second, the expert reversal effect (Kalyuga et al, 2001) was confirmed by one of findings in the study. When worked example instruction was provided, the higher prior knowledge level groups reported lower cognitive load by viewing the text-only presentation format; in contrast, the low prior knowledge level group reported lower cognitive load by viewing the text-plus-graphic presentation format. It indicated novices might need more detailed guidance in worked example instruction. Third, the study discovered that the low prior knowledge level group reported lower cognitive load by viewing the text-plus-graphic worked examples instead of text-only worked examples. It indicated that integrating text and graphics in worked examples might help novice learn better. Lastly, the findings of the study showed that high prior
knowledge level group performed better on the posttest by using worked examples than
general statement. The study indicated that worked examples may not only benefit
novices as previous studies addressed (Crissman, 2006; Kalyuga, et al., 1998), it may also
work for experts.

Approved: _____________________________________________________________

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CHAPTER ONE: INTRODUCTION

Background of the Study

Designing instruction requires the consideration of a number of factors including physical limitations and psychological characteristics. Human cognitive architecture is one of these important factors and has its own traits. According to information processing theory, there are three segments of human cognitive architecture, including sensory register, short-term store (short-term memory or working memory) and long-term store (long-term memory) (Atkinson & Shiffrin, 1968). Among these segments, some researchers have paid more attention to short-term memory and long-term memory; they consider the unique characteristics of short-term memory determine instruction design effectiveness and long-term memory is responsible for storing schemas which contribute to knowledge construction (Sweller, van Merriënboer, & Paas, 1998).

Short-term memory can organize, contrast and compare information, but it has a limited capacity as it is not able to hold many elements at one time. Therefore, ignoring its limit may result in overloading its capacity and thus hinder learning. In contrast, long-term memory is like an unlimited container; its information stored in the network of schemas (Kirschner, 2002). A schema, a domain-specific knowledge structure, allows people to treat multiple elements of information as a unit (Kalyuga, Chandler, & Sweller, 1998; Sweller et al., 1998; van Merriënboer & Sweller, 2005), because it consists of the overlapping elements of related problems (Cooper & Sweller, 1987). Therefore, the more effective schemas one generates, the easier one processes information since the transfer of knowledge is enhanced (Gick & Holyoak, 1983). For example, if a person who has a
schema of an internet connection, he is able to utilize it to troubleshoot a problem when confronted with a new internet disconnection situation. If he does not have any relevant schema, he may struggle through a trial and error process and not able to connect previous experience to the current situation.

After extensive and continuous practice, schema retrieval becomes automatic without cognitive efforts, which frees up working memory resources (Artino, 2008; van Merriënboer & Sweller, 2005). It is easier for learners to perform the familiar tasks accurately and efficiency with schemas automation because the burden on working memory is reduced dramatically (Cooper & Sweller, 1987; Kalyuga, 2006; Sweller & Chandler, 1994; Sweller et al., 1998). Schema automation is extremely important to learning. Effective schemas can be regarded as prior knowledge. Having more prior knowledge is the key difference that distinguishes experts from novices. An expert who has more prior knowledge can solve problems independently, whereas a novice who has less prior knowledge may need extra guidance. Appropriate instructional designs can provide guidance to optimize novices’ capability of working memory and help them to achieve schema automation (Chandler & Sweller, 1991; Cooper & Sweller, 1987; Sweller & Cooper, 1985).

To construct an appropriate instructional design, cognitive load theorists suggest that an instructor needs to consider cognitive load while designing learning materials (Chandler & Sweller, 1991; Cooper & Sweller, 1987; Sweller & Cooper, 1985). Cognitive load refers to the limitations involved in the processing of information in working memory (Hogg, 2006). There are three different types of cognitive load,
intrinsic, extraneous and germane cognitive load (Sweller, 2005; Sweller et al., 1998).

Intrinsic cognitive load refers to the nature of tasks, the element interactivity and the expertise of the learner (Kalyuga, 2006; Sweller, 1998; van Merriënboer, Kester, & Paas, 2006). If the material is composed of numerous related elements that must be considered simultaneously before understanding occurs (high element interactivity); it may result in a high intrinsic cognitive load. If the content contains low element interactivity, it can be learned in isolation without connecting to other content, which may result in a lower intrinsic cognitive load (Kalyuga, 2006). To manage intrinsic load, Clark, Nguyen and Sweller (2006) recommended instructors to segment and sequence content into a series of instructional events, such as an outline. In addition, Gerjets, Scheiter and Catrambone (2004) mentioned presenting and explaining a complex problem solution in smaller meaningful units may help to reduce intrinsic load. Another way to reduce intrinsic cognitive load is to adopt an isolated-followed-by-interacting-elements approach. Accordingly, the intrinsic cognitive load can be reduced by presenting elements of information sequentially in an isolated form and following a fully interactive form (Pollock, Chandler, & Sweller, 2002; van Merriënboer & Sweller, 2005). Except for the solutions mentioned above, designers cannot do much to alter intrinsic cognitive load directly, but they can refine instructions to control extraneous cognitive load.

Extraneous cognitive load results from the learning activities, which do not contribute to schema construction or automation (Pociask & Morrison, 2008; van Merriënboer & Ayres, 2005; Sweller, 1994, 2005; Sweller et al., 1998; Sweller & Chandler, 1994). In other words, poor-quality instructions may result in high extraneous
cognitive load and reduce available cognitive resources in working memory for schema construction or automation. For example, Kalyuka et al. (1999) mentioned that duplicate text-based and graphical instructional formats may split learners’ attention and increase their extraneous cognitive load.

In addition to reducing intrinsic and extraneous cognitive load as much as possible in instruction, designers need to utilize effective instructional strategies to engage learners in advanced cognitive processes that are associated with germane cognitive load (Artino, 2008; Gerjets & Scheiter, 2003), because it is “the load related to processes that contributes to the schemas construction and automation” (Pass, Tuovinen, Tabbers, & Gerven, 2003, p. 65). van Lehn, Jones, & Chi (1992) have suggested that encouraging students to explain examples to themselves while solving problems may increase their germane cognitive load and improve learning.

Overall, the total cognitive load is the sum of intrinsic cognitive load plus extraneous cognitive load plus germane cognitive load. Since instructional designers have limited control over intrinsic cognitive load, cognitive load theorists suggest improving the quality of instruction by controlling extraneous cognitive load may save more room in working memory for germane cognitive load thus creating more possibilities of schema construction and automation (Sweller, 1988; Sweller & Cooper, 1985).

To control extraneous cognitive load, Sweller and his associates (1985, 1988) proposed that worked examples may be a possible instructional intervention. A worked example usually consists of a problem statement, steps leading to a solution and a final answer (Atkinson, Renkl, & Merrill, 2003; Renkl, 1997). Students who follow worked
examples with step-by-step guidance may have better learning performances (Carroll, 1994; Zhu & Simon, 1987). For example, Zhu and Simon (1987) found that students using worked examples performed better than the students using conventional methods. Another example, in Carroll’s (1994) experiments, students in algebra classes benefited from worked examples more than they did from conventional practice.

Although the effectiveness of worked examples has been confirmed by many studies (Carroll, 1994; Cooper & Sweller, 1987; Crissman, 2006; Pawley, 2004; Lee, Nicoll, & Brooks, 2004; Shen, 2005; Sweller & Cooper, 1985; Zhu & Simon, 1987), there are still some areas of uncertainty. Some researchers have argued that worked examples are not universally effective for learners (Catrambone & Holyoak, 1989; Renkl, 1999; Ward & Sweller, 1990). Learners may not be able to apply the experiences learned from worked examples to novel problems because of the worked example design (e.g., presentation formats of worked examples) or individual differences (e.g., learners’ prior knowledge levels).

Some studies show different presentation formats may affect the effectiveness of worked examples, particularly the inclusion and arrangement of text and graphics (Ward & Sweller, 1990). In a traditional classroom setting, text-based learning is common. Many researchers suggested adding graphics into the instructional materials may benefit learning more than the text-only materials (Mayer & Gallini, 1990; Smaldino, Lowther, & Russell, 2007). Graphics have different functions to learning, such as maintaining motivation, attracting attention, minimizing cognitive load and fostering in-depth processing (Anglin, Vaez, & Cunningham, 2004; Carney & Levin, 2002; Clark & Lyons,
2004; Peeck, 1993). For example, an instructor can use transformational graphics to help learners more easily remember the changes in objects over time or space (Clark & Lyons, 2004). Clark and Lyons (2004) broadly defined graphics as, “iconic expressions of content that are designed to optimize learning and performance in ways that improve the bottom-line performance of organizations” (p. 9). Accordingly, graphics can be presented in different formats including static art (illustration, photographic and modeled) and dynamic art (animation, video and virtual reality) (Clark & Lyons, 2004).

Based on cognitive load theory, integrating text and graphics in instruction can be enhanced by following particular rules, for example, text and graphics together should not be randomly arranged together, because it may result in split-attention effect and redundancy effect (Chandler & Sweller, 1991; Sweller & Chandler, 1994; Tarmizi & Sweller, 1988). To illustrate further, when the materials are presented in split source formats (e.g., separate text and graphics), it often imposes a heavy extraneous cognitive load on working memory, because learners need to spend more time on mentally integrating the text and graphics. Additionally, if instructors place irrelevant and redundant graphics aside the solution statements, it may reduce learners’ available working memory because two different sources of information must be identified and connected. Therefore, attention should be paid to arranging text and graphics in worked examples.

There is another factor which may affect the arrangement of the text and graphics when using worked examples: the level of prior knowledge. As previously mentioned, having more prior knowledge allows people to process information faster. Prior
knowledge has an impact on the learners’ needs for instructional materials. In Kalyuga et al. (1998) study, they found that novices who possess less schemas gained more benefits from worked examples in text-and graphic versions, but experts do not need the detailed information that text may provide. Experts can learn well from graphic-only worked examples, because they already have effective schemas to perform the tasks; in contrast, information that is too detailed may become redundant for them. Researchers called this phenomenon “expertise reversal effect” (p. 38). Novices need more detailed guidance while learning; however, the same guidance may become redundant for experts, which imposes a high extraneous load. To construct suitable worked example designs, presentation format and prior knowledge are essential variables that need to be considered.

Purpose of the Study

The aim of this study was to explore whether worked examples, their presentation formats and learners’ prior knowledge levels affect the effectiveness of instruction or not. For educators, improving instruction is always a desirable goal. During the process of teaching a class on pedagogy and technology for undergraduate, pre-service teachers, the researcher found that many students have different prior knowledge levels. The variety of prior knowledge created learning problems. Because the course was an introduction class, the learning material was simple for a person who already had some technical background, while it may have been difficult for a person who had less prior knowledge. Providing an appropriate instructional design to accommodate individual differences was important for everyone to be successful.
Statement of the Problem

The purpose of this study was to explore whether worked examples, their presentation formats and learners’ prior knowledge, affect the effectiveness of instruction or not and the interaction among these three factors. The effectiveness of instruction in this study included learners’ scores on the posttest, cognitive load, time spent on the posttest and instructional efficiency. Combining subjective (cognitive load) and objective (posttest score and time spent on the posttest) measures may achieve a full understanding of student learning performance in the study. Instructional efficiency was also included in the performance measures because it could be used to detect the mental effectiveness of instructional conditions. The questions of this study were listed as follows:

1. Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different instructions (general statements and worked examples)?

2. Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic)?

3. Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low)?
4. Is there a significant interaction among instructions, presentation formats and prior knowledge levels in the pre-service teachers’ performance (posttest, cognitive load, time spent on the posttest and instructional efficiency)?

Significance of the Study

Early Cognitive Load Theory (CLT) research focused on identifying instructional designs that effectively reduce cognitive burden (e.g., worked examples and presentation formats). Most recently, the focus of CLT research has shifted to individual difference (e.g., prior knowledge and motivation) (Artino, 2008; Moreno, 2006). The study involved worked examples, presentation formats and prior knowledge levels, which may be a useful reference for designing effective instructions. In addition, the study conducted a true experiment on the web to collect data. A web-based experiment was able to reach more participants off the campus and avoid experimenter bias (Reips, 2002a, 2002b), which allowed the study to gather more data and participants’ opinions about worked example design.

Delimitations of the Study

Delimitations are about the scope of the study. It should tell the reader the elements of the study and the reason why they are included and excluded (Mauch & Park, 2003). The following points were addressed in this study:

1. The participants of this study were undergraduate education majors in a large comprehensive Midwestern university.
2. Independent variables were instructional conditions (general statements and worked examples), presentation formats (text-only and text-plus-graphic) and prior
knowledge levels (high, medium and low) and the dependent variables were learning performance (scores on the posttest, scores on the rating of the difficulty of the materials, time spent on the posttest and instructional efficiency).

3. A 10-item pretest about internet disconnection troubleshooting process was used to determine participants’ prior knowledge levels. A participant who had scores above 6 was assigned to the high knowledge level group; a participant who had scores below 5 was assigned to the low knowledge level group; a participant who had scores of 5 or 6 was assigned to the medium knowledge level group. The same 10-item posttest was used to examine the learning performance after the instructions.

4. The true experiment was processed through an online experimental tool built with Flash, ASP and Access, which allowed the researcher to invite more participants to join the experiment because participants could participant the experimental at anytime and anyplace as long as they had internet access.

Limitations of the Study

A limitation is a factor that may affect the outcome of the study, but is not under control of the researcher (Mauch & Park, 2003). This study was processed on a web-based experimental tool which was built with Flash, ASP and Access. Conducting a web-based experiment may lose some control in the experiment (Schmidt, 1997). For example, the researcher may not be available to answer questions, deal with concerns and provide troubleshooting. Regarding this concern, the researcher implemented the following strategies for a better interface design to mediate this limitation:
1. A detailed introductory message was presented at the beginning of every session to let a participant know what he or she was going to do in the coming session.

2. Programmed guidance was provided to assist participant’s interaction with the interface appropriately. For example, if a participant clicked a wrong button or forgot to answer some items, an interactive message appeared up immediately leading him or her to the next step.

3. The important information that a participant needed to know was marked in red, which gained his or her attention throughout the experimental process.

4. The reminding message kept appearing on the top or bottom of interface to remind a participant which sessions he or she was in which prevented him from getting lost in the transition between sessions.

Definition of Terms

Cognitive Load: Cognitive load refers to the cognitive load placed in working memory during the task. The rating of the difficulty of the materials was used to measure cognitive load invested in the performance tests, which was revised from Kalyuga et al. (1999)’s rating of the difficulty of the materials from 7 points to 9 points. At the high end of the scale, ‘9’ was associated with the learner’s investment of high cognitive load and at the low end, ‘1’ was associated with low cognitive load. The participants in this study needed to complete a pre-rating of the difficulty of the materials and a post-rating of the difficulty of the materials before and after the instructions.

Instructional Condition: In this study, there were two different instructional conditions, including general statements and worked examples. The general statement
instruction was displayed in a conventional bullet writing style focusing on the troubleshooting procedure; the worked example instruction started with a problem, followed by troubleshooting steps and ended with a final answer.

Instructional Efficiency (E): Instructional efficiency (E) in this study was calculated using Paas and van Merriënboer (1993) and Pass et al. (2003) procedure, which standardized and performance scores (obtained from the test) and mental load (obtained from the rating of the difficulty of the materials) into Z scores and calculated the data into the formula: 
\[
Z_{\text{Performance}} - Z_{\text{Mental Load}} / \sqrt{2}
\]
This approach was used to combine mental effort and performance measures, derive information on the relative effectiveness of instructions and estimate the relevant cognitive efforts. High efficiency occurred under conditions of high test performance and low cognitive load, whereas low efficiency occurred under low test performance and high cognitive load.

Learning Gain: In this study, learning gain indicated the score difference between pre-learning performance (scores on the pretest, cognitive load, time spent on the pretest and instructional efficiency) and post-learning performance (scores on the posttest, cognitive load, time spent on the posttest and instructional efficiency), which was used to examine the improvement after the instructions.

Learning Performance (the effectiveness of worked examples): In this study, the learning performance included scores on the posttest, cognitive load, time spent on the posttest and instructional efficiency.

Performance Test (pretest and posttest): In this study, both the pretest and the posttest were composed by 10 multiple choice questions in two difficulty levels and the
content related to an internet disconnection troubleshooting process. The pretest was used to determine a learner’s prior knowledge level and the posttest was used to detect a learner’s learning performance.

Presentation Format: Presentation format refers to how information is presented. In this study, there were two different presentation formats, including text-only and text-plus-graphic. In the text-only presentation format, the troubleshooting process was presented in a written form, whereas the text information about the troubleshooting process was integrated with relevant graphics in the text-plus-graphic presentation format.

Prior Knowledge: Prior knowledge refers to one’s previous experiences and domain knowledge. In this study, prior knowledge focused on an internet disconnection troubleshooting process. A participant who had scores on a 10-item pretest above 6 was assigned to the high knowledge level group; a participant who had scores below 5 was assigned to the low knowledge level group and a participant who had scores of 5 or 6 was assigned to the medium knowledge level group.

Worked Example: A worked example usually consists of a problem statement, steps leading to a solution and a final answer. In this study, worked examples contained an internet disconnection problem, troubleshooting steps and a final solution to solve the problem.

Summary of the Study

This dissertation is organized into five chapters.
Chapter 1 focuses on the introduction of the study, which provides the background, purpose, research questions, significance of the study and the delimitations and limitations of the study.

Chapter 2 provides the review of the literature, which consists of the human memory systems, cognitive load theory, worked example effect, presentation formats, the relationship between worked examples, presentation format and prior knowledge and the effectiveness of worked examples, learning performance (the effectiveness of worked examples) and web-based experiment.

Chapter 3 describes the methodology of the study, which includes research questions, null hypotheses, participants, instructional materials, instrumentation, dependent and independent variables, research design, pilot study, reliability and validity, data collection procedure and data analysis procedures.

Chapter 4 presents the results and findings of the data.

Chapter 5 discusses the conclusions and implications of the study and provides recommendations for future studies.
CHAPTER TWO: LITERATURE REVIEW

Introduction

Designing quality instruction to enhance learning performance is important, but it is not an easy task, because many factors need to be considered in the design process. The human memory system is one of the important factors; it plays an essential role in instructional design. Designers have to consider the system’s unique characteristics in order to create effective instruction. Based on the limits of human memory system, cognitive load theorists suggest many useful design strategies for instructors.

The application of worked examples is one of these strategies. A worked example usually consists of a problem statement, steps leading to a solution and a final answer (Atkinson et al., 2003; Renkl, 1997); it may help learners perform better through a systematic and complete process of solving the problem presented. Although its effectiveness has been widely confirmed (Carroll, 1994; Cooper & Sweller, 1987; Crissman, 2006; Pawley, 2004; Lee et al., 2004; Shen, 2005; Sweller & Cooper, 1985; Zhu & Simon, 1987), some researchers pointed out that only appropriately designed worked examples could have superior effectiveness (Catrambone & Holyoak, 1989; Renkl, 1999; Tarmizi & Sweller, 1988; Ward & Sweller, 1990). Designers should pay more attention to worked example design and take individual difference into consideration (Kalyuga et al., 1998; Tarmizi & Sweller, 1988; Ward & Sweller, 1990).

In the following review, the human memory system is discussed in part 1; cognitive load theory is discussed in part 2; worked example effect is discussed in part 3; presentation formats are discussed in part 4; the relationship between worked examples,
presentation format and prior knowledge is discussed in part 5; learning performance (the
effectiveness of worked examples) is addressed in part 6; and in the last part, web-based
experiment is covered.

Human Memory Systems

According to the information processing theory, human beings have unique
memory systems, which can be divided into three segments: Sensory resister (sensory
memory), short-term store (short-term memory or working memory) and long-term store
(long-term memory) (Atkinson & Shiffrin, 1968). Each segment contributes its special
function to information processing. The first step of information processing is sensory
memory, which deals with external stimuli, such as sights, sounds, smells, tastes and
touches. These stimuli can only be retained for a very brief period in sensory memory
after they have been removed. In this initial stage, one needs to determine which stimuli
are important enough to pay attention to and transfer the messages to the second step,
short-term memory.

Short-term memory is hypothesized to be located at the frontal lobes of the
cerebral cortex in human brain (Usher & Cohen, 1999) and can be regarded as a
workspace between sensory memory and long-term memory. Baddeley and Hitch (1974)
and Baddeley (1992) mentioned that short-term memory is composed of a visuo-spatial
sketchpad for storing visual information, a phonological loop for storing verbal and
numerical information and a central executive as a coordinating processor. The capability
of working memory can be enhanced by the use of both visual and auditory channels. In
general, short-term memory takes charge of organizing, contrasting and comparing
information, but it has its own limitations. Information is lost when short-term memory hold over 7±2 chunks (units of information) at any one time (Miller, 1956). If one deals with too much information at one time, it may overburden short-term memory and decrease learning effectiveness (Pawley, Ayres, Cooper, & Sweller, 2005; Sweller & Chandler, 1994). Continuous rehearsals help to maintain information and encode it into meaningful schemas in long-term memory, which expands the capabilities of working memory.

The last step of information processing is long-term memory. Long-term memory can store unlimited schemas permanently and allows repeated retrievals (Kirschner, 2002; Sweller et al., 1998). A schema can be defined as a domain-specific knowledge structure stored in long-term memory, which allows a person to treat multiple elements of information as a single element and reduce working memory load (Kalyuga et al., 1998; Sweller et al., 1998; van Merriënboer & Sweller, 2005), because it consists of the overlapping elements of related problems (Cooper & Sweller, 1987). In other words, when dealing with knowledge that is already organized in schemas, working memory only needs to retrieve the existing knowledge in schemas and is able to process less information at one time. In contrast, when dealing with novel and unorganized information, one needs to process all the new information at one time which may overburden working memory. For example, a person who has a schema of an internet connection (e.g. desktops, routers and servers) knows how to utilize the relevant technical knowledge and skills to troubleshoot and solve the current problems while dealing with disconnected situations. However, if a person does not have any schema about an internet
connection, he may be struggling in trial and error process of finding out possible solutions. Therefore, the more relevant schemas one has, the easier one processes information.

Researchers have pointed out that expertise heavily relies on the schema acquisition in long-term memory (Larkin, McDermott, Simon, & Simon, 1980). After extensive and continuous practice, schema retrieval becomes automatic without cognitive efforts, which frees up working memory resources (Artino, 2008; van Merriënboer & Sweller, 2005). It is easier for learners to perform the familiar tasks accurately and efficiency with schemas automation because the burden on working memory is reduced dramatically (Cooper & Sweller, 1987; Kalyuga, 2006; Sweller & Chandler, 1994; Sweller et al., 1998). In other words, schema automation triggers more effective problem solving and allows a person to perform a complex task well with minimal aid from working memory (Cooper & Sweller, 1987; Schnitz & Kurschner, 2007; Sweller et al., 1998; van Merriënboer, Kirschner, & Kester, 2003).

From the review above, it is evident that schema acquisition and automation are important for solving problem and accumulating expertise. Experts who have effective schemas can generate appropriate responses and often use a forward working strategy to solve problems. A forward working strategy allows a person to begin with the current problem and work forwards to solve problems until the ultimate goal is reached, which relies upon their previous knowledge or relevant schemas. In contrast, novices who have less effective schemas often use the means-ends analysis to solve the problem. Mean-ends analysis, a form of backward working strategy, involves the following steps: (a)
identifying the problem, (b) finding differences between the current state and the goal, (c) choosing an action that will reduce this difference, (d) carrying out the action and (e) breaking down the problem to several sub-goals. If a good solution cannot be found, this process keeps repeating until a possible answer appears (Heyworth, 1999).

Researchers found that novices who used backward working strategy often were required to consider multiple moves simultaneously, which may result in a heavy cognitive load (Kalyuga et al., 1998; Sweller, 1988). To control the cognitive overloaded situation, instructors need to construct good instructions for novices to encourage their schema construction and automation (Sweller et al., 1998). Cognitive load theory (CLT) provides a useful theoretical framework to trigger schema construction and automation and overcoming the limitations of human memory systems (Chandler & Sweller, 1991; Paas, Renkl, & Sweller, 2003).

**Cognitive Load Theory**

Cognitive load theory highlights the interactions between the limitations of the human memory system, instructional design and learning efficiency; in particular, it emphasizes an optimal use of working memory (Sweller et al., 1998). Because the working memory cannot handle too much information at one time, inappropriately designed instruction may impose heavy cognitive demands on learners. Many cognitive load theorists are devoted to seeking better instructional designs to avoid overloading working memory (Ayres, 2006). Once cognitive load is reduced, one has more available working memory capability for schema construction and automation.
Cognitive load can be defined as “the processing of information that occurs in working memory” (Hogg, 2006, p. 188). Sweller et al. (1998) have identified three types of cognitive loads that have an impact on working memory during instruction, these include intrinsic, extraneous and germane cognitive load. Hogg (2006) provided a detailed diagram to explain the relationship among cognitive loads, human memory systems and learning materials (see Figure 1).

To illustrate further, intrinsic cognitive load relates to the nature of tasks, element interactivity and the expertise of learners (Kalyuga, 2006; Sweller, 1998; van Merriënboer et al., 2006). Easier and low-element interactivity tasks can be fully understood without holding too many elements in working memory and learned serially rather than simultaneously (Kalyuga, 2006). In contrast to easier information, complex and high-element interactivity tasks require learners to put more effort into figuring out the relationship among the elements before understanding the materials; it may result in a high intrinsic cognitive load (Pawley et al., 2005; Sweller & Chandler, 1994; Sweller et al., 1998). To manage intrinsic load, Clark et al. (2006) recommended instructors segment and sequence content into a series of instructional events, such as an outline. In addition, Gerjets et al. (2004) mentioned presenting and explaining a complex problem solution in smaller meaningful units helps to reduce intrinsic load. Another way to reduce intrinsic cognitive load is to adopt an isolated-followed-by-interacting-elements approach. Accordingly, the intrinsic cognitive load can be reduced by presenting elements of information sequentially in an isolated form and following a fully interactive form (Pollock et al., 2002; van Merriënboer & Sweller, 2005). Except for the solutions
above, intrinsic cognitive load cannot be directly altered by instructors (Sweller et al., 1998). The best way to manage intrinsic cognitive load is to construct appropriately designed instructions which help learners to develop effective schemas for complex problem solving because compared to novices the same tasks are easier for experts who have effective schemas (van Merriënboer & Ayres, 2005).

To create appropriately designed instructions, extraneous cognitive load needs to be considered, because extraneous load refers to the mental load resulting from inappropriately designed instructional format or irrelevant cognitive activities that are not directed to schema construction and automation (Pociask & Morrison, 2008; Sweller, 1994, 2005; Sweller et al., 1998; Sweller & Chandler, 1994; van Merriënboer & Ayres, 2005). Poorly designed instruction and unorganized materials may distract and confuse learners, which brings about a high extraneous cognitive load and hinder learning (Bannert, 2002; Kalguya et al., 1998). For example, Kalyuka et al. (1999) mentioned that duplicate text-based and graphical instructional formats may split learners’ attention and increase their extraneous cognitive load. To illustrate further, while learners are spending more time on mental integration for unorganized materials instead of schema construction, their extraneous cognitive load increases. In contrast, appropriately designed instructions are able to decrease the extraneous load and gain more germane cognitive load for schema construction.

Germane cognitive load refers to the mental load resulting from intentional cognitive activities directly relevant to schema construction and automation in long-term memory (Paas et al., 2003; Schnitz & Kurschner, 2007; Sweller et al., 1998; van
Merriënboer & Ayres, 2005; van Merriënboer et al., 2003). The following types of cognitive activities may increase germane cognitive load in working memory and promote learning: (a) apply relevant learning strategies to learning consciously, (b) search for patterns in learning materials consciously to create cognitive schemata and semantic macrostructures, (c) restructure problem representations to solve a task and (d) taking conscious control of cognition and learning (meta-cognitive process) (Schnotz & Kurschner, 2007; van Lehn et al., 1992). When one gets involved in the cognitive activities above, one needs to devote more germane cognitive load to complete the tasks, which achieves a deeper understanding of instructional materials (Paas & van Gog, 2006; Schnotz & Kurschner, 2007; Sweller, 2005; Sweller et al., 1998).

Overall, the total cognitive load is the sum of intrinsic cognitive load plus extraneous cognitive load plus germane cognitive load. Since intrinsic cognitive load directly relates to the nature of tasks, the element interactivity and the expertise of learners, instructional designers cannot alter it directly but may create appropriate instructional designs to control extraneous cognitive load. Cognitive load theorists assumed that once extraneous cognitive load is under control, more mental resources in working memory can be devoted as germane cognitive load to schema construction while solving complex cognitive tasks. Designing quality instruction to reduce extraneous load and increase germane cognitive load may help learners achieve better learning outcomes (Ayres, 2006; Sweller et al., 1998).
Cognitive load theory (CLT) provides many useful instructional design strategies to construct better instruction (see Table 1). For example, element interactivity effect is used to explain how the degree of element interactivity relates to manage the intrinsic
cognitive load and affect learning (Sweller 1994; Sweller et al., 1998; Sweller & Chandler, 1994). Additionally, many instructional strategies could be used to control extraneous cognitive load and improve learning, including completion problem effect (Paas & van Merriënboer, 1994; Sweller, 2004), goal-free effect (Sewller, 1988, 2004), expertise reversal effect (Kalyuga et al., 1998), modality effect (Mayer, 1997, 2001; Kalyuga et al., 1999), redundancy effect (Kalyuga et al., 1999; Sweller & Chandler 1994), split-attention effect (Kalyuga et al., 1999), and worked example (Carroll, 1994; Cooper & Sweller, 1987; Crissman, 2006; Pawley, 2004; Lee et al., 2004; Shen, 2005; Sweller & Cooper, 1985; Zhu & Simon, 1987). Furthermore, imagination effect (Cooper, Tindall-Ford, Chandler & Sweller, 2001; Leahy & Sweller, 2008) and self-explanation effect (Chi, Bassok, Lewis, Reimann, & Glaser, 1989; van Lehn et al., 1992) are possible strategies to increase germane cognitive load for schemas construction while learning.

Table 1

<table>
<thead>
<tr>
<th>Cognitive Load Effects</th>
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<tbody>
<tr>
<td>Name</td>
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<tr>
<td>Completion Effect</td>
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Table 1

*Cognitive Load Effects (Continued)*

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<thead>
<tr>
<th>Name</th>
<th>About</th>
<th>Relevant Cognitive Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element interactivity effect</td>
<td>Element interactivity effect relates to the degree of relevance among elements (chunks of knowledge) in materials. If instructional material contains many unrelated elements, its element interactivity is low and can be understood and learned serially. However, if the material is consisting of too many related elements, then its element interactivity is high and not easy to be absorbed, because too many elements need to be considered simultaneously before understanding occurs, which may exceed the capability of working memory.</td>
<td>Intrinsic</td>
</tr>
<tr>
<td>Expertise reversal effect</td>
<td>Expertise reversal effect indicates different learning needs for novices and experts. Novices who posses less schemas gained more benefits from more detailed worked examples; once they gain more knowledge and construct more schemas, the benefit of worked example decreases, the same detailed information may become redundant for them afterward.</td>
<td>Extraneous</td>
</tr>
<tr>
<td>Goal-free effect</td>
<td>Goal-free problems simply focus problem states and available operators, which may reduce working memory load.</td>
<td>Extraneous</td>
</tr>
<tr>
<td>Imagination effect</td>
<td>Imagining requires the learner to mentally visualize the procedures in working memory. The imagination effect occurs when learners try to imagine information while processing the relevant schemas in working memory under high element interactivity conditions, which assists schemas construction and automation.</td>
<td>Germane</td>
</tr>
<tr>
<td>Modality effect</td>
<td>The modality effect occurs when students try to learn from both auditory and visual information, because the capability of working memory can be enhanced by the use of both visual and auditory channels.</td>
<td>Extraneous</td>
</tr>
<tr>
<td>Redundancy effect</td>
<td>The redundancy effect occurs when students try to process additional information related to the initial information, which may waste the mental resources in working memory.</td>
<td>Extraneous</td>
</tr>
</tbody>
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Table 1

*Cognitive Load Effects (Continued)*

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<tr>
<th>Name</th>
<th>About</th>
<th>Relevant Cognitive Load</th>
</tr>
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<tbody>
<tr>
<td>Self-explanation Effect</td>
<td>The self-explanation effect occurs when students try explaining examples to themselves while solving problems, which helps them learn better and use analogies more efficiently.</td>
<td>Germane</td>
</tr>
<tr>
<td>Split-attention effect</td>
<td>Split-attention occurs when students need to mentally integrate several sources of information placed in isolation for a better understanding of materials, which may overburden the capacity of working memory.</td>
<td>Extraneous</td>
</tr>
<tr>
<td>Worked example Effect</td>
<td>Worked example effect while student use a worked example to learn, which consists of a problem statement, steps leading to a solution and a final answer. It helps them to learn step by step and reduce cognitive load.</td>
<td>Extraneous</td>
</tr>
</tbody>
</table>

**Worked Example Effect**

Worked examples are one of the instructional design strategies above that helps reduce extraneous cognitive load. A worked example usually consists of a problem statement, steps leading to a solution and a final answer (Atkinson et al., 2003; Renkl, 1997). Learners can learn from the expert mental models provided in worked examples to solve problems correctly without trial and error, which can release more working memory capability available for schema construction and automation (Sweller, 1988, 2006; Sweller et al., 1998; Sweller & Cooper, 1985). Research has provided empirical evidence of the effectiveness of worked examples, for example, Sweller and Cooper (1985) and Cooper and Sweller (1987) found that students who used worked examples
performed better in the transfer test and spent less time in training. Another example, Zhu and Simon (1987) have conducted experiments with high school students in an algebra class; the results showed that students using worked examples performed and applied the procedures better than the students using conventional methods. Furthermore, Carroll (1994) conducted experiments with high school students by using worked examples while learning how to translate English expressions into algebraic equations. In his first experiment, worked examples were used to support students with their assignments; the results indicated that students benefited from worked examples more than they did from conventional training. In the second experiment, pre-algebra students who reviewed worked examples significantly outperformed students who only had instruction and practice problems. Pawley (2004) had similar results. Pawley used worked examples to teach grade 8 and 9 students algebraic problems. In the first experiment, he found out that worked examples worked for both students with higher and lower levels of prior knowledge in mathematics. Lee et al. (2004) found out students in the worked example group scored significantly higher on an assessment than the inquiry group. In addition, Shen (2005) examined the effectiveness of worked examples on problem solving in a game-based environment. 72 adults were randomly assigned into the worked examples group or the control group in his study. Each group was asked to play the computer game and after each of the two rounds of game playing, all participants were asked to complete the knowledge mapping system and problem-solving strategy questions of retention and transfer. Only the worked examples group was asked to study the worked examples before the second round of game playing. The results showed that the worked example
group improved significantly more than the control group in content retention and problem-solving strategies. Lastly, Crissman (2006) conducted a meta-analysis of multiple studies to examine if worked examples had positive effect on learning. The results of the meta-analysis showed worked examples did have a moderate positive effect on learning performance and cognitive load.

Although the effectiveness of worked examples has been widely confirmed, some researchers argued that the effectiveness of worked examples is only evident when the examples are well-constructed (Catrambone & Holyoak, 1989; Renkl, 1999; Tarmizi & Sweller, 1988; Ward & Sweller, 1990). Atkinson, Derry, Renkl and Wortham (2000) suggested that the following factors may affect the effectiveness of worked examples: (a) self-explanation effect, (b) situational factors and (c) example design. First of all, self-explanation effect occurs when learners explain the solutions of the examples to themselves, which stimulates them to learn better and use analogies more economically (Chi et al., 1989; Crissman, 2006; van Lehn et al., 1992). Chi et al. (1989) have provided learners worked examples containing text and graphics in their study; the findings showed that students who generated more self-explanations scored higher than those who provided fewer explanations. Second, situational factors depend on an instructor’s instructional abilities or other situational conditions, which may also influence learning outcomes. If instructors provide learners with clearer instructional explanations and set up proper learning goals during learning, learners may have more understanding about how to use a worked example correctly. Third, worked examples design (e.g., presentation format) may also affect the effectiveness of worked examples. For example,
Ward and Sweller (1990) found that students who received the integrated worked examples of geometric optics and kinematics performed better than students who received conventional problems or non-integrated worked examples, because they did not need to split their attention between text and graphics while learning integrated worked examples. From the above concerns, a designer may need to consider the worked example design, because only appropriate designed worked examples can enhance learning performance.

Presentation Format

Presentation format has its impact on worked example design, particularly the inclusion and arrangement of text and graphics (Ward & Sweller, 1990). People often learn from text-based materials, such as storybooks, textbooks, newspapers and manuals (Mcnamara, Kintsch, Songer, & Kintsch, 1996; Moore, 1989; Smaldino et al., 2007). The process of learning from text is complex and is not completely understood. Mcnamara et al. (1996) have pointed out that the coherence of a text and the amount of active processing it requires may affect the comprehension levels.

Researchers have proposed that adding graphics into instructional materials may enhance learning, because graphics have many benefits to learning, such as maintaining motivation, attracting attention, minimizing cognitive load and fostering in-depth processing (Anglin et al., 2004; Carney & Levin, 2002; Clark & Lyons, 2004; Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Mayer & Gallini, 1990; Peeck, 1993; Smaldino et al., 2007). For example, Ainsworth and Loizou (2003) found that graphics could stimulate learners to generate more self-explanations than text. The more self-
explanations generated, the better learning outcome achieved (Chi et al., 1989; van Lehn et al., 1992) because self-explanations relate to germane cognitive load. Clark and Lyons (2004) have broadly defined graphics as, “iconic expressions of content that are designed to optimize learning and performance in ways that improve the bottom-line performance of organizations” (p. 9). However, some researchers have argued that graphics are not always effective, because some graphics are even more difficult for learners (Berends, 2009; Butcher, 2006; Hegarty, Carpenter, & Just, 1991; Wu, Krajcik, & Soloway, 2001). Therefore, several factors needed to be considered while forming and selecting graphics for learning: (a) learning goals, lesson content and the nature of tasks, (b) graphics and individual difference, (c) functions of graphics and (d) the relationship between graphics and associated text (Clark, 2003; Clark & Lyons, 2004; Cox, 1999; Cuevas, Fiore, & Oser, 2002; Smaldino et al., 2007).

First of all, selecting graphics should base on learning goals, lesson content and the nature of tasks. For example, an instructor can use transformational graphics to help learners more easily remember the changing process of objects over time or space. Second, individual difference (e.g., prior knowledge level) may affect how learners learn from graphics, for example, learners who have a visual/nonverbal preference or a stronger spatial ability learn better from visuals. Jester and Miller (2000) mentioned that visual/nonverbal learner prefer to learn from information presented visually and in a graphical format (e.g., pictures, diagrams, flowcharts, video, and animation). Learner’s prior knowledge level may affect his performance while learning from graphics as well (Butcher, 2006; Hegarty et al., 1991; Petre & Green, 1993). For example, Butcher (2006)
found out simplified graphics benefited novices more in the information integration process during learning.

Third, Clark and Lyons (2004) mentioned that graphics could be presented in different surface features including static art (illustration, photographic and modeled) and dynamic art (animation, video and virtual reality) and have different functions to learning, including communication and psychological functions. First of all, communication functions of graphics include: (a) decorative graphics: add aesthetics or humor to the instructional display, (b) representational graphics: present concrete concepts and factual information, (c) mnemonic graphics: incorporate the meaning of the word with associated images, (d) organizational graphics: show qualitative relationships among the main ideas which orients learners to the structure and sequence of lesson content, (e) relational graphics: present quantitative relationships of lesson content, such as bar charts and pie charts, (f) transformational graphics: present the movement through space or changes over time, (g) interpretive graphics: build the understanding of abstract concepts and principles. Secondly, graphics also have their psychological functions, including (a) support attention: draw the learner’s attention, (b) activate prior knowledge: remind the learners of what should have been learned, (c) minimize cognitive load: simplify information that is difficult to understand, (d) build mental models: construct new memories, (e) support transfer of learning: promote deeper understanding and (f) support motivation: motivate learners by using interesting images (Clark & Lyons, 2004). Cuevas, et al. (2002) even found out graphics could support learners with low verbal ability for their knowledge acquisition and meta-comprehension of complex systems in a
computer-based training environment. In addition, Smaldino et al. (2007) added two more functions of graphics, such as (a) make abstract ideas concrete and (b) use relevant visuals to repeat the information which gives learners a chance to comprehend visually.

Fourth, Cox (1999) mentioned that a balanced relationship between associated texts is hard to achieve while designing instructional materials. Cognitive load theorists have proposed that the split-attention and redundancy effect need to be considered while integrating text and graphics for worked examples (Chandler & Sweller, 1991; Sweller & Chandler, 1994). The split-attention effect was derived directly from the worked example effect. Thus effect occurs when the materials are presented in split source formats (e.g., separate text and graphics), which may impose a heavy extraneous cognitive load on working memory and thus hinder learning (Chandler & Sweller, 1991; Pociask & Morrison, 2008; Purnell, Solman, & Sweller, 1991; Sweller 1999; Sweller & Chandler 1994), because they require learners to focus on mentally integrating the graphics and text. Mental integration means learners have to search appropriate relevant information between the text and graphics and then to make sense of them, but not every learner is able to do the mental integration quickly, which may relate to a learners’ spatial ability or expertise. Learner with low spatial ability or less experiences may not be able to make referential linkages between the two recourses effectively (Mayer & Sims, 1994). Therefore, worked examples which require learners to split their attention between multiple sources of information may be no more effective than other instructional designs (Ward & Sweller, 1990; Tarmizi & Sweller, 1988).
In addition to the split-attention effect, the redundancy effect needs to be considered when designing worked examples (Pociask & Morrison, 2008). The redundancy effect occurs when irrelevant graphics are presented aside the text statements; it may waste learners’ working memory capability to identify two different sources of information and make the connection. Chandler and Sweller (1991) have presented information about how heat functions in two different modes (text and graphics); the results showed that the elimination of text that describes the content of a graphic could enhance learning. If two sources of information can be understood in isolation without reference to each other, there is no need to present the information in two different formats, because learners may spend too much time integrating the two sources of information. In this case, eliminating one of the formats may reduce unnecessary extraneous cognitive load and allow learners to focus working memory available on understanding the content. Pawley et al. (2005) had similar results; they found that students needed to process the learning material presented in two different modes twice, which produced a heavier cognitive burden on working memory.

Instead of wasting working memory resources to mentally integrate two sources of information or irrelevant information, physical integration of instructional materials is necessary. Hegarty and Just (1993) found that learners did better in text-plus-graphic group than learners who studied either one alone. Compared to text-only or graphic-only formats; the integrated presentation format may be more effective for learning. In addition, Pociask and Morrison (2008) have examined the redundancy and split attention effects in their study about teaching orthopedic physical therapy skills. There were two
groups in the study: the modified instruction group received a modified instruction designed to reduce cognitive load, while the control group received a traditional instruction. The results indicated that the modified instruction group scored significantly higher on the posttest and psychomotor tasks and reported a lower cognitive load on both tasks.

The Relationship between Worked Examples, Presentation Format and Prior Knowledge

From the review above, several points can be made. Worked examples can enhance learning and overcome the shortcomings of human memory systems by leading learners to solve problems systematically. However, to construct an effective worked example needs to consider its design, especially its presentation format. Cognitive load theorists have proposed split-attention effect (Chandler & Sweller, 1991; Pociask & Morrison, 2008; Sweller, 1999; Sweller & Chandler, 1994) and redundancy effect (Chandler & Sweller, 1991; Pawley et al., 2005) to adjust the presentation format of worked examples. In addition, individual difference (e.g. prior knowledge) needs to be considered because learners with different prior knowledge levels (the amount of relevant schemes) may learn differently from worked examples provided (Kalyuga et al, 1998; Hegarty et al., 1991). In this section, the relationship between worked examples, presentation format and prior knowledge are discussed.

*Worked Examples vs. Presentation Format*

Integrating multiple resources of information has more benefits for the learners (Butcher, 2006; Hegarty & Just, 1993; Pociask & Morrison, 2008; Purnell et al., 1991),
because it can reduce extraneous cognitive load (Sweller, Chandler, Tierney, & Cooper, 1990; Ward & Sweller, 1990). In addition, the complexity of the graphics also needs to be addressed, because a too complex graphic may decrease its effectiveness for learning and confuse learners (Butcher, 2006; Hegarty et al., 1991). For example, Butcher (2006) conducted two experiments to investigate learning outcomes and comprehension of the heart and circulatory system with three different presentation formats, including (a) text-only, (b) text with simplified graphics designed to highlight important structure of heart and circulatory system and (c) text with more detailed graphics reflecting a more complete representation. The first experiment found that both types of integrated formats supported learning, but simplified graphics best supported factual learning. The second experiment replicated the first experiment and tested the influence of graphics on novices’ comprehension processes. The results showed that both integrated formats supported learning, but simplified graphics most strongly benefited novices on the information integration process during learning.

**Worked Examples vs. Prior Knowledge**

Although research supports that worked examples are beneficial for learners (Carroll, 1994; Cooper & Sweller, 1987; Crissman, 2006; Pawley, 2004; Lee et al., 2004; Shen, 2005; Sweller & Cooper, 1985; Zhu & Simon, 1987), they do not have equal benefits for all learners, especially for experts (Crissman, 2006; Kalyuga, et al., 1998). Crissman (2006) conducted a meta-analysis of multiple studies to examine if worked examples have positive effect on learning. The results showed that worked examples benefited more to students with lower prior knowledge than the ones with higher prior
knowledge. The main reason for this inequity is prior knowledge. Experts who had more effective schemas can generate proper responses to problems presented, whereas novices with fewer schemas needed more cognitive supports (Mayer, 2001). Kalyuga, Chandler, Tuovinen and Sweller (2001) found that inexperienced trainees clearly benefited most from the worked examples while dealing with complex tasks. After two training sessions, once inexperienced trainees gained more experiences and knowledge, the worked example effects decreased. To illustrate, while inexperienced learners were dealing with new complex problems, they might have few cues and experience a heavy cognitive load. However, once they accumulated more experiences after a period of learning time, when they met with similar problems, they might be able to solve problems easily without experiencing the same amount of cognitive overload anymore, because continuous practice could facilitate schema automation. At this point, they may not need worked examples as extra mental aids; they may need to learn from more challenging activities (e.g., problem-solving activities).

Presentation Format vs. Prior Knowledge

Graphics have many advantages for learning (Mayer et al., 1996; Mayer & Gallini, 1990), but Wu et al. (2001) have pointed out that some students may have more difficulties understanding graphics than instructors expected, even though the graphics are well-designed. The reason causing this problem is that instructors may neglect individual differences, especially prior knowledge levels. Kalyuga et al. (1988) found that knowledgeable electrical trainees benefited more from instructional material that consisted of an electrical circuit graphic without any additional textual information. In
contrast, electrical trainees who had less knowledge need training materials that include
additional textual explanations with graphics. In other words, integrating text and graphic
has more benefits for novices, not experts. In addition, Hegarty et al. (1991) found out
students with little prior knowledge had difficulty distinguishing between relevant and
irrelevant information on graphics, so too complex graphics might easily confuse
learners. When they tried to interpret the key concepts, they were not able to create
abstract mental models and only focused on surface features of graphics (Butcher, 2006).
Furthermore, Butcher (2006) replicated learning effects from his first experiment and
tested the influence of graphics on novices’ comprehension processes; the results showed
that simplified graphics provided the strongest support for novices processing
information. In contrast, experts were able to go beyond the surface features of graphics
because they already had well-developed prior knowledge, which allowed them to
connect two different presentations and develop a more comprehensive mental model
(Cook, 2006).

Learning Performance (The Effectiveness of Worked Examples)

After exploring the ideas about prior knowledge, worked example design and
presentation format, how to evaluate the effectiveness of worked examples is discussed in
this section. Cognitive load is an internal process and hard to observe directly, so
researchers developed different methods to estimate and measure cognitive load.
Brunken, Plass and Leutner (2003) have classified the measurement of cognitive load in
four categories (Indirect/Subjective, Direct/Subjective, Indirect/Subjective
Direct/Objective) based on the objectivity and causal relations. The objectivity describes
whether the measure uses subjective self-report or objective observations and the causal relation relates to “the type of relation of the phenomenon observed by the measure and the actual attribute of interest” (p. 55). For example, self-reported invested mental effort belongs to the subjective and indirect dimensions, because it relies on a subjective reporting and cannot be observed directly.

*Indirect/Subjective Measures*

Paas and van Merriënboer have conducted two experiments in 1993: One was related to the computer-based training strategies and the other was related geometrical problem solving. In these two experiments, they used a 9-point subjective rating scale to measure the mental load invested in understanding learning materials indirectly. At the high end of the scale, ‘9’ was associated with the learner’s investment of “very, very high mental effort,” and at the low end, ‘1’ was associated with “very, very low mental effort.” The reliability of the subjective rating scale was high, with Cronbach’s alpha .90 and .82 for their two experiments. They also developed a formula to combine task performance and mental load invested to measure the mental efficiency of instructional conditions, which called instructional efficiency. To obtain a measure of instructional efficiency, performance scores (obtained from the performance test) and the mental effects (obtained from the mental load scale) need to be standardized to Z scores, which can be displayed in two dimensions mental effort on the x-axis and performance on the y-axis. After the standardized process, the z scores data needs to be entered into a formula: $E = Z_{\text{Performance}} - Z_{\text{Mental Load}} / \sqrt{2}$. The square root 2 is used calculate the distance from a point $(X_{\text{Mental Loads}}, Y_{\text{Performance}})$ and E stands to the degree of instructional efficiency. If E is positive, it
means the instruction is highly efficient, because it minimizes the amount of mental effort needed for the task and maximizes the performance on that task at the same time.

However, if E is negative, it means the instruction is less efficient, because the performance is lower than can be expected based on the invested amount of mental effort. If E= 0, it means an intermediate neutral efficiency condition.

Direct/Subjective Measures

Kalyuga et al. (1999) revised Paas and van Merriënboer (1993)’s mental load scale and proposed a subjective measure, the rating of the difficulty of the materials, to measure the mental efforts invested during learning. The scale relates directly to the cognitive load imposed. It is a 7-point Likert-type scale from extremely easy (corresponding to the score 1) to extremely difficult (corresponding to the score 7). The higher score learners got, the higher mental load they experienced while learning.

Indirect/Objective Measures

Indirect/objective measures are the most common method of investigating cognitive load effects, including outcome and physiological measurement. Outcome measurement refers to test scores, physical performance, the time that learners invested and the errors that learners made (Schnotz & Kurschner, 2007). Physiological measurement indirectly relates to the cognitive load used, such as eye-tracking analysis, heart rate, pupil dilation, and electro-encephalography (EEG). First of all, eye tracking helps measure the eye movement (includes fixations, saccades and gaze) which relates to the effects of cognitive load invested while learning (Wiebe & Annetta, 2008). Second, Paas and van Merriënboer (1994) have used heart-rate variability as a measure of
cognitive load; high-cognitive load provoked high stress in an individual, which may lead to changes in heart rate. Third, Kahneman and Beatty (1966) have used the first pupillometric analysis of task-evoked pupillary responses in a short-term memory task; the results indicated that papillary diameter increased during problem solving until the point of solution appeared and peak dilation was larger while dealing with more difficult problems. Fourth, Whelan (2006) mentioned electroencephalography (EEG) can be used to measure the mental load indirectly. Electroencephalography (EEG) is a measure of brain waves, which provides evidence of how the brain functions over time (Jensen & Tesche, 2002).

**Direct/Objective Measures**

Direct/Objective measures are more close to the human brain, such as the use of neuro-imaging techniques and dual-task performance. Smith and Jonides (1997) have used fMRI (functional magnetic resonance imaging) to measure brain activation when learners operate tasks, including auditory sentence comprehension and mental rotation of visually depicted 3-D objects. Their findings revealed when learners performed these auditory and visual tasks concurrently, and activation of their brains was less than the sum of the activation when performing these two tasks alone. This finding supported the modality effect discovered by cognitive load theorists (Kalyuga et al., 1999; Mayer, 1997, 2001). In addition, dual-task performance can be used for measuring the mental load directly by visualizing brain region activation in working memory (Brunkene et al., 2003; Just et al., 2001).
Web-based Experiments

Web-based experiments are experiments which are delivered over the web and can be accessed via web browsers (Reips & Lengler, 2005). There are several terms have been used for representing this type of study such as web experiment, online experiment, web-based experiment, World Wide Web (WWW) experiment, and internet experiment (Reips, 2002a). Web-based experiment is the most commonly used term. In the recent years, more and more researchers have begun to conduct web-based experiments (Reips, 2001). One of the reasons that the researchers choose to conduct web-based experiments instead of traditional experiments is because of high internet speed, the availability of internet access, and the advanced web-based technologies. Participants can use different web browsers to complete the experiment on the internet easily. Musch and Reips (2000) have found out the data collected from 18 web experiments were highly consistent with and the lab experiments. In addition, conducting a web-based experiment has many advantages: (a) increasing sample size, (b) getting sample diversity, (c) accessing sample specialty, (d) encouraging voluntary participation and (e) reducing the cost of money and time and (f) avoiding experimenter bias (i.e. experimenter expectation) (Reips, 2000).

Therefore, many tools have been created for designing experimental research, such as PsychExperiment, FactorWiz and WEXTOR (Reips, 2002a). These tools are created by different technologies such as Authorware® and Javascript. For example, PsychExperiments has been developed by using Authorware®, a powerful authoring tool used for instruction and research. Researchers can use iconized objects and condition boxes in Authorware® to compose a complex research design (Reips, 2001). In addition,
FactorWiz is developed by using Javascript to create within-subject factorial design (Birnbaum, 2000). Another example of Javascript application, WEXTOR, allows researchers create their own between-, within-, and quasi-experiments though a 10-step process (Reips & Neuhaus, 2002). In addition to the above web-based technologies, Song (2004) has mentioned Adobe® Flash® could be used to build powerful web based tools.

Adobe® Flash® is multimedia software created by Macromedia® and currently developed and distributed by Adobe® Systems. Flash has become a popular technology for creating animation and interactive applications since 1996, because it can handle both vector and raster graphics and support bi-directional streaming of audio and video files. ActionScript embedded in Flash is used to compose commands behind the scene (Ulrich, 2004). Most of the current web browsers and operating systems are compatible with Flash®. Additionally, Flash® files can be compressed to very small file sizes and can be downloaded rapidly.

Before starting to build a web-based experimental tool, several research issues need to be considered. First of all, web-based research may involve a loss of control by the experimenter, which means that the experimenter is unavailable to answer questions, deal with concerns, or troubleshoot problems during the experimental process (Schmidt, 1997). To avoid confusions, a clear instruction, warm-up messages, pop-up reminders and breadcrumbs need to be provided, so participants can have clear instructions for completing the experiment. Secondly, Reips (2002a) has pointed out that web-based research usually has a high drop-out rate; which may affect the research results. To lower the drop-out rate, informed consent questions (i.e., age and consent form) need to be
provided at the beginning of the experiment, so participants can decide whether they want to participate the experiment or not. In addition, offering incentives and applying ActionScript for focus completion function can be implemented to decrease missing responses. For example, if one forgets to fill out a question, a reminder message pops up and prevents him or her to go to the next page till he provides the response. Thirdly, Reips (2002a) also mentioned that a multiple submission problem may occur in web-based experiment; therefore, it is essential to use password control, ask for ID identification and monitor the participants’ IP address to avoid redundancy. Fourthly, if the experiment involves online testing, an appropriate time control can prevent online cheating. Lastly, if it belongs to a between-subjects research design, randomization techniques should be used to randomly assign the participants into different treatments.

Summary

From the discussions above, human memory systems have limits. To overcome these limits and to help learners achieve schema automation, an appropriately designed instructional intervention is needed. Cognitive load theory provides many useful strategies for instructors and worked example is one of them. Students who follow worked examples with step-by-step guidance may have better learning performances. Although the effectiveness of worked examples has been widely confirmed, instructors still need to pay attention to presentation formats (e.g., text and graphics) and individual differences (e.g., prior knowledge levels). Therefore, the aim of this study is to examine the effectiveness of worked examples by manipulating possible factors (worked
examples, presentation format and prior knowledge) and generate an improved worked example design for learners.
CHAPTER THREE: METHODS

The previous chapter has provided a review of the relevant literature. This chapter will discuss the research design step-by-step. Mauch and Birch (1989) suggest that an appropriate research plan needs to include the following components: (a) research questions, (b) null hypotheses, (c) participants, (d) instructional materials, (e) instrumentation, (f) dependent and independent variables, (g) research design, (h) pilot study, (i) validity and reliability, (j) data collection procedure and (k) data analysis procedures.

Research Questions

Research questions determine every facet of research design and provide the basis for making research planning decisions, including measurement, data collection and evaluation (Light, Singer, & Willett, 1990). Accordingly, the following components need to be addressed in research questions: (a) target population, (b) outcome variables, (c) the type of research (e.g., descriptive, relational or experimental study) and (d) background characteristics. The aim of this study was to explore whether worked examples, their presentation formats and learners’ prior knowledge levels affect the effectiveness of instruction or not and the interaction among the three factors. The effectiveness of instruction in this study included learners’ scores on the posttest, cognitive load reported, time on the posttest and instructional efficiency. Combining subjective (cognitive load) and objective (posttest score and time spent on the posttest) measures may achieve a full understanding of student learning performance in the study. In addition, instructional efficiency was another important measure in cognitive load theory research, which was
used to detect the mental effectiveness of instructional conditions. According to the purposes of study, this study explored the following questions.

1. Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different instructions (general statements and worked examples)?

2. Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic)?

3. Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low)?

4. Is there a significant interaction among instructions, presentation formats and prior knowledge levels in the pre-service teachers’ performance (posttest, cognitive load, time spent on the posttest and instructional efficiency)?

Null Hypotheses

Research questions and hypotheses can guide the researcher in shifting through a mass of data. The hypothesis should be stated as a suggested solution to a problem or as the relationship of specified variables (Mauch & Birch, 1989). According to the research questions stated in the previous section, the null hypotheses in this study were listed as follows:
1. H01.1: There is no significant mean difference for the learning performance (posttest) among the pre-service teachers who view different instructions (general statements and worked examples).

2. H01.2: There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers who view different instructions (general statements and worked examples).

3. H01.3: There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers who view different instructions (general statements and worked examples).

4. H01.4: There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers who view different instructions (general statements and worked examples).

5. H02.1: There is no significant mean difference for the learning performance (posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

6. H02.2: There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

7. H02.3: There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).
8. H02.4: There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

9. H03.1: There is no significant mean difference for the learning performance (posttest) among the pre-service teachers with different prior knowledge levels of internet connection (high, medium and low).

10. H03.2: There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low).

11. H03.3: There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low).

12. H03.4: There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low).

13. H04.1: There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (posttest).

14. H04.2: There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (cognitive load).
15. H04.3: There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (time spent on the posttest).

16. H04.4: There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (instructional efficiency).

Participants

The population is “the group about which the researcher wants to gain information and draw conclusions.” (Tuckman, 1999, p. 259). Light et al. (1990) have suggested the following to define the population: (a) inclusion criteria relates to the reason why the researcher wants to study this particular population, (b) exclusion criteria relates to the people whom should be to exclude, (c) expected effect size relates to the types of target populations that the researcher wants to find, (d) feasibility relates to the condition for choosing a target population. In other words, researchers have to identify the reason for choosing the target population, consider which group of people should be included or excluded, and estimate which group of people should be generalized. In this study, the researcher was interested in improving instructional technology programs for pre-service teachers, so pre-service teachers who took an introductory integration of technology to the classroom classes at a large Midwestern university were considered the target sample in this study.

To generalize the finding of this study to the target population, the appropriate sample size is important (Lenth, 2001), because an over-sized or under-sized sample plan
may impact the results of study and subjects. Tuckman (1999) has suggested sample size should be selected based upon three factors: alpha level, power and effect size. First, the alpha level is the probability of making a false positive conclusion or rejecting the null hypothesis when it is true, which is usually set at .05. Second, the power of a statistical test is the probability of obtaining statistically relevant results, which is usually set at .80. Third, the effect size is the magnitude of the finding. Cohen (1988) proposed the conventional level of effect size for analysis of variance can be divided into three categories: small (.10), medium (.25) and large (.40). Medium effect size is large enough to detect the significant results (Light et al., 1990).

To answer the research questions and hypotheses, this study was conducted using a three-way 2x2x3 ANOVA statistic method. The alpha level was set at .05, the expected statistical power was set as .80 and the effect size was set at .35. According to Cohen’s (1988) sample size table and cell sample size formula: \( N_c = \frac{(n' - 1)(u + 1)}{\text{number of cells}} + 1 \), the total number of sample size for this study was expected to be 108. This study recruited 136 undergraduate students who enrolled education classes at a large Midwestern university in the 2008 winter and spring quarter.

Instructional Materials

The instructional materials used were related to internet disconnection troubleshooting and presented in four different versions (include text-only general statement, text-plus-graphic general statement, text-only worked examples, and text-plus-graphic worked examples). Relevant concepts and technical terms were explained at the beginning of all the instructions, such as network card, router, cable modem, and ISP.
server. The general statement instruction was displayed in a traditional bullet writing style focusing on the troubleshooting procedure, including (a) check cords, (b) check command prompt screen, (c) check network card, (d) check router, (e) check cable modem and (f) check DNS server (refer to Figure 2). The worked example instruction started with a disconnected internet problem, followed by the troubleshooting process, including (a) check cords, (b) check command prompt screen, (c) check network card, (d) check router, (e) check cable modem and (f) check DNS server (see Figure 2) and ended with a final answer. The screenshots of both instructions were provided below (see Figure 3).

Figure 2. The troubleshooting procedure of internet disconnection.
Text-plus-graphic general statement

A successful Internet connection is usually composed of the following components:

1. Network Card: A network card is a piece of hardware designed to allow computers to communicate over a network. Network card has one Ethernet port used to connect to a router.

2. Router: A router is a device used to connect at least two networks, like your local network and ISP’s network. A 5-Port router has five ports: One is used to connect the cable modem, the other ports are used to connect computers.

3. Cable Modem: A cable modem is a device that provides access to a data signal sent over the coax cable television infrastructure. Cable modem has one Ethernet port used to connect to a router and one cable hole used to connect the ISP’s network.

4. ISP Company: An ISP (Internet service provider) is a business or organization that provides consumers or businesses access to the Internet and related services.

Text-plus-graphic worked example

A successful Internet connection allows you to connect to the world of information. However, if you find that you cannot connect to the Internet, you can follow the procedure on the next screen to solve the problem easily.

*Important Instruction for the next screen:* Please press “Start” button to review the procedure on the next screen. On the next screen, a diagram is presented on the screen. Please use mouse to move over the rectangle buttons to review the troubleshooting process. When you get ready to take the posttest after reviewing the instruction, please press “Ready for the posttest” button.

Problem statement: John uses the Internet to connect to the outside world. Someday he finds he is not able to connect to a site. He is upset, unfortunately he cannot get any help because it is midnight, his ISP help desk is closed. He attempts to solve the problem by himself. He finds the problem-solving procedure on the next screen is helpful.

*Important Instruction for the next screen:* Please press “Start” button to review the procedure on the next screen. On the next screen, a diagram is presented on the screen. Please use mouse to move over the rectangle buttons to review the troubleshooting process. When you get ready to take the posttest after reviewing the instruction, please press “Ready for the posttest” button.

Troubleshooting procedure for Internet connection (Use mouse to move over the buttons):

1. Check cards
2. Run command prompt screen
3. Check network card
4. Check router
5. Check DNS server
6. Check cable modem

John checks all the related cards to see if they are plugged properly. He finds they are O.K.
Figure 3. Screenshots of both general statement instruction and worked example instruction.

In addition, the difference between text-only and text-plus-graphic presentation formats was the arrangement of text and graphics. In the text-only presentation format, the troubleshooting process was presented in a written form, whereas the text information about the troubleshooting process was integrated with relevant graphics in the text-plus-graphic presentation format. The screenshots of both presentation formats were provided below (see Figure 4).
Text-only presentation format

A successful internet connection is usually composed of the following components:

1. **Network Card**: A network card is a piece of hardware designed to allow computers to communicate over a network. A network card has one Ethernet port used to connect to a router.

2. **Router**: Router is a device used to connect at least two networks, like your local network and ISP’s network. A 5-port router has five ports. One is used to connect the cable modem, the other ports are used to connect computers.

3. **Cable Modem**: A cable modem is a device that provides access to the data signal sent over the cable television infrastructure. Cable modem has one Ethernet port used to connect to a router and one cable hole used to connect the ISP’s network.

4. **ISP Company**: An ISP (Internet service provider) is a business or organization that provides consumers or businesses access to the Internet and related services.

**Problem statement**: John uses the internet to connect to the outside world. Someday he finds he is not able to connect to a site. He is upset, unfortunately he cannot get any help because it is midnight, his ISP help desk is closed. He attempts to solve the problem by himself. He finds the following problem-solving procedure on the next screen is helpful.

Time left available: 10 minutes

*Please be patient to read through the instruction, thanks!*

---

Text-plus-graphic presentation format

A successful internet connection is usually composed of the following components:

1. **Network Card**: A network card is a piece of hardware designed to allow computers to communicate over a network. Network card has one Ethernet port used to connect to a router.

2. **Router**: Router is a device used to connect at least two networks, like your local network and ISP’s network. A 5-port router has five ports. One is used to connect the cable modem, the other ports are used to connect computers.

3. **Cable Modem**: A cable modem is a device that provides access to the data signal sent over the cable television infrastructure. Cable modem has one Ethernet port used to connect to a router and one cable hole used to connect the ISP’s network.

4. **ISP Company**: An ISP (Internet service provider) is a business or organization that provides consumers or businesses access to the Internet and related services.

**Problem statement**: John uses the internet to connect to the outside world. Someday he finds he is not able to connect to a site. He is upset, unfortunately he cannot get any help because it is midnight, his ISP help desk is closed. He attempts to solve the problem by himself. He finds the problem-solving procedure on the next screen is helpful.

* Important instruction for the next screen: 

Please press “start” button to review the procedure on the next screen. On the next screen, a diagram is presented on the screen. Please use mouse to move over the rectangle buttons to review the troubleshooting process. When you get ready to take the posttest after reviewing the instruction, please press “Ready for the posttest” buttons.

Please press the “step” buttons on the left to review the troubleshooting process. When you get ready to take the posttest, please press “Ready for the posttest” buttons on the Step 6 screen.

Time left available: 9 minutes

*Please be patient to read through the instruction, thanks!*

---
Please press the "step" buttons on the left to review the troubleshooting process. When you get ready to take the posttest, please press "Ready for the posttest" buttons on the Step 6 screen.

**Instruction W1**

**Step 1** Check network card

**Step 2** Check DNS server

**Step 3** Check cable modem

**Step 4** Check router

**Step 5** Check modem

**Step 6** Check cable modem

Time left available: 9 minutes

* Please be patient to read through the instructions. Thanks!

---

**Instruction W2**

**Step 1** Check cards

**Step 2** Check DNS server

**Step 3** Check network card

**Step 4** Check router

**Step 5** Check modem

**Step 6** Check cable modem

Time left available: 9 minutes

* Please be patient to read through the instructions. Thanks!

---

**Instruction W3**

**Step 1** Check cards

**Step 2** Check DNS server

**Step 3** Check network card

**Step 4** Check router

**Step 5** Check modem

**Step 6** Check cable modem

Time left available: 9 minutes

* Please be patient to read through the instructions. Thanks!

---

**Instruction W4**

**Step 1** Check cards

**Step 2** Check DNS server

**Step 3** Check network card

**Step 4** Check router

**Step 5** Check modem

**Step 6** Check cable modem

Time left available: 9 minutes

* Please be patient to read through the instructions. Thanks!
Figure 4. Screenshots of both text-only and text-plus-graphic presentation formats.

Instrumentation

Performance Test

The performance tests included an 8-minute, 10-question pretest and an 8-minute, 10-question posttest session. The pretest was used to determine a participant’s prior knowledge levels, and the posttest was used to determine a participant’s learning performance. Questions in the pretest and posttest were the same but displayed in a different order to prevent the possibility of students to remember the content of pretest
(Light et al., 1990). Additionally, the content related to an internet disconnection troubleshooting process: (a) check cords, (b) check command prompt screen, (c) check network card, (d) check router, (e) check cable modem and (f) check DNS server (see Appendix B). There were only 10 questions in the pretest, and 1/3 participants’ scores had a median in the middle. A score of 5 or 6 made it difficult to classify participants as being in the low prior knowledge level group or not. Therefore, adding a medium prior knowledge level group was essential. A student who had scores on the pretest above 6 was assigned to high prior knowledge level group; a student who had scores below 5 was assigned to the low prior knowledge level group; a student who had scores of 5 or 6 was assigned to the medium prior knowledge level group.

Bloom (1956)’s taxonomy of cognitive knowledge indicates that cognitive knowledge can be divided to six categories: (a) knowledge: a learner needs to recall information, (b) comprehension: a learner need to understand the meaning of learning materials, (c) application: a learner need to apply a concept to a new situation, (d) analysis: a learner need to separate concepts into smaller components for better understanding, (e) synthesis: a learner needs to build a structure from diverse elements and (f) evaluation: a learner needs to make judgments about the value of materials (Bloom, 1956). Anderson and Krathwohl (2001) have redefined Bloom’s taxonomy of cognitive knowledge to another six categories: (a) remembering, (b) understanding, (c) applying, (d) analyzing, (e) evaluating, and (f) creating. Accordingly, the higher level of knowledge involves more complex learning and decision making.
The content of the instruction in this study related to an internet disconnection troubleshooting process, which required participants to have a higher level of knowledge other than knowledge or comprehension to make a better decision for troubleshooting. Therefore, the knowledge involved in the pretest and posttest were presented in two difficulty levels to detect whether participants could learn more from the instructions offered and to determine if they could apply relevant knowledge to new situations. Questions 1 to 5 involved basic knowledge, participants needed to fill out the questions based on recalling the relevant concepts in the instruction. For example, a participant needed to know the usage of network card to answer question 1. Further, questions 6 to 10 were involved more complex thinking; participants needed to comprehend the instruction and then apply the relevant knowledge to their decision making process for problem solving. For example, a participant needed to understand the relevant knowledge, make correct decisions and apply what he knew to solve question 6 (see Table 2). A complete list of questions and their relevant cognitive knowledge is presented in Appendix C.
Table 2

Question 1 & 6 and Their Relevant Cognitive Knowledge

<table>
<thead>
<tr>
<th>Question Items</th>
<th>Cognitive Knowledge Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is a Network Card?</td>
<td>Relevant knowledge involved:</td>
</tr>
<tr>
<td>1) A piece of hardware for the network communication *</td>
<td>1) network card.</td>
</tr>
<tr>
<td>2) A piece of hardware for audio signals.</td>
<td></td>
</tr>
<tr>
<td>3) A piece of hardware for media storage.</td>
<td></td>
</tr>
<tr>
<td>6. Sarah finds that she cannot connect to the internet. When she types in IPCONFIG on the command prompt screen, she finds that she does not have an IP address assigned. What problem does she have?</td>
<td>Relevant knowledge involved:</td>
</tr>
<tr>
<td>1) She may have a problem with the router.</td>
<td>1) IPCONFIG;</td>
</tr>
<tr>
<td>2) She may have a problem with the network card*</td>
<td>2) Command prompt screen;</td>
</tr>
<tr>
<td>3) She may have a problem with the cable modem.</td>
<td>3) IP address;</td>
</tr>
<tr>
<td>4) router;</td>
<td>4) router;</td>
</tr>
<tr>
<td>5) Network card;</td>
<td>5) Network card;</td>
</tr>
<tr>
<td>6) Cable modem.</td>
<td>6) Cable modem.</td>
</tr>
</tbody>
</table>

Note. * indicates the answer key

Rating of the Difficulty of the Materials

In this study, the rating of the difficulty of the materials was revised from Kalyuga et al. (1999) 7-point rating of the difficulty of the materials. According to Light et al. (1990), as long as participants can distinguish among the options provided, the observed scores from longer scales are most likely to reflect any true variation that exists across participants. Therefore, since there were only 10 items in the rating of the difficulty of the materials, the researcher extended the scale from 7 points to 9 points to collect more
reliable data. Points are scaled from extremely easy to extremely difficult to indicate different amount of mental investment. ‘1’ means the item was really easy for the participant and he did not invest too much cognitive load on this item, in contrast, ‘9’ means the item was really difficult for the participant and he invested a lot of cognitive load on this item (see Figure 5).

![Difficulty Rating Scale](image)

*Figure 5. Rating of the Difficulty of the Materials.*

**Online Experimental Tool**

The instrument in this study was built using Flash CS3®, ASP and Access database. Flash served as the main platform of the experiment, including a one-minute review of background information, an eight-minute ten-question pretest, a ten-minute instructional session and an eight-minute ten-question posttest. Action script 2.0 was used to control the interaction between participants and system, guide them through the experimental process and record time spent on each task. Further, ASP was used to pass values from Flash® to Access database and monitor participants’ login time and IP address to prevent non-target participants’ access to the experiment and repeated submissions. The database used in this tool was Access (see Figure 6).
There are several characteristics of this tool: (a) 2x2x3 factorial before and after design: The tool marked participants in different prior knowledge levels (high, medium and low) based on their pretest scores and randomly assigned them to different instructions (including text-only general statement, text-plus-graphic general statement, text-only worked example and text-plus-graphic worked example), (b) Randomization: Randomization is the most important and basic of all the control methods; it is helpful in controlling unknown sources of variation and assures the control of extraneous variables (Christensen, 1991; Light et al., 1990). This tool randomly assigned participants to different instructions after completing the pretest, (c) Time control: Time spent on each task was recorded and counted by seconds. The tool sent the relevant data to the database, which could be retrieved as participants’ learning performance, (d) IP tracking:
Participants’ IP address were recorded to present non-target participants’ access and repeated submissions and (e) No manual data entry: The data stored in Access database could be easily transferred to SPSS without manual data entry.

Dependent and Independent Variables

Dependent Variables

Scores on the posttest (performance test): In this study, the posttest was composed of 10 multiple-choice questions. The content of questions was related to an internet disconnection troubleshooting process and presented in two difficulty levels. Once a participant had one correct answer, he could get 1 point for that particular item. The range of scores was from 0-10.

Cognitive load: Cognitive load refers to the cognitive load placed in working memory during the task. In this study, the cognitive load was measured by a 9-point categorical scale. ‘1’ means the item was really easy for the participant and he did not invest too much mental load on this item. In contrast, ‘9’ means the item was really difficult for the participant and he invested a lot of mental load on this item.

Time spent on the posttest: Time was recorded by the experimental tool and counted by seconds.

Instructional efficiency: Instructional efficiency was calculated using Paas and van Merriënboer (1993) and Pass et al. (2003) procedure, which standardized and performance scores (obtained from the posttest) and mental load (obtained from the rating of the difficulty of the materials) into Z scores and calculated the data into the formula: \( E = \frac{Z_{\text{Performance}} - Z_{\text{Mental Load}}}{\sqrt{2}} \). This approach was used to combine mental
effort and performance measures, derived information on the relative effectiveness of instructions and estimated the relevant cognitive efforts. If $E$ is positive, it means the instruction is highly efficient, because it minimizes the amount of mental effort needed for the task and maximizes the performance on that task at the same time. If $E$ is negative, it means the instruction is less efficient, because the performance is lower than can be expected based on the invested amount of mental effort. If $E=0$, it means an intermediate neutral efficiency condition.

**Independent Variables**

Instructional condition: This study had two different types of instruction interventions. The general statement instruction was displayed in a traditional bullet writing style focusing on an internet disconnection troubleshooting procedure; the worked example instruction started with an internet disconnection problem, followed by troubleshooting steps and ended with a final answer.

Presentation format: Presentation format may affect the effectiveness of worked examples (Ward & Sweller, 1990). In this study, there were two different presentation formats (text-only and text-plus-graphic). In the text-only presentation format, the troubleshooting process was presented in a written form, whereas the text information about the troubleshooting process was integrated with relevant graphics in the text-plus-graphic presentation format.

Prior knowledge level: From the literature discussed, prior knowledge may affect the effectiveness of worked examples (Kalyuga et al., 1998). In this study, a prior knowledge level referred to participants’ previous experiences regarding internet
disconnection troubleshooting. A 10-item pretest was used to decide the participants’ prior knowledge levels. Because it was a short test, almost 1/3 participants got scores between 5 and 6 on a pre-test in the pilot study, which made it difficult to classify participants as being in the low prior knowledge level group or not. Therefore, a medium prior knowledge group has been added into the formal design. A participant who had scores on the pretest above 6 was assigned to high prior knowledge level group; a participant who had scores below 5 was assigned to low prior knowledge level group; a participant who had scores of 5 or 6 was assigned to medium prior knowledge level group.

Research Design

The research design of this study is a true experiment. It was employed on a specially designed web-based experiment tool built by Flash, ASP and Access, which randomly assigned participants to different treatments and guides them through the experimental process step by step. A 2 instructions (general statement and worked example) x 2 presentation formats (text-only and text-plus-graphic) x 3 levels of prior knowledge (high, medium and low) matrix was used to investigate whether worked example, presentation format and prior knowledge affected the effectiveness of instruction or not (see Table 3). In addition, a before-and-after design was added to detect the learning gain after the instructions received.
Table 3

*2x2x3 Factorial Design*

<table>
<thead>
<tr>
<th>Prior Knowledge Level</th>
<th>General Statement</th>
<th>Worked Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Text-only</td>
<td>Text-plus-graphic</td>
</tr>
<tr>
<td>High</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Medium</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Low</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Pilot Study

A pilot study should take place before the actual study. It is used to determine feasibility and detect the possible error in the process of data collection. It should describe when, where, and how the study will be carried out. After the pilot study is completed, the researcher needs to decide whether the proposed procedures need to be revised or not (Mauch & Birch, 1989). The original study was designed in 2x4 factorial before-and-after design to explore whether presentation format and prior knowledge affect the effectiveness of worked examples, including 2 levels of prior knowledge (low and high) and 4 instructions (no worked example, text-only worked example, graphic-only worked example and text-plus-graphic worked example).

The invitation letter was sent out via e-mail (see Appendix D) to possible participants and the online consent was provided before the experiment (see Appendix E). Once the participants agreed to attend the experiment, they could access it via the link provided in the invitation letter. The participants in the pilot study were 16 students in a
graduate instructional design course in the 2007 fall quarter, including 15 graduate and 1 undergraduate students (senior). Seven of them major in Instructional Technology, 7 of them were in Computer Education and Technology, 1 was in Computer Science and 1 was in Curriculum and Instruction. Nine of them were male and 7 of them were female. Seven of them were in 18-29 years old and 9 of them were in 30-49 years old (see Table 4).

Table 4

Participant Distribution in Each Group for Pilot Study

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Text-only</th>
<th>Graphic-only</th>
<th>Integrated</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior Knowledge level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• High</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>• Low</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Male</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>• Female</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 18-29</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>• 30-49</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>

Because the experiment was conducted through a specially designed online instrument, the participants needed to complete the true experiment online. At the beginning of the experiment, the participant needed to fill out several background questions, including gender, age, class year and major (see Appendix F).

After filling out the background questions, participants needed to complete a 10-question pretest about the IP address conversion between decimal and binary formats, which was used to determine the participants’ prior knowledge level (see Appendix F). If
a participant got scores above 5, he was assigned to the high prior knowledge level group, and if he got scores lower than 5, he was assigned to the low prior knowledge level group.

After the pretest section, the tool randomly assigned the participants to different instructions. The instructions were related to the conversion between IP addresses (decimal forms) and binary forms and presented in different worked example formats (including no worked example, text-only worked example, graphic-only worked example and text-plus-graphic worked example (see Appendix G).

After reviewing the instructions, participants completed a 10-question posttest (see Appendix F) and a 9-point rating of the difficulty of the materials (see Appendix H). Score on the posttest, rating of the difficulty of the materials, and time spent on the posttest were used to measure the effectiveness of worked examples. A concept of instructional efficiency introduced by Paas and van Merriënboer in 1993 was used to measure the effectiveness of instruction received.

Data gathered from the pilot study was evaluated to determine if any changes were necessary. The reliability of the pretest, posttest, pre-rating of the difficulty of the materials and post-rating of the difficulty of the materials are .68, .85, .98 and .99 (see Table 5). In addition, a two-way ANCOVA was employed to compare the mean difference in each group, and a dependent t test was used to compare the mean difference between scores on the pretest and posttest, ratings of the difficulty of the materials, time spent on the pre- and post-test, and pre- and post-instructional efficiency.
Table 5

*Internal Reliability of the Instruments for Pilot Study*

<table>
<thead>
<tr>
<th>Categories</th>
<th>Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>.68</td>
</tr>
<tr>
<td>Posttest</td>
<td>.85</td>
</tr>
<tr>
<td>Pre-Rating of the difficulty of the materials</td>
<td>.98</td>
</tr>
<tr>
<td>Post-Rating of the difficulty of the materials</td>
<td>.99</td>
</tr>
</tbody>
</table>

According to the initial data analysis, there were no statistically significant results in both two-way ANCOVA and dependent t test analyses. The lack of significance may indicated that the prior knowledge and presentation format did not have any impact on the effectiveness of worked example or there were some other possible factors existed, such as individual visual preference, or that the sample size was too small to produce results. However, it may indicate that the content of instructions and initial instruments may need some revisions. From the pilot data, participants only spent 3.43 minutes in completing the posttest, which might affect the results of this study. In addition, some participants mentioned that repeating the converting process between binary forms and decimal forms bored them especially they did not have a calculator at hand while taking the posttest. This may be a possible reason to explain why the participants spent insufficient time on the posttest.

To solve the problems above, the researcher gathered the results of the pilot study, feedback from participants and the suggestions from committee members to make the following changes in the formal study:
1. The content of instructional materials was changed from IP addresses to internet disconnection troubleshooting, because participants have reported the former topic could not motivate them to complete the experiment. After asking experts’ and novices’ opinions, a practical instruction related to an internet disconnection troubleshooting process was used for the formal study.

2. Prior knowledge level was changed from 2-level to 3-level, because of the shortcoming of the pretest. The pretest only contained 10 items, and 1/3 participants’ scores had a median in the middle. A score of 5 or 6 made it difficult to classify participants as being in the low prior knowledge level group or not, therefore, adding a medium prior knowledge level group was essential.

3. Treatments were changed to text-only general statement, text-plus-graphic general statement, text-only worked example and text-plus-graphic worked example, because the new design can answer the research questions of this study better.

Reliability and Validity

Reliability of the performance test refers to consistency or stability. Validity refers to whether you are measuring what you want to measure (Osterlind, 1998; Light et al., 1990). Ideally reliability and validity are essential for dependent variables. Constructing a test needs to establish the reliability first and then validity. Reliability of the dependent variables can be established by the consistency of responses on the instrument (Christensen, 1991). The reliabilities of the pretest, posttest, pre-rating of the difficulty of the materials, and post- rating of the difficulty of the materials were .43, .60, .89 and .94 (see Table 6).
Table 6

Internal Reliability of the Instruments for Formal Study

<table>
<thead>
<tr>
<th>Categories</th>
<th>Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>.43</td>
</tr>
<tr>
<td>Posttest</td>
<td>.60</td>
</tr>
<tr>
<td>Pre-Rating of the difficulty of the materials</td>
<td>.89</td>
</tr>
<tr>
<td>Post-Rating of the difficulty of the materials</td>
<td>.94</td>
</tr>
</tbody>
</table>

Validity describes how well a measure actually assesses what you want it to (Light et al., 1990). The rating of the difficulty of the materials in this study was revised from Kalyuga et al. (1999) 7-point rating of the difficulty of the materials. According to Light et al. (1990), as long as participants can distinguish among the options provided; the observed scores from longer scales are most likely to reflect any true variation that exists across participants. Therefore, since there were only 10 items in the rating of the difficulty of the materials, the researcher extended the scale from 7 points to 9 points to establish the content validity of the instrument.

Data Collection Procedure

The procedure of collecting data needs to match the research problem and the specific nature of the data (Mauch & Birch, 1989). This study recruited students taking Technology Apps Education class in winter and spring quarters. An online experimental tool was used to collect all the data needed and the whole data collection procedure was presented as follows:

1. Acquire access to potential participants’ e-mail: To acquire access to the students’ e-mail addresses, the researcher obtained the consent from the instructors first.
2. Invitation: After acquiring the agreement from instructors, the invitation letter was sent out via e-mail (see Appendix I). The online consent was provided before the experiment (see Appendix J), which contained the explanation of the study, such as the purpose, procedures, risks and discomforts, benefits, confidentiality and compensation of this study. It was hard to get participants’ signatures during a web-based experiment. To enable the process of consent, this study built a digital key generator to generate a unique 6-digits digital key and distributed it with each e-mail. A participant needed to type in his or her 6-digits digital key and oak e-mail account to identify himself or herself and made an agreement on the consent form. If he clicked the "Yes, I consent" button. The system led him or her to the experiment. If he clicked "No, I do not wish to participate," the system stopped immediately because the participant was not willing to participate in this study after reviewing the consent form. A participant could exit the experiment at any time by closing the application. In addition, he or she could print out the online consent form and keep a copy.

3. Background information and pretest: After a participant agreed to participate in the experiment, the system led him or her to the first step of the experiment. Before the pretest, a participant needed to provide his background information, including gender, class year, age and major. After the background info session, a participant needed to complete an 8-minute 10-question pretest and a pre-rating of the difficulty of the materials. The content of a pretest is related to internet disconnection troubleshooting. Questions 1 to 5 were involved basic knowledge, a participant needed to fill out the questions based on recalling the relevant concepts in the instruction. Further, questions 6-
were involved more complex thinking, a participant needed to comprehend the instruction and then apply the relevant knowledge to his or her decision making process for problem solving (see Appendix K). In addition, a participant needed to fill in a pre-rating of the difficulty of the materials at the same time. There were 9 points in this scale from extremely easy to extremely difficult. ‘1’ means the item was really easy for the participant and he did not invest too much mental load on this item. In contrast, ‘9’ means the item was really difficult for the participant and he invested a lot of mental load on this item (see Appendix L). It was used to compare a post-rating of the difficulty of the materials to see if there was any improvement on cognitive loads after instructions.

According to the scores on the pretest, the system marked the participants in different knowledge levels. A participant who had scores on the pretest above 6 was assigned to the high prior knowledge level group; a participant who had scores below 5 was assigned to the low prior knowledge level group; a participant who had scores of 5 or 6 was assigned to the medium prior knowledge level group. After the pretest, he was randomly assigned to one of the treatments.

4. Instructions: In the instruction session, four treatments were provided. The content of the instructions guided the participants through the troubleshooting procedure of internet disconnection. These instructions were made in two different instructional formats and two presentation formats, including text-only general statement, text-only worked example, text-plus-graphic general statement and text-plus-graphic worked example (see Appendix M).
5. Posttest: After the instructions, the participants completed a posttest to see how much they learned from the instructions provided. In addition, they needed to complete a post-rating of the difficulty of the materials at the same time (see Appendix K and L). Questions in the pretest and posttest were the same, but put in different order.

6. Data submission: In this experiment, the system tool recorded the following information: (a) submitted time, (b) login IP, (c) student oak ID, (d) background information, (e) time spent on each task, (f) scores on the pretest and posttest, (g) scores on the cognitive load scales and (h) the comments the student provided. After participants completed the experiment, the data was directly sent into an Access database. All information the student provided was kept confidential and only the principal researcher in this study could accept the raw data.

Data Analysis Procedure

This study used SPSS15.0 to run the collected data. First, descriptive analysis was used to analyze the participants’ background information. Second, although there were multiple dependent variables (posttest, cognitive load, time spent on the posttest, instructional efficiency) in the study, a three-way ANOVA was chosen for the data analysis. The reason why the study adopted an ANOVA statistical method instead of a MANOVA statistical method was because one of the dependent variables, instructional efficiency, came from the combination calculation of the z score of the other two dependent variables (posttest and cognitive load), which blocked the Box’s test for a MONOVA test. Therefore, a three-way analysis of variance (ANOVA) was employed to answer research questions 1, 2, 3 and 4, which compared the mean difference for the
learning performances among groups. In addition, according to Bonate (2000), an analysis of variance may not be optimal to analyze pretest-posttest data because there was no guarantee that the groups are at the comparable baseline. In particular, the pretest in this study was used to as a grouping variable to determine participants’ prior knowledge levels, so participants with different prior knowledge levels (high, medium and low) should perform differently on the pretest, the rating of the difficulty of the materials, the time spent on the pretest and pre-instructional efficiency. Therefore, to prevent ignoring the variation within subjects, an additional 2X2 analysis of variance (ANOVA) on the difference between the pre- and post-learning performance (learning gain) was conducted to detect the improvement after instructions received. Except for the analysis of leaning gain, additional analysis of gender and class year factors have also been conducted. The level of statistical significance for all procedures was set at $\alpha \leq .05$.

Summary

This study primarily used quantitative methods and conducts an online experiment to investigate whether worked example, presentation format and prior knowledge affect the effectiveness of instructions. A 2 instructions (general statement and worked example) x 2 presentation formats (text-only and text-plus-graphic) x 3 levels of prior knowledge (high, medium and low) was applied. To answer the research questions of this study, a three-way analysis of ANOVA was employed.
CHAPTER FOUR: ANALYSIS OF DATA AND RESULTS

Introduction

This study examined whether worked example, presentation format and prior knowledge affect the effectiveness of instructions. A three-way analysis of variance was employed for answering the following research questions:

1. Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different instructions (general statements and worked examples)?

2. Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic)?

3. Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low)?

4. Is there a significant interaction among instructions, presentation formats and prior knowledge levels in the pre-service teachers’ performance (posttest, cognitive load, time spent on the posttest and instructional efficiency)?

Demographic Data

One hundred and thirty six undergraduate students who enrolled in education classes at a large Midwestern university in the 2008 winter and spring quarter participated in this study. There were no missing data because a forced completion
function in the experimental tool was used to present incomplete submissions. Demographic information included gender, age, class year and major. The sample consisted of 106 females and 30 males between the ages of 19 and 39. There are 54 sophomores, 62 juniors and 20 seniors in the study. They were mainly students in Education (15), Early Childhood Education (33), Adolescent Young Adult Education (31), Middle Childhood Education (22), Special Education (13), Physical Education (2) and other (20) disciplines in Education. Appendix N presents a summary of the demographic information.

Descriptive Statistics for the Learning Performance

Scores on the Posttest

The posttest was composed by 10 multiple choice questions in two difficulty levels and the content related to an internet disconnection troubleshooting process. Once a participant had one correct answer, he could get 1 point for that particular item. The range of scores was from 0-10. According to Table 7, among the instructions the low prior knowledge level group who received the text-only general statement instruction got the highest score on the posttest ($M_{low} = 6.11$); the medium prior knowledge level group who viewed the text-plus-graphic general statement instruction got the highest score on the posttest ($M_{medium} = 8.31$); the high prior knowledge level group who studied the text-only worked example got the highest score on the posttest ($M_{high} = 8.23$).
Table 7

Descriptive Statistics of Means/Standard Deviation (N) for the Posttest Scores by Instruction, Presentation Format and Prior Knowledge

<table>
<thead>
<tr>
<th></th>
<th>General Statement</th>
<th>Worked Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Text-only</td>
<td>Text-plus-graphic</td>
</tr>
<tr>
<td>Low</td>
<td>6.11/1.83(9)</td>
<td>5.78/1.79(9)</td>
</tr>
<tr>
<td>Medium</td>
<td>7.21/1.93(14)</td>
<td>8.31/1.11(13)</td>
</tr>
<tr>
<td>High</td>
<td>7.17/1.85(12)</td>
<td>8.23/1.24(13)</td>
</tr>
</tbody>
</table>

Cognitive Load

Points on the rating of the difficulty of the materials are scaled from extremely easy to extremely difficult to indicate different amount of mental investment. ‘1’ means the item was really easy for a participant and he did not invest too much cognitive load on this item, in contrast, ‘9’ means the item was really difficult for a participant and he invested a lot of cognitive load on this item. According to Table 8, among the instructions the low prior knowledge level group who received the text-plus-graphic worked example instruction reported the least cognitive load invested on the posttest ($M_{\text{low}} = 4.97$); the medium prior knowledge level group who viewed the text-only worked example instruction reported the least cognitive load invested on the posttest ($M_{\text{medium}} = 3.97$); the high prior knowledge level group who studied the text-only worked example reported the least cognitive load invested on the posttest ($M_{\text{high}} = 3.24$).
Table 8

Descriptive Statistics of Means/Standard Deviation (N) for the Cognitive Load by Instruction, Presentation Format and Prior Knowledge

<table>
<thead>
<tr>
<th></th>
<th>General Statement</th>
<th>Worked Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Text-only</td>
<td>Text-plus-graphic</td>
</tr>
<tr>
<td>Low</td>
<td>5.23/2.05(9)</td>
<td>5.88/1.91(9)</td>
</tr>
<tr>
<td>Medium</td>
<td>5.04/1.60 (14)</td>
<td>4.53/1.88 (13)</td>
</tr>
<tr>
<td>High</td>
<td>4.00/1.50 (12)</td>
<td>4.14/1.07 (14)</td>
</tr>
</tbody>
</table>

Time Spent on the Posttest

Time spent on the posttest were recorded by the experimental tool and counted by seconds. According to Table 9, among the instructions the low prior knowledge level group who received the text-only worked example instruction spent the smallest amount of time to complete the posttest ($M_{\text{low}} = 95.11$); the medium prior knowledge level group who viewed the text-plus-graphic worked example instruction spent the smallest amount of time to complete the posttest ($M_{\text{medium}} = 104.36$); the high prior knowledge level group who studied the text-only general statement instruction spent the smallest amount of time to complete the posttest ($M_{\text{high}} = 125.50$).
Table 9

Descriptive Statistics of Means/Standard Deviation (N) for the Time Spent on the Posttest by Instruction, Presentation Format and Prior Knowledge

<table>
<thead>
<tr>
<th></th>
<th>General Statement</th>
<th>Worked Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Text-only</td>
<td>Text-plus-graphic</td>
</tr>
<tr>
<td>Low</td>
<td>101.56/39.97(9)</td>
<td>119.56/45.21(9)</td>
</tr>
<tr>
<td>Medium</td>
<td>132.07/49.50(14)</td>
<td>118.69/32.81(13)</td>
</tr>
<tr>
<td>High</td>
<td>125.50/29.20(12)</td>
<td>127.14/37.70(14)</td>
</tr>
</tbody>
</table>

*Instructional efficiency*

Instructional efficiency (E) comes from the combination calculation of the Z scores of performance scores and mental load. If E is negative, it means the instruction is less efficient, because the performance is lower than can be expected based on the invested amount of mental effort. If E is positive, it means the instruction is more efficient, because the performance is higher than can be expected based on the invested amount of mental effort. If E = 0, it means an intermediate neutral efficiency condition. According to Table 10, among the instructions the low prior knowledge level group who received the text-only general statement instruction got the highest instructional efficiency (M<sub>low</sub> = -.58); the medium prior knowledge group who viewed the text-plus-graphic general statement instruction got the highest instructional efficiency (M<sub>medium</sub> = .49); the high prior knowledge level group who studied the text-only worked example instruction got the highest instructional efficiency (M<sub>high</sub> = 1.01).
Table 10

Descriptive Statistics of Means/Standard Deviation (N) for the Instructional efficiency by Instruction, Presentation Format and Prior Knowledge

<table>
<thead>
<tr>
<th></th>
<th>General Statement</th>
<th>Worked Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Text-only</td>
<td>Text-plus-graphic</td>
</tr>
<tr>
<td>Low</td>
<td>-.58/1.23(9)</td>
<td>-.97/1.28(9)</td>
</tr>
<tr>
<td>Medium</td>
<td>-.11/1.24(14)</td>
<td>.49/.98(13)</td>
</tr>
<tr>
<td>High</td>
<td>.31/1.22(12)</td>
<td>.32/1.06(14)</td>
</tr>
</tbody>
</table>

Analysis of the Learning Performance

The learning performance in the study includes the posttest scores, cognitive load, time spent on the posttest and instructional efficiency. A 2X2X3 analysis of variance was chosen to analyze the learning performance data. The independent variables include instructions, presentation formats and prior knowledge levels. The purpose of an ANOVA is to determine if there is any statistically significant mean difference among groups. In order to perform an ANOVA test, the following three basic assumptions need to be fulfilled: (a) Normality: Assume the population distributions are normal, (b) Independent Observations: The observations within each treatment must be independent, and (c) Equal Variances: Assume the population distributions have the equal variance. Because 136 participants were randomly assigned to treatments (text-only general statement, text-only worked example, text-plus-graphic general statement and text-plus-graphic worked example), it is highly possible to get an unequal number of subjects for each treatment. Based on the numbers of subjects in Table 11, the smallest cell size is 7 and the largest cell size is 15. According to Stevens (1999), if the largest cell size/the
smallest cell size > 1.5, it could be an unbalanced design (unequal cell size). In the study, the largest cell size (15)/the smallest cell size (7) > 1.5, so it is an unbalanced design. Overall and Spiegel have discussed that regression approach (Type III method), experimental approach (Type II method) and hierarchical approach (Type I method) could be used for analyzing factorial design (as cited in Stevens, 1999, p. 162). In particular, Langsrud (2003) has claimed that Type II sum of squares is preferable and powerful for analyzing unbalanced factorial designs. However, according to Shaw and Mitchell-Olds (1993), they found out Type III sum of squares (unique sum of squares) is more powerful for analyzing the unbalanced design data than Type II sum of squares, because it could “adjust each effect for all other effects in the design to obtain it unique contribution” (Stevens, 1999, p. 162). Shaw and Mitchell-Olds recommended researchers to use Type III sum of squares for analyzing an unbalanced design without any missing data. Stevens (1999) and Field (2005) also supported that Type III sums of squares can be used for unbalanced designs. Therefore, this study adopted Type III sums of squares for analyzing the unbalanced factorial design. Additionally, the Tukey–Kramer method was chosen as the post hoc test for the unbalanced factorial design to find which means are significantly different from one another (Stevens, 1999).
Table 11

*Numbers of Subjects in the 2 X 2 X 3 Analysis of Variance*

<table>
<thead>
<tr>
<th></th>
<th>General Statement</th>
<th>Worked Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Text-only</td>
<td>Text-plus-graphic</td>
</tr>
<tr>
<td>Low</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Medium</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>High</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

*Posttest*

In this study, the posttest was composed by 10 multiple choice questions in two difficulty levels and the content related to an internet disconnection troubleshooting process. Once a participant had one correct answer, he could get 1 point for that particular item. The range of scores was from 0-10. A three-way analysis of variance was used to answer the following null hypotheses:

H₀₁.₁: There is no significant mean difference for the learning performance (posttest) among the pre-service teachers who view different instructions (general statements and worked examples).

H₀₂.₁: There is no significant mean difference for the learning performance (posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

H₀₃.₁: There is no significant mean difference for the learning performance (posttest) among the pre-service teachers with different prior knowledge levels of internet connection (high, medium and low).
H04.1: There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (posttest).

Levene’s test (1960) was used to test the homogeneity of variance. The F-test from Levene’s test indicated no significance, F (11, 124) = 1.273, \( p = .248 \), and the assumption of the homogeneity was met. Regarding the test of between-groups effects, F-ratio, as shown in Table 12, indicated the following results:

1. There is no significant mean difference for the learning performance (posttest) among the pre-service teachers who view different instructions (general statements and worked examples) (F (1, 124) = .559, \( p > .05 \), Partial \( \eta^2 = .004 \)).

2. There is no significant mean difference for the learning performance (posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic) (F (1, 124) = .002, \( p > .05 \), Partial \( \eta^2 = .000 \)).

3. There is a significant mean difference for the learning performance (posttest) among the pre-service teachers with different prior knowledge levels of internet connection (high, medium and low) (F (2, 124) = 16.673, \( p < .05 \), Partial \( \eta^2 = .212 \)). A Tukey–Kramer method for Post-ANOVA Pair-Wise Comparisons was run for detecting the significant mean difference on the posttest among different prior knowledge groups. According to the Table 13, the medium prior knowledge level group (M_{medium} = 7.350) and the high prior knowledge level group (M_{high} = 7.739) scored significantly higher than the low prior knowledge level group (M_{low} = 5.528) on the posttest.
4. There is a significant interaction effect between worked examples and prior knowledge levels in the pre-service teachers’ learning performance (posttest) ($F (2, 124) = 3.869, p < .05, \text{Partial } \eta^2 = .059$). According to Table 14 and Figure 7, the low prior knowledge level group and the medium prior knowledge level group performed better on the posttest by using the general statement instruction ($M_{\text{low}} = 5.94; M_{\text{medium}} = 7.76$) than the worked example instruction ($M_{\text{low}} = 5.11; M_{\text{medium}} = 6.94$). In contrast, the high prior knowledge level group performed better on the posttest by using the worked example instruction ($M_{\text{high}} = 8.22$) than the general statement instruction ($M_{\text{high}} = 7.26$).

Table 12

*3-way ANOVA Test for the Score on the Posttest*

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked Example</td>
<td>1.767</td>
<td>1</td>
<td>1.767</td>
<td>.559</td>
<td>.456</td>
<td>.004</td>
</tr>
<tr>
<td>Presentation Format</td>
<td>.007</td>
<td>1</td>
<td>.007</td>
<td>.002</td>
<td>.962</td>
<td>.000</td>
</tr>
<tr>
<td>Prior Knowledge Level</td>
<td>105.409</td>
<td>2</td>
<td>52.704</td>
<td>16.673</td>
<td>.000</td>
<td>.212</td>
</tr>
<tr>
<td>Worked Example * Presentation Format</td>
<td>3.561</td>
<td>1</td>
<td>3.561</td>
<td>1.126</td>
<td>.291</td>
<td>.009</td>
</tr>
<tr>
<td>Worked Example * Prior Knowledge</td>
<td>24.460</td>
<td>2</td>
<td>12.230</td>
<td>3.869</td>
<td>.023</td>
<td>.059</td>
</tr>
<tr>
<td>Presentation Format * Prior Knowledge</td>
<td>1.018</td>
<td>2</td>
<td>.509</td>
<td>.161</td>
<td>.851</td>
<td>.003</td>
</tr>
<tr>
<td>Worked Example * Presentation Format * Prior Knowledge</td>
<td>6.573</td>
<td>2</td>
<td>3.287</td>
<td>1.040</td>
<td>.357</td>
<td>.016</td>
</tr>
<tr>
<td>Error</td>
<td>391.976</td>
<td>124</td>
<td>3.161</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7280.000</td>
<td>136</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 13

A Tukey–Kramer Test for the Posttest Scores among Prior Knowledge Groups

<table>
<thead>
<tr>
<th></th>
<th>Low (5.528)</th>
<th>Medium (7.350)</th>
<th>High (7.739)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (5.528)</td>
<td>.00*</td>
<td></td>
<td>.00*</td>
</tr>
<tr>
<td>Medium (7.350)</td>
<td>.00*</td>
<td>.606</td>
<td></td>
</tr>
<tr>
<td>High (7.739)</td>
<td>.00*</td>
<td>.606</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* The mean difference is significant at the .05 level.

Table 14

Descriptive Statistics of Means for the Posttest Scores by Instruction and Prior Knowledge

<table>
<thead>
<tr>
<th>Knowledge</th>
<th>General Statement</th>
<th>Worked Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>5.94</td>
<td>5.11</td>
</tr>
<tr>
<td>Medium</td>
<td>7.76</td>
<td>6.94</td>
</tr>
<tr>
<td>High</td>
<td>7.26</td>
<td>8.22</td>
</tr>
</tbody>
</table>
Figure 7. Graph for the interaction between instruction and prior knowledge level on the posttest.

Cognitive Load

In this study, the rating of the difficulty of the materials was revised from Kalyuga et al. (1999)’s rating of the difficulty of the materials from 7 points to 9 points. At the high end of the scale, ‘9’ was associated with the learner’s investment of high cognitive load and at the low end, ‘1’ was associated with low cognitive load. A three-way analysis of variance was used to answer the following null hypotheses:

H01.2: There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers who view different instructions (general statements and worked examples).
H02.2: There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

H03.2: There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low).

H04.2: There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (cognitive load).

Levene’s test (1960) was used to test the homogeneity of variance. The F-test from Levene’s test indicated no significance, $F(11, 124) = 1.053, p = .405$, and the assumption of the homogeneity was met. Regarding the test of between-groups effects, F-ratio, as shown in Table 15, indicated the following results:

1. There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers who view different instructions (general statements and worked examples) $(F(1, 124) = .172, p > .05, \eta^2 = .001)$.

2. There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic) $(F(1, 124) = 1.660, p > .05, \eta^2 = .013)$.

3. There is a significant mean difference for the learning performance (cognitive load) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low) $(F(2, 124) = 7.809, p < .05,$
Partial $\eta^2 = .112$). A Tukey–Kramer Test for Post-ANOVA Pair-Wise Comparisons was run for detecting the significant mean difference on the cognitive load among different prior knowledge groups. According to the Table 16, the medium prior knowledge level group ($M_{\text{medium}} = 4.613$) and the high prior knowledge group ($M_{\text{high}} = 4.119$) reported significantly lower cognitive load than the low prior knowledge level group ($M_{\text{low}} = 5.504$) on the rating of the difficulty of the materials.

4. There is a significant interaction effect between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (cognitive load) ($F (2, 124) = 3.303, p < .05, \text{Partial } \eta^2 = .051$). According to Table 17 and Figure 8, when general statement instruction was provided, the low prior knowledge group and the high prior knowledge level group reported lower cognitive load by viewing the text-only presentation format ($M_{\text{low}} = 5.23; M_{\text{high}} = 4.00$) than the text-plus-graphic presentation format ($M_{\text{low}} = 5.88; M_{\text{high}} = 4.14$); the medium prior knowledge level group reported lower cognitive load by viewing the text-plus-graphic presentation format ($M_{\text{medium}} = 4.53$) than the text-only presentation format ($M_{\text{medium}} = 5.04$). When worked example instruction was provided, the medium prior knowledge level group and the high prior knowledge level group reported lower cognitive load by viewing the text-only presentation format ($M_{\text{medium}} = 3.97; M_{\text{high}} = 3.24$) than the text-plus-graphic presentation format ($M_{\text{medium}} = 4.91; M_{\text{high}} = 5.10$); in contrast, the low prior knowledge level group reported lower cognitive load by viewing the text-plus-graphic presentation format ($M_{\text{low}} = 4.97$) than the text-only presentation format ($M_{\text{low}} = 5.93$).
### Table 15

*A 3-way ANOVA Test for the Cognitive Load Invested on the Posttest*

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked Example</td>
<td>.422</td>
<td>1</td>
<td>.422</td>
<td>.172</td>
<td>.679</td>
<td>.001</td>
</tr>
<tr>
<td>Presentation Format</td>
<td>4.059</td>
<td>1</td>
<td>4.059</td>
<td>1.660</td>
<td>.200</td>
<td>.013</td>
</tr>
<tr>
<td>Prior Knowledge Level</td>
<td>38.191</td>
<td>2</td>
<td>19.095</td>
<td>7.809</td>
<td>.001</td>
<td>.112</td>
</tr>
<tr>
<td>Worked Example * Presentation Format</td>
<td>2.230</td>
<td>1</td>
<td>2.230</td>
<td>.912</td>
<td>.341</td>
<td>.007</td>
</tr>
<tr>
<td>Worked Example * Prior Knowledge</td>
<td>1.231</td>
<td>2</td>
<td>.615</td>
<td>.252</td>
<td>.778</td>
<td>.004</td>
</tr>
<tr>
<td>Presentation Format * Prior Knowledge</td>
<td>7.351</td>
<td>2</td>
<td>3.675</td>
<td>1.503</td>
<td>.226</td>
<td>.024</td>
</tr>
<tr>
<td>Worked Example * Presentation Format * Prior Knowledge</td>
<td>16.151</td>
<td>2</td>
<td>8.076</td>
<td>3.303</td>
<td>.040</td>
<td>.051</td>
</tr>
<tr>
<td>Error</td>
<td>303.202</td>
<td>124</td>
<td>2.445</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3302.340</td>
<td>136</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 16

*A Tukey–Kramer Test for the Cognitive Load among Prior Knowledge Groups*

<table>
<thead>
<tr>
<th></th>
<th>Low (5.504)</th>
<th>Medium (4.613)</th>
<th>High (4.119)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (5.504)</td>
<td>.018*</td>
<td></td>
<td>.000*</td>
</tr>
<tr>
<td>Medium (4.613)</td>
<td>.018*</td>
<td>.213</td>
<td></td>
</tr>
<tr>
<td>High (4.119)</td>
<td>.000*</td>
<td>.213</td>
<td></td>
</tr>
</tbody>
</table>

* The mean difference is significant at the .05 level.
Table 17

*Descriptive Statistics of Means/Standard Deviation (N) for the Cognitive Load by Instruction and Prior Knowledge*

<table>
<thead>
<tr>
<th></th>
<th>General Statement</th>
<th>Worked Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Text-only</td>
<td>Text-plus-graphic</td>
</tr>
<tr>
<td>Low</td>
<td>5.23/2.05(9)</td>
<td>5.88/1.91(9)</td>
</tr>
<tr>
<td>Medium</td>
<td>5.04/1.60(14)</td>
<td>4.53/1.88(13)</td>
</tr>
<tr>
<td>High</td>
<td>4.00/1.50(12)</td>
<td>4.14/1.07(14)</td>
</tr>
</tbody>
</table>

*Figure 8.* Graph for the interaction between instruction condition and prior knowledge level on the cognitive load.
Time spent on the posttest were recorded by the experimental tool and counted by seconds. A three-way analysis of variance was used to answer the following null hypotheses:

$H_{01.3}$: There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers who view different instructions (general statements and worked examples).

$H_{02.3}$: There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

$H_{03.3}$: There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low).

$H_{04.3}$: There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (time spent on the posttest).

Levene’s test (1960) was used to test the homogeneity of variance. The F-test from Levene’s test indicated no significance, $F(11, 124) = .840$, $p = .600$, and the assumption of the homogeneity was met. Regarding the test of between-groups effects, F-ratio, as shown in Table 18, indicated the following results:
1. There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers who view different instructions (general statement and worked example) ($F(1, 124) = .838, p > .05, \text{Partial } \eta^2 = .007$).

2. There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic) ($F(1, 124) = .026, p > .05, \text{Partial } \eta^2 = .000$).

3. There is a significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low) ($F(2, 124) = 3.801, p < .05, \text{Partial } \eta^2 = .058$). A Tukey–Kramer Test for Post-ANOVA Pair-Wise Comparisons was run for detecting the significant mean difference on the time spent on the posttest among different prior knowledge groups. According to the Table 19, the high prior knowledge level group ($M_{\text{high}} = 130.31$) spent significantly more time on the posttest than the low prior knowledge level group ($M_{\text{low}} = 107.734$).

4. There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (time spent on the posttest) ($F(2, 124) = .115, p > .05, \text{Partial } \eta^2 = .002$).
Table 18

A 3-way ANOVA Test for the Time Spent on the Posttest

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked Example</td>
<td>1178.744</td>
<td>1</td>
<td>1178.744</td>
<td>.838</td>
<td>.362</td>
<td>.007</td>
</tr>
<tr>
<td>Presentation Format</td>
<td>36.039</td>
<td>1</td>
<td>36.039</td>
<td>.026</td>
<td>.873</td>
<td>.000</td>
</tr>
<tr>
<td>Prior Knowledge Level</td>
<td>10695.629</td>
<td>2</td>
<td>5347.814</td>
<td>3.801</td>
<td>.025</td>
<td>.058</td>
</tr>
<tr>
<td>Worked Example * Presentation Format</td>
<td>.033</td>
<td>1</td>
<td>.033</td>
<td>.000</td>
<td>.996</td>
<td>.000</td>
</tr>
<tr>
<td>Worked Example * Prior Knowledge</td>
<td>4117.510</td>
<td>2</td>
<td>2058.755</td>
<td>1.463</td>
<td>.235</td>
<td>.023</td>
</tr>
<tr>
<td>Presentation Format * Prior Knowledge</td>
<td>3517.829</td>
<td>2</td>
<td>1758.914</td>
<td>1.250</td>
<td>.290</td>
<td>.020</td>
</tr>
<tr>
<td>Worked Example * Presentation Format * Prior Knowledge</td>
<td>324.570</td>
<td>2</td>
<td>162.285</td>
<td>.115</td>
<td>.891</td>
<td>.002</td>
</tr>
<tr>
<td>Error</td>
<td>174445.584</td>
<td>124</td>
<td>1406.819</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2136830.000</td>
<td>136</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 19

A Tukey–Kramer Test for the Time Spent on the Posttest among Prior Knowledge Groups

<table>
<thead>
<tr>
<th></th>
<th>Low (107.734)</th>
<th>Medium (116.665)</th>
<th>High (130.301)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (107.734)</td>
<td>.467</td>
<td></td>
<td>.020*</td>
</tr>
<tr>
<td>Medium (116.665)</td>
<td>.467</td>
<td></td>
<td>.189</td>
</tr>
<tr>
<td>High (130.301)</td>
<td>.020*</td>
<td></td>
<td>.189</td>
</tr>
</tbody>
</table>

Note. * The mean difference is significant at the .05 level.

Instructional efficiency

Instructional efficiency (E) comes from the combination calculation of the Z scores of performance scores and mental load. If E is negative, it means the instruction is
less efficient; if E is positive, it means the instruction is more efficient; if E = 0, it means an intermediate neutral efficiency condition. A three-way analysis of variance was used to answer the following null hypotheses:

H₀₁.₄: There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers who view different instructions (general statements and worked examples).

H₀₂.₄: There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

H₀₃.₄: There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low).

H₀₄.₄: There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (instructional efficiency).

Levene’s test (1960) was used to test the homogeneity of variance. The F-test from Levene’s test indicated no significance, F (11, 124) = .800, p = .640, and the assumption of the homogeneity was met. Regarding the test of between-groups effects, F-ratio, as shown in Table 20, indicated the following results:

1. There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers who view different instructions (general statement and worked example) (F (1, 124) = .034, p > .05, Partial η² = .000).
2. There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic) \( (F (1, 124) = .648, p > .05, \text{Partial } \eta^2 = .005) \).

3. There is a significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low) \( (F (2, 124) = 16.276, p < .05, \text{Partial } \eta^2 = .208) \). A Tukey–Kramer Test for Post-ANOVA Pair-Wise Comparisons was run for detecting the significant mean difference on the time spent on the instructional efficiency among different prior knowledge groups. According to the Table 21, the medium prior knowledge level group \( (M_{\text{medium}} = .118) \) and the high prior knowledge level group \( (M_{\text{high}} = .464) \) had significantly higher instructional efficiency than low prior knowledge level group \( (M_{\text{low}} = -.906) \).

4. There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (instructional efficiency) \( (F (2, 124) = 2.221, p > .05, \text{Partial } \eta^2 = .035) \).
Table 20

A *3-way ANOVA Test for the Instructional Efficiency*

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked Example</td>
<td>.040</td>
<td>1</td>
<td>.040</td>
<td>.854</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Presentation Format</td>
<td>.770</td>
<td>1</td>
<td>.770</td>
<td>.422</td>
<td>.854</td>
<td>.005</td>
</tr>
<tr>
<td>Prior Knowledge Level</td>
<td>38.666</td>
<td>2</td>
<td>19.333</td>
<td>16.276</td>
<td>.000</td>
<td>.208</td>
</tr>
<tr>
<td>Worked Example * Presentation Format</td>
<td>1.690</td>
<td>1</td>
<td>1.690</td>
<td>.235</td>
<td>.422</td>
<td>.011</td>
</tr>
<tr>
<td>Worked Example * Prior Knowledge</td>
<td>1.889</td>
<td>2</td>
<td>.945</td>
<td>.454</td>
<td>.422</td>
<td>.013</td>
</tr>
<tr>
<td>Presentation Format * Prior Knowledge</td>
<td>.972</td>
<td>2</td>
<td>.486</td>
<td>.665</td>
<td>.422</td>
<td>.007</td>
</tr>
<tr>
<td>Worked Example * Presentation Format</td>
<td>5.277</td>
<td>2</td>
<td>2.639</td>
<td>.113</td>
<td>.422</td>
<td>.035</td>
</tr>
<tr>
<td>Error</td>
<td>147.293</td>
<td>124</td>
<td>1.188</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>199.876</td>
<td>136</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 21

*A Tukey–Kramer Test for the Instructional Efficiency among Prior Knowledge Groups*

<table>
<thead>
<tr>
<th>Low (-.906)</th>
<th>Medium (.118)</th>
<th>High (.464)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (-.906)</td>
<td>.000*</td>
<td>.000*</td>
</tr>
<tr>
<td>Medium (.118)</td>
<td>.000*</td>
<td>.260</td>
</tr>
<tr>
<td>High (.464)</td>
<td>.000*</td>
<td>.260</td>
</tr>
</tbody>
</table>

*Note.* *. The mean difference is significant at the .05 level.

Analysis of Responses to the Open-Ended Question

There was an open-ended question at the end of the experiment, which asked participants their opinions about the instructions received, presentation formats and the overall experiment. A total of 24 responses were listed in Appendix O. In sum, there are five different types of responses:
Opinions about instruction received

Five participants expressed their opinions about the instruction received. First of all, two participants thought the instructions they received were helpful for them to learn this particular subject. For example, a participant with low prior knowledge level who received text-plus-graphic worked example instruction said “The information provided was somewhat difficult to comprehend but the explanation after the pre-test effective.” Another example, a participant with high prior knowledge level who received text-only worked example instruction expressed “Very good setup, explanation in steps was helpful but difficult to remember/transfer to the posttest.” Secondly, one participant with high prior knowledge level who received text-only general statement instruction asked if the definitions and step could be emphasized more, which may help him to learn better. He addressed “I think that if more emphasis is placed on definitions and steps (going over it more than once) I would have been able to remember more! I read through everything quickly and then when taking the test, forgot everything quickly as well!” In addition, one participant even expressed that he was willing to take a course that taught this subject. He said “I wish that I had a better understanding of this topic, but this is the first time that I have been instructed. I still feel that I need more instruction and would gladly take a course that taught such things.”
Opinions about the presentation format

Two participants expressed their opinions about the presentation format. First of all, one participant with high prior knowledge level who received the text-only general statement instruction expressed that he did not like the text-only presentation format. He said “I did not really like this format. It was hard for me to remember the information I did not already know, so I just guessed.” In addition, another participant mentioned the animation provided in the text-only worked example instruction was distracting to him. He said “the animation in the beginning was distracting.”

Opinions about the difficulty of instructional materials

Nine participants expressed that they felt the instructional materials are hard to learn, for example, “It was hard and a lot of information to take in, in one setting” and “Very difficult I felt like it was a different language” and etc. One participant even expressed that “The longer questions were difficult I think. I do not have a great knowledge of internet protocol and things so it was difficult.”

Opinions about the time constraint

Two participants found out the time constraint could be a problem preventing them to learn. They addressed that they needed more time to comprehend the materials. For example, one said, “The time constraint was difficult. I read through the material quickly and I did not read it thoroughly,” and the other one also mentioned “I feel as though the timer was intimidating. I think either longer time to take it, or no timer at all would have made this go more smoothly.”
Opinions about the overall experiment

Six participants expressed positive opinions about the overall experiment. Some of them thought the experiment was interesting and helpful. For example, one said “This was very interesting and somewhat fun,” and another one also mentioned “Good test. It was helpful learning information like that because it is something a person who uses computer often should know but usually don’t. I had heard of most of the words but never knew what they were or did. It was helpful.” In addition, some of them thought the experiment is organized. For example, one said “I think this survey was very organized. I liked that it asked the reader the questions to see what they already know, and then gave them the information. After reading the information you gave the same survey to see what they found out and learned.”

Additional Analysis of the Learning Gain

Additionally, a 2 X 2 analysis of variance was used to detect the difference between the pre- and post-learning performance (learning gain). After the instructions (see Table 22). The alpha level was set at .05, the he expected statistical power was set as .80 and the effect size was set at .35. According to Cohen’s (1988) sample size table, the expected sample size this additional analysis needs to be at least 33. The total number of participants in this study is 136, which meets the statistical requirement. In addition, based on the numbers of subjects in Table 22, the smallest cell size is 28 and the largest cell size is 37. According to Stevens (1999), if the largest cell size/the smallest cell size < 1.5, it is a balanced design for this additional analysis, so the Tukey method was chosen
as the post hoc test for a balanced factorial design to find which means are significantly different from one another.

Table 22

*Numbers of Subjects in the 2 X 2 Analysis of Variance*

<table>
<thead>
<tr>
<th>Presentation Format</th>
<th>Instructional condition</th>
<th>General Statement</th>
<th>Worked Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text-only</td>
<td></td>
<td>35</td>
<td>37</td>
</tr>
<tr>
<td>Text-plus-graphic</td>
<td></td>
<td>36</td>
<td>28</td>
</tr>
</tbody>
</table>

There are three questions needed to be answered in this section:

1. Are there significant mean differences for the learning gain between pre-learning performance (pretest, cognitive load, time spent on the pretest and instructional efficiency) and post-learning performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different instructions (general statements and worked examples)?

2. Are there significant mean differences for the learning gain between pre-learning performance (pretest, cognitive load, time spent on the pretest and instructional efficiency) and post-learning performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic)?
3. Is there a significant interaction among instructions and presentation formats in the learning gain between the pre-service teachers’ pre-learning performance (pretest, cognitive load, time spent on the pretest and instructional efficiency) and post-learning performance (posttest, cognitive load, time spent on the posttest and instructional efficiency)?

*Learning Gain between the Pretest and Posttest*

The first type of learning gain is the difference between the scores on the pretest and posttest, which is used to detect the improvement after the instruction received. A two-way analysis of variance was used to answer the following null hypotheses:

H₀₁.₁: There is no significant mean difference for the learning gain between pre-learning performance (pretest) and post-learning performance (posttest) among the pre-service teachers who view different instructions (general statements and worked examples).

H₀₂.₁: There is no significant mean difference for the learning gain between pre-learning performance (pretest) and post-learning performance (posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

H₀₃.₁: There is no significant interaction between instructions and presentation formats in the learning gain between the pre-service teachers’ pre-learning performance (pretest) and post-learning performance (posttest).

Levene’s test (1960) was used to test the homogeneity of variance. The F-test from Levene’s test indicated no significance, F(3, 132) = 1.407, \( p = .244 \), and the
assumption of the homogeneity was met. Regarding the test of between-groups effects, F-ratio, as shown in Table 23, indicated the following results:

1. There is no significant mean difference for the learning gain between pre-learning performance (pretest) and post-learning performance (posttest) among the pre-service teachers who view different instructions (general statements and worked examples) (F (1, 132) = .088, $p > .05$, Partial $\eta^2 = .001$).

2. There is no significant mean difference for the learning gain between pre-learning performance (pretest) and post-learning performance (posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic) (F (1, 132) = .663, $p > .05$, Partial $\eta^2 = .005$).

3. There is no significant interaction between instructions and presentation formats in the learning gain between the pre-service teachers’ pre-learning performance (pretest) and post-learning performance (posttest) (F (1, 132) = 1.615, $p > .05$, Partial $\eta^2 = .012$).

Table 23

A 2-way ANOVA Test for the Learning Gain between the Pretest and Posttest

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked Example</td>
<td>.383</td>
<td>1</td>
<td>.383</td>
<td>.088</td>
<td>.767</td>
<td>.001</td>
</tr>
<tr>
<td>Presentation Format</td>
<td>2.875</td>
<td>1</td>
<td>2.875</td>
<td>.663</td>
<td>.417</td>
<td>.005</td>
</tr>
<tr>
<td>Worked Example * Presentation Format</td>
<td>7.004</td>
<td>1</td>
<td>7.004</td>
<td>1.615</td>
<td>.260</td>
<td>.012</td>
</tr>
<tr>
<td>Error</td>
<td>572.611</td>
<td>132</td>
<td>4.338</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>835.000</td>
<td>136</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Learning Gain between the Pre- and Post-Cognitive Load

The second type of learning gain is the difference between the scores on the pre- and post-rating of the difficulty of the materials, which is used to detect the improvement after the instruction received. A three way analysis of variance was used to answer the following null hypotheses:

$H_{01.2}$: There is no significant mean difference for the learning gain between pre-learning performance (cognitive load) and post-learning performance (cognitive load) among the pre-service teachers who view different instructions (general statement and worked example).

$H_{02.2}$: There is no significant mean difference for the learning gain between pre-learning performance (cognitive load) and post-learning performance (cognitive load) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

$H_{03.2}$: There is no significant interaction between instructions, presentation formats and prior knowledge levels in the learning gain between the pre-service teachers’ pre-learning performance (cognitive load) and post-learning performance (cognitive load).

Levene’s test (1960) was used to test the homogeneity of variance. The F-test from Levene’s test indicated no significance, $F (3, 132) = 1.149, p = .332$, and the assumption of the homogeneity was met. Regarding the test of between-groups effects, F-ratio, as shown in Table 24, indicated the following results:
1. There is no significant mean difference for the learning gain between pre-learning performance (cognitive load) and post-learning performance (cognitive load) among the pre-service teachers who view different instructions (general statement and worked example) (F (1, 132) = .000, \( p > .05 \), Partial \( \eta^2 = .000 \)).

2. There is no significant mean difference for the learning gain between pre-learning performance (cognitive load) and post-learning performance (cognitive load) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic) (F (1, 132) = .115, \( p > .05 \), Partial \( \eta^2 = .001 \)).

3. There is no significant interaction between instructions, presentation formats and prior knowledge levels in the learning gain between the pre-service teachers’ pre-learning performance (cognitive load) and post-learning performance (cognitive load) (F (1, 132) = .052, \( p > .05 \), Partial \( \eta^2 = .000 \)).

Table 24

A 2-way ANOVA Test for the Learning Gain between the Pre- and Post-Cognitive Load

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Partial ( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked Example</td>
<td>.001</td>
<td>1</td>
<td>.001</td>
<td>.000</td>
<td>.984</td>
<td>.000</td>
</tr>
<tr>
<td>Presentation Format</td>
<td>.235</td>
<td>1</td>
<td>.235</td>
<td>.115</td>
<td>.735</td>
<td>.001</td>
</tr>
<tr>
<td>Worked Example * Presentation Format</td>
<td>.106</td>
<td>1</td>
<td>.106</td>
<td>.052</td>
<td>.820</td>
<td>.000</td>
</tr>
<tr>
<td>Error</td>
<td>269.309</td>
<td>132</td>
<td>2.040</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>644.230</td>
<td>136</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Learning Gain between the Time spent on the Pretest and Posttest

The third type of learning gain is the difference between the time spent on the pretest and posttest, which is used to detect the improvement after the instruction received. A three-way analysis of variance was used to answer the following null hypotheses:

H_{01.3}: There is no significant mean difference for the learning gain between pre-learning performance (time spent on the pretest) and post-learning performance (time spent on the posttest) among the pre-service teachers who view different instructions (general statement and worked example).

H_{02.3}: There is no significant mean difference for the learning gain between pre-learning performance (time spent on the pretest) and post-learning performance (time spent on the posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

H_{03.3}: There is no significant interaction between instructions, presentation formats and prior knowledge levels in the learning gain between the pre-service teachers’ pre-learning performance (time spent on the pretest) and post-learning performance (time spent on the posttest).

Levene’s test (1960) was used to test the homogeneity of variance. The F-test from Levene’s test indicated no significance, F (3, 132) = .917, p = .435, and the assumption of the homogeneity was met. Regarding the test of between-groups effects, F-ratio, as shown in Table 25, indicated the following results:
1. There is no significant mean difference for the learning gain between pre-learning performance (time spent on the pretest) and post-learning performance (time spent on the posttest) among the pre-service teachers who view different instructions (general statement and worked example) \((F (1, 132) = .196, p > .05, \text{Partial } \eta^2 = .001)\).

2. There is no significant mean difference for the learning gain between pre-learning performance (time spent on the pretest) and post-learning performance (time spent on the posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic) \((F (1, 132) = 1.707, p > .05, \text{Partial } \eta^2 = .013)\).

3. There is no significant interaction between instructions, presentation formats and prior knowledge levels in the learning gain between the pre-service teachers’ pre-learning performance (time spent on the pretest) and post-learning performance (time spent on the posttest) \((F (1, 132) = 4.605, p > .05, \text{Partial } \eta^2 = .013)\).

Table 25

* A 2-way ANOVA Test for the Learning Gain between the Time spent on the Pretest and Posttest *

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Partial (\eta^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked Example</td>
<td>318.102</td>
<td>1</td>
<td>318.102</td>
<td>.196</td>
<td>.659</td>
<td>.001</td>
</tr>
<tr>
<td>Presentation Format</td>
<td>2777.730</td>
<td>1</td>
<td>2777.730</td>
<td>1.707</td>
<td>.194</td>
<td>.013</td>
</tr>
<tr>
<td>Worked Example * Presentation Format</td>
<td>2912.164</td>
<td>1</td>
<td>2912.164</td>
<td>1.790</td>
<td>.183</td>
<td>.013</td>
</tr>
<tr>
<td>Error</td>
<td>214756.446</td>
<td>132</td>
<td>1626.943</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>464983.000</td>
<td>136</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Learning Gain between the Pre- and Post-Instructional Efficiency

The fourth type of learning gain is the difference between the pre- and post-instructional efficiency, which is used to detect the improvement after the instruction received. A three-way analysis of variance was used to answer the following null hypotheses:

H₀₁.₄: There is no significant mean difference for the learning gain between pre-learning performance (instructional efficiency) and post-learning performance (instructional efficiency) among the pre-service teachers who view different instructions (general statement and worked example).

H₀₂.₄: There is no significant mean difference for the learning gain between pre-learning performance (instructional efficiency) and post-learning performance (instructional efficiency) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

H₀₃.₄: There is no significant interaction between instructions, presentation formats and prior knowledge levels in the learning gain between the pre-service teachers’ pre-learning performance (instructional efficiency) and post-learning performance (instructional efficiency).

Levene’s test (1960) was used to test the homogeneity of variance. The F-test from Levene’s test indicated no significance, F (3, 132) = .768, p = .514, and the assumption of the homogeneity was met. Regarding the test of between-groups effects, F-ratio, as shown in Table 26, indicated the following results:
1. There is no significant mean difference for the learning gain between pre-
learning performance (instructional efficiency) and post-learning performance
(instructional efficiency) among the pre-service teachers who view different instructions
(general statement and worked example) \( (F (1, 132) = .075, p > .05, \text{Partial } \eta^2 = .001) \).

2. There is no significant mean difference for the learning gain between pre-
learning performance (instructional efficiency) and post-learning performance
(instructional efficiency) among the pre-service teachers who view different presentation
formats (text-only and text-plus-graphic) \( (F (1, 132) = .385, p > .05, \text{Partial } \eta^2 = .003) \).

3. There is no significant interaction between instructions, presentation formats and prior
knowledge levels in the learning gain between the pre-service teachers’ pre-learning
performance (instructional efficiency) and post-learning performance (instructional
efficiency) \( (F (1, 132) = .255, p < .05, \text{Partial } \eta^2 = .002) \).

Table 26

A 2-way ANOVA Test for the Learning Gain between the Pre- and Post-Instructional
Efficiency

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked Example</td>
<td>.088</td>
<td>1</td>
<td>.088</td>
<td>.075</td>
<td>.784</td>
<td>.001</td>
</tr>
<tr>
<td>Presentation Format</td>
<td>.449</td>
<td>1</td>
<td>.449</td>
<td>.385</td>
<td>.536</td>
<td>.003</td>
</tr>
<tr>
<td>Worked Example * Presentation Format</td>
<td>.298</td>
<td>1</td>
<td>.298</td>
<td>.255</td>
<td>.614</td>
<td>.002</td>
</tr>
<tr>
<td>Error</td>
<td>153.931</td>
<td>132</td>
<td>1.166</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>154.818</td>
<td>136</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Additional Analysis for the Relationship between Worked Example, Presentation Format and Gender

Several additional 2X2X2 three-way ANOVAs were conducted to examine the relationship between worked example, presentation format and gender on the learning performance and learning gain. According to the Crosstabs results, the p-value for Pearson’s Chi-Square is equal to .192 > .05, so there is no relationship between prior knowledge and gender variables in this study. Since the largest cell size (31)/the smallest cell size (5) > 1.5, it could be an unbalanced design (unequal cell size). This study adopted Type III sums of squares for analyzing the unbalanced factorial design. Additionally, an independent test was used to find which mean are significantly different from the other. Levene’s test (1960) was used to test the homogeneity of variance. The results were presented as follows:

1. There is no significant mean difference for the learning performance (posttest) between male and female pre-service teachers (F(1, 128)= 3.356, p > .05, Partial $\eta^2$= .026).

2. There is no significant interaction between instructions, presentation formats and gender in the pre-service teachers’ learning performance (posttest) (F(1, 128)= 3.634, $p > .05$, Partial $\eta^2$= .028).

3. There is a significant mean difference for the learning performance (cognitive load) between male and female pre-service teachers (F(1, 128)= 7.782, $p < .05$, Partial $\eta^2$= .057). An independent T-test was run for detecting the significant mean difference on the cognitive load between male and female groups ($t= -2.325$, $p < .05$). The results
indicated that the male group (M_{male} = 4.01) reported significantly lower cognitive load on the posttest than the female group (M_{female} = 4.81).

4. There is no significant interaction between instructions, presentation formats and gender in the pre-service teachers’ learning performance (cognitive load) (F(1, 128) = .026, p > .05, Partial \( \eta^2 = .000 \)).

5. There is no significant mean difference for the learning performance (time spent on the posttest) between male and female pre-service teachers (F(1, 128) = 1.00, p > .05, Partial \( \eta^2 = .008 \)).

6. There is no significant interaction between instructions, presentation formats and gender in the pre-service teachers’ learning performance (time spent on the posttest) (F(1, 128) = .034, p > .05, Partial \( \eta^2 = .000 \)).

7. There is a significant mean difference for the learning performance (instructional efficiency) between male and female pre-service teachers (F (1, 128) = 7.231, p < .05, Partial \( \eta^2 = .053 \)). An independent T-test was run for detecting the significant mean difference on the instructional efficiency between male and female groups (t=2.508, p < .05). The results indicated that male group (M_{male} = .4826) had a significantly higher instructional efficiency than the female group (M_{female} = -.137).

8. There is no significant interaction between instructions, presentation formats and genders in the pre-service teachers’ learning performance (instructional efficiency) (F(1, 128) = 1.472, p > .05, Partial \( \eta^2 = .011 \)).
9. There is no significant mean difference for the learning gain between pre-
learning performance (pretest) and post- learning performance (posttest) between male
and female pre-service teachers (F(1, 128)= 1.214, \( p > .05 \), Partial \( \eta^2 = .009 \)).

10. There is no significant interaction between instructions, presentation formats
and genders in the learning gain between the pre-service teachers’ pre- learning
performance (pretest) and post- learning performance (posttest) (F(1, 128)= 1.360, \( p > .05 \), Partial \( \eta^2 = .011 \)).

11. There is no significant mean difference for the learning gain between pre-
learning performance (cognitive load) and post- learning performance (cognitive load)
between male and female pre-service teachers (F(1, 128)= .930, \( p > .05 \), Partial \( \eta^2 = .007 \)).

12. There is a significant interaction between instructions and gender in the
learning gain between the pre-service teachers’ pre- learning performance (cognitive
load) and post- learning performance (cognitive load) (F(1, 128)= 5.349, \( p < .05 \), Partial \( \eta^2 = .040 \)). According to Figure 9, compared to the pre- cognitive load invested, male
participants reported less cognitive load invested on the posttest by studying the worked
example instruction (\( M_{\text{male}} = -2.46 \)) than the general statement instruction (\( M_{\text{male}} = -1.37 \));
in contrast, female participants reported less cognitive load invested by studying the
general statement instruction (\( M_{\text{female}} = -1.76 \)) than the worked example instruction
(\( M_{\text{female}} = -1.50 \)).
Figure 9. Graph for the interaction between instruction and gender on the learning gain between the pre- and post- cognitive load.

13. There is no significant mean difference for the learning gain between pre-learning performance (time spent on the pretest) and post-learning performance (time spent on the posttest) between male and female pre-service teachers ($F (1, 128) = .416, p > .05$, Partial $\eta^2 = .003$).

14. There is no significant interaction between instructions, presentation formats and gender in the learning gain between the pre-service teachers’ pre-learning
15. There is no significant mean difference for the learning gain between pre-learning performance (instructional efficiency) and post-learning performance (instructional efficiency) between male and female pre-service teachers (F (1, 128) = .843, p > .05, Partial η² = .007).

16. There is no significant interaction between instructions, presentation formats and gender in the learning gain between the pre-service teachers’ pre-learning performance (instructional efficiency) and post-learning performance (instructional efficiency) (F (1, 128) = .032, p > .05, Partial η² = .000).

Additional Analysis for the Relationship between Worked Example, Presentation Format and Class Year

Several additional 2X2X3 three-way ANOVAs were conducted to examine the relationship between worked example, presentation format and class year on the learning performance and learning gain. According to the Crosstabs results, the p-value for Pearson’s Chi-Square is equal to .058 > .05, so there is no relationship between prior knowledge and class year variables in this study. Since the largest cell size (31)/the smallest cell size (5) > 1.5, it could be an unbalanced design (unequal cell size). This study adopted Type III sums of squares for analyzing the unbalanced factorial design. Additionally, the Tukey–Kramer method was chosen as the post hoc test for the unbalanced factorial design to find which means are significantly different from one
another. Levene’s test was used to test the basic assumption. The results were presented as follows:

1. There is no significant mean difference for the learning performance (posttest) among the pre-service teachers of different class years (sophomore, junior and senior) ($F$ $(1, 124) = .469, p > .05, \text{Partial } \eta^2 = .008$).

2. There is no significant interaction between instructions, presentation formats and class years in the pre-service teachers’ learning performance (posttest) ($F$ $(2, 124) = 2.522, p > .05, \text{Partial } \eta^2 = .039$).

3. There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers of different class years (sophomore, junior and senior) ($F$ $(2, 124) = 2.466, p > .05, \text{Partial } \eta^2 = .038$).

4. There is no significant interaction between instructions, presentation formats and class years in the pre-service teachers’ learning performance (cognitive load) ($F$ $(2, 124) = 1.784, p > .05, \text{Partial } \eta^2 = .028$).

5. There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers of different class years (sophomore, junior and senior) ($F$ $(2, 124) = .151, p > .05, \text{Partial } \eta^2 = .002$).

6. There is no significant interaction between instructions, presentation formats and class years in the pre-service teachers’ learning performance (time spent on the posttest) ($F$ $(2, 124) = 1.811, p > .05, \text{Partial } \eta^2 = .028$).
7. There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers of different class years (sophomore, junior and senior) \( (F (2, 124) = 1.250, p > .05, \text{Partial } \eta^2 = .020) \).

8. There is no significant interaction between instructions, presentation formats and class years in the pre-service teachers’ learning performance (instructional efficiency) \( (F (2, 124) = 2.644, p > .05, \text{Partial } \eta^2 = .041) \).

9. There is no significant mean difference for the learning gain between pre-learning performance (pretest) and post-learning performance (posttest) among the pre-service teachers of different class years (sophomore, junior and senior) \( (F (2, 124) = 1.277, p > .05, \text{Partial } \eta^2 = .020) \).

10. There is a significant interaction between instructions, presentation formats and class years in the learning gain between the pre-service teachers’ pre-learning performance (pretest) and post-learning performance (posttest) \( (F (2, 124) = 3.138, p < .05, \text{Partial } \eta^2 = .048) \). According to Figure 10, when general statement instruction was provided, the sophomore group and the junior group scored better by viewing the text-plus-graphic presentation format \( (M_{\text{ sophomore}} = 1.31; M_{\text{ junior}} = 2.20) \) than the text-only presentation format \( (M_{\text{ sophomore}} = .22; M_{\text{ junior}} = 1.54) \); in contrast, the senior group scored better by viewing the text-only presentation \( (M_{\text{ senior}} = 3.00) \) format than the text-plus-graphic presentation format \( (M_{\text{ senior}} = 1.75) \). When worked example instruction was provided, the sophomore group and the junior group scored better by viewing the text-only presentation format \( (M_{\text{ sophomore}} = 1.58; M_{\text{ junior}} = 1.52) \) than the text-plus-graphic presentation format \( (M_{\text{ sophomore}} = 1.09; M_{\text{ junior}} = .92) \); in contrast, the senior group scored
better by viewing the text-plus-graphic presentation format ($M_{\text{senior}} = 2.50$) than the text-only presentation format ($M_{\text{senior}} = .000$).

![General Statement](image1.png)

![Worked Example](image2.png)

*Figure 10.* Graph for the interaction between instruction and class year on the learning gain between the pretest and posttest.

11. There is no significant mean difference for the learning gain between pre-learning performance (cognitive load) and post-learning performance (cognitive load) among the pre-service teachers of different class years (sophomore, junior and senior) ($F(2, 124) = 2.774, p > .05, \text{Partial } \eta^2 = .043$).

12. There is no significant interaction between instructions, presentation formats and class years in the learning gain between the pre-service teachers’ pre-learning performance (cognitive load) and post-learning performance (cognitive load) ($F(2, 124) = .685, p > .05, \text{Partial } \eta^2 = .011$).
13. There is no significant mean difference for the learning gain between pre-
learning performance (time spent on the pretest) and post- learning performance (time 
spent on the posttest) among the pre-service teachers of different class years (sophomore, 
junior and senior) (F (2, 124) = .005, p > .05, Partial $\eta^2$ = .000).

14. There is no significant interaction between instructions, presentation formats 
and class years in the learning gain between the pre-service teachers’ pre- learning 
performance (time spent on the pretest) and post- learning performance (time spent on the 
posttest) (F (2, 124) = 1.554, p > .05, Partial $\eta^2$ = .024).

15. There is no significant mean difference for the learning gain between pre-
learning performance (instructional efficiency) and post- learning performance 
(instructional efficiency) among the pre-service teachers of different class years 
(sophomore, junior and senior) (F (2, 124) = 2.305, p > .05, Partial $\eta^2$ = .036).

16. There is no significant interaction between instructions, presentation formats 
and class years in the learning gain between the pre-service teachers’ pre- learning 
performance (instructional efficiency) and post- learning performance (instructional 
efficiency) (F (2, 124) = .606, p > .05, Partial $\eta^2$ = .010).
CHAPTER FIVE: DISCUSSION AND CONCLUSION

Summary of Results

A summary of results to the research problems, responses to the open-ended question and additional findings were presented as follows. Table 27 presented an overview of better performance within each particular prior knowledge group; Table 28 presented an overview of ANOVA results of research questions; Table 29 presented an overview of ANOVA results of learning gain; Table 30 presented an overview of ANOVA results of gender data; Table 31 presented an overview of ANOVA results of class year data. More detailed findings followed right after each table. Then, the discussion and conclusion of this study were discussed followed by the limitations of this research and the researcher’s recommendations for future research.

Summary of Descriptive Results

1. Among the instructions the low prior knowledge level group who received the text-only general statement instruction got the highest score on the posttest; the medium prior knowledge level group who viewed the text-plus-graphic general statement instruction got the highest score on the posttest; the high prior knowledge level group who studied the text-only worked example got the highest score on the posttest.

2. Among the instructions the low prior knowledge level group who received the text-plus-graphic worked example instruction reported the least cognitive load invested on the posttest; the medium prior knowledge level group who viewed the text-only worked example instruction reported the least cognitive load invested on the posttest; the
high prior knowledge level group who studied the text-only worked example reported the least cognitive load invested on the posttest.

3. Among the instructions the low prior knowledge level group who received the text-only worked example instruction spent the smallest amount of time to complete the posttest; the medium prior knowledge level group who viewed the text-plus-graphic worked example instruction spent the smallest amount of time to complete the posttest; the high prior knowledge level group who studied the text-only general statement instruction spent the smallest amount of time to complete the posttest.

4. Among the instructions the low prior knowledge level group who received the text-only general statement instruction got the highest instructional efficiency; the medium prior knowledge group who viewed the text-plus-graphic general statement instruction got the highest instructional efficiency; the high prior knowledge level group who studied the text-only worked example instruction got the highest instructional efficiency.
Table 27

A Summary Table of Descriptive Results

<table>
<thead>
<tr>
<th>Prior Knowledge</th>
<th>Worked Example</th>
<th>Presentation Format</th>
<th>Test</th>
<th>Mental Load</th>
<th>Time</th>
<th>E</th>
</tr>
</thead>
<tbody>
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<td>T</td>
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<td></td>
<td>G T</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T + G</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
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<td>T + G</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>G T</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>T + G</td>
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<td></td>
<td></td>
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<td>W T</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T + G</td>
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<td></td>
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<tr>
<td></td>
<td>G T</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T + G</td>
<td>✓</td>
<td></td>
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</tr>
</tbody>
</table>

Note. W stands Worked Example; G stands General Statement; T stands Text; T + G stands Text-plus-graphic; ✓ indicates better performance within the particular prior knowledge level groups.

Summary of Results to the Research Questions

There were four research questions in this study, which were centered on the relationship between worked example, presentation format and prior knowledge on learning performance. Table 28 and a summary of results to the research problems was presented below.

Research Question 1: Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different instructions (general statement and worked example)?
1) There is no significant mean difference for the learning performance (posttest) among the pre-service teachers who view different instructions (general statement and worked example).

2) There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers who view different instructions (general statement and worked example).

3) There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers who view different instructions (general statement and worked example).

4) There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers who view different instructions (general statement and worked example).

Research Question 2: Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic)?

1) There is no significant mean difference for the learning performance (posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

2) There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).
3) There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

4) There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

Research Question 3: Are there significant mean differences in performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low)?

1) There is a significant mean difference for the learning performance (posttest) among the pre-service teachers with different prior knowledge levels of internet connection (high, medium and low). The results showed that the medium prior knowledge level group and the high prior knowledge level group scored significantly higher than the low prior knowledge level group on the posttest.

2) There is a significant mean difference for the learning performance (cognitive load) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low). The results showed the medium prior knowledge level group and the high prior knowledge group reported significantly lower cognitive load than the low prior knowledge level group on the cognitive load scale.
3) There is a significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low). The results showed that the high prior knowledge level group spent significantly more time on the posttest than the low prior knowledge level group.

4) There is a significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers with different prior knowledge levels of internet disconnection troubleshooting (high, medium and low). The results showed that the medium prior knowledge level group and the high prior knowledge level group had significantly higher instructional efficiency than low prior knowledge level group.

Research Question 4: Is there a significant interaction among instructions, presentation formats and prior knowledge levels in the pre-service teachers’ performance (posttest, cognitive load, time spent on the posttest and instructional efficiency)?

1) There is a significant interaction effect between worked examples and prior knowledge levels in the pre-service teachers’ learning performance (posttest). The results showed that the low prior knowledge level group and the medium prior knowledge level group performed better on the posttest by using the general statement instruction than the worked example instruction. In contrast, the high prior knowledge level group performed better on the posttest by using the worked example instruction than the general statement instruction.
2) There is a significant interaction effect between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (cognitive load). The results showed that when general statement instruction was provided, the low prior knowledge group and the high prior knowledge level group reported lower cognitive load by viewing the text-only presentation format than the text-plus-graphic presentation format; the medium prior knowledge level group reported lower cognitive load by viewing the text-plus-graphic presentation format than the text-only presentation format. When worked example instruction was provided, the medium prior knowledge level group and the high prior knowledge level group reported lower cognitive load by viewing the text-only presentation format) than the text-plus-graphic presentation format; in contrast, the low prior knowledge level group reported lower cognitive load by viewing the text-plus-graphic presentation format than the text-only presentation format.

3) There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (time spent on the posttest).

4) There is no significant interaction between instructions, presentation formats and prior knowledge levels in the pre-service teachers’ learning performance (instructional efficiency).
Table 28

*Table 29 Summary Table of ANOVA Data for Research Questions

<table>
<thead>
<tr>
<th></th>
<th>Test</th>
<th>Mental Load</th>
<th>Time</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Worked Example (W)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Presentation Format (P)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior Knowledge (K)</td>
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<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W*P</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P*K</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W*K</td>
<td>*</td>
<td></td>
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<tr>
<td>W<em>P</em>K</td>
<td></td>
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</tr>
</tbody>
</table>

Note. * indicates a significant result

Summary of Responses to the Open-ended Question

1. Opinions about the instruction: Five participants expressed their opinions about the instruction received. First of all, two participants thought the instructions they received were helpful for them to learn this particular subject. Secondly, one participant asked if the definitions and step could be emphasized more, it may help him to learn better. In addition, one participant even expressed that he was willing to take a course that taught this subject.

2. Opinions about the presentation format: Two participants expressed their opinions about the presentation format. First of all, one participant expressed that he did not like the text-only presentation format. In addition, another participant mentioned the animation provided in the text-only worked example instruction was distracting to him.

3. Opinions about the difficulty of instructional materials: Nine participants expressed that they felt the instructional materials are hard to learn.
4. Opinions about the time constraint: Two participants found out the time constraint could be a problem for them to learn. They addressed that they needed more time to comprehend the materials.

5. Opinions about the overall experiment: Six participants expressed positive opinions about the overall experiment. Some of them thought the experiment was interesting and helpful, and some of them thought the experiment is organized.

Summary of Additional Results about Learning Gain

1. There is no significant mean difference for the learning gain between pre-learning performance (pretest, cognitive load, time spent on the pretest and instructional efficiency) and post-learning performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different instructions (general statements and worked examples).

2. There is no significant mean difference for the learning gain between pre-learning performance (pretest, cognitive load, time spent on the pretest and instructional efficiency) and post-learning performance (posttest, cognitive load, time spent on the posttest and instructional efficiency) among the pre-service teachers who view different presentation formats (text-only and text-plus-graphic).

3. There is no significant interaction among instructions and presentation formats in the learning gain between the pre-service teachers’ pre-learning performance (pretest, cognitive load, time spent on the pretest and instructional efficiency) and post-learning performance (posttest, cognitive load, time spent on the posttest and instructional efficiency)?
Table 29

*A Summary Table of ANOVA Data for Learning Gain*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Test- LG</th>
<th>Mental Load - LG</th>
<th>Time - LG</th>
<th>E - G</th>
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<td>Worked Example (W)</td>
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<tr>
<td>Prior Knowledge (K)</td>
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<tr>
<td>W<em>P</em>K</td>
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</tbody>
</table>

*Note.* * indicates a significant result

*Summary of Additional Results about Gender*

1. There is no significant mean difference for the learning performance (posttest) between male and female pre-service teachers.

2. There is no significant interaction between instructions, presentation formats and gender in the pre-service teachers’ learning performance (posttest).

3. There is a significant mean difference for the learning performance (cognitive load) between male and female pre-service teachers. The results indicated that the male group reported significantly lower cognitive load on the posttest than the female group.

4. There is no significant interaction between instructions, presentation formats and gender in the pre-service teachers’ learning performance (cognitive load).

5. There is no significant mean difference for the learning performance (time spent on the posttest) between male and female pre-service teachers.

6. There is no significant interaction between instructions, presentation formats and gender in the pre-service teachers’ learning performance (time spent on the posttest).
7. There is a significant mean difference for the learning performance (instructional efficiency) between male and female pre-service. The results indicated that male group had a significantly higher instructional efficiency than the female group.

8. There is no significant interaction between instructions, presentation formats and genders in the pre-service teachers’ learning performance (instructional efficiency).

9. There is no significant mean difference for the learning gain between pre-learning performance (pretest) and post-learning performance (posttest) between male and female pre-service teachers.

10. There is no significant interaction between instructions, presentation formats and genders in the learning gain between the pre-service teachers’ pre-learning performance (pretest) and post-learning performance (posttest).

11. There is no significant mean difference for the learning gain between pre-learning performance (cognitive load) and post-learning performance (cognitive load) between male and female pre-service teachers.

12. There is a significant interaction between instructions and gender in the learning gain between the pre-service teachers’ pre-learning performance (cognitive load) and post-learning performance (cognitive load). The results showed compared to the pre-cognitive load invested, male participants reported less cognitive load invested on the posttest by studying the worked example instruction than the general statement instruction; in contrast, female participants reported less cognitive load invested by studying the general statement instruction than the worked example instruction.
13. There is no significant mean difference for the learning gain between pre-
learning performance (time spent on the pretest) and post- learning performance (time 
spent on the posttest) between male and female pre-service teachers.

14. There is no significant interaction between instructions, presentation formats 
and gender in the learning gain between the pre-service teachers’ pre- learning 
performance (time spent on the pretest) and post- learning performance (time spent on the 
posttest).

15. There is no significant mean difference for the learning gain between pre-
learning performance (instructional efficiency) and post- learning performance 
(instructional efficiency) between male and female pre-service teachers.

16. There is no significant interaction between instructions, presentation formats 
and gender in the learning gain between the pre-service teachers’ pre- learning 
performance (instructional efficiency) and post- learning performance (instructional 
efficiency).

Table 30

A Summary Table of ANOVA Data for Gender Data

<table>
<thead>
<tr>
<th>Test Mental Load</th>
<th>Time</th>
<th>E</th>
<th>Test Mental Load</th>
<th>Time</th>
<th>E</th>
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<tr>
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</tbody>
</table>

Note. LG stands Learning Gain; * indicates a significant result
Summary of Additional Results about Class Year

1. There is no significant mean difference for the learning performance (posttest) among the pre-service teachers of different class years (sophomore, junior and senior).

2. There is no significant interaction between instructions, presentation formats and class years in the pre-service teachers’ learning performance (posttest).

3. There is no significant mean difference for the learning performance (cognitive load) among the pre-service teachers of different class years (sophomore, junior and senior).

4. There is no significant interaction between instructions, presentation formats and class years in the pre-service teachers’ learning performance (cognitive load).

5. There is no significant mean difference for the learning performance (time spent on the posttest) among the pre-service teachers of different class years (sophomore, junior and senior).

6. There is no significant interaction between instructions, presentation formats and class years in the pre-service teachers’ learning performance (time spent on the posttest).

7. There is no significant mean difference for the learning performance (instructional efficiency) among the pre-service teachers of different class years (sophomore, junior and senior).

8. There is no significant interaction between instructions, presentation formats and class years in the pre-service teachers’ learning performance (instructional efficiency).
9. There is no significant mean difference for the learning gain between pre-
learning performance (pretest) and post-learning performance (posttest) among the pre-
service teachers of different class years (sophomore, junior and senior).

10. There is a significant interaction between instructions, presentation formats
and class years in the learning gain between the pre-service teachers’ pre-learning
performance (pretest) and post-learning performance (posttest). The sophomore group
and the junior group scored better by viewing the text-plus-graphic presentation format
than the text-only presentation format; in contrast, the senior group scored better by
viewing the text-only presentation format than the text-plus-graphic presentation format.
When worked example instruction was provided, the sophomore group and the junior
group scored better by viewing the text-only presentation format than the text-plus-
graphic presentation format; in contrast, the senior group scored better by viewing the
text-plus-graphic presentation format than the text-only presentation format.

11. There is no significant mean difference for the learning gain between pre-
learning performance (cognitive load) and post-learning performance (cognitive load)
among the pre-service teachers of different class years (sophomore, junior and senior).

12. There is no significant interaction between instructions, presentation formats
and class years in the learning gain between the pre-service teachers’ pre-learning
performance (cognitive load) and post-learning performance (cognitive load).

13. There is no significant mean difference for the learning gain between pre-
learning performance (time spent on the pretest) and post-learning performance (time
spent on the posttest) among the pre-service teachers of different class years (sophomore, junior and senior).

14. There is no significant interaction between instructions, presentation formats and class years in the learning gain between the pre-service teachers’ pre-learning performance (time spent on the pretest) and post-learning performance (time spent on the posttest).

15. There is no significant mean difference for the learning gain between pre-learning performance (instructional efficiency) and post-learning performance (instructional efficiency) among the pre-service teachers of different class years (sophomore, junior and senior).

16. There is no significant interaction between instructions, presentation formats and class years in the learning gain between the pre-service teachers’ pre-learning performance (instructional efficiency) and post-learning performance (instructional efficiency).

Table 31

A Summary Table of ANOVA Data for Class Year Data

<table>
<thead>
<tr>
<th>Test Mental Load</th>
<th>Time E</th>
<th>Test - LG Mental Load</th>
<th>Time - LG</th>
<th>E - G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked Example (W)</td>
<td>Presentation Format (P)</td>
<td>Class Year (C)</td>
<td>W*P</td>
<td>P*C</td>
</tr>
</tbody>
</table>

*Note. LG stands Learning Gain; * indicates a significant result*
Discussion and Conclusion

First of all, previous research suggested that students who studied worked examples would have a better performance than students who studied conventional practice (Carroll, 1994; Cooper & Sweller, 1987; Crissman, 2006; Pawley, 2004; Lee et al., 2004; Shen, 2005; Sweller & Cooper, 1985; Zhu & Simon, 1987). Yet, this study revealed that worked example did not significantly impact students’ learning performance (posttest, cognitive load, time spent on the posttest and instructional efficiency). It was expected that participants who viewed worked example instruction could perform better than participants who viewed general statement instruction. However, the expectation was not supported by this study. Individual difference may be a factor, which affects the results (Kalyuga et al., 1998; Ward & Sweller, 1990; Tarmizi & Sweller, 1988). In addition, if more participants get invited in the study, the result may be different, because one of the descriptive data revealed that among the instructions the low prior knowledge level group who received the text-plus-graphic worked example instruction reported the least cognitive load invested on the posttest; the medium and high prior knowledge level group who viewed the text-only worked example instruction reported the least cognitive load invested on the posttest. To improve the effectiveness of worked example, Shen (2006) recommended the following designs could add to the worked example itself: (a) practice problems, (b) fading procedure, (c) self-explanations, (d) verbal instruction and (e) subgoals. Crissman (2006) also confirmed that fading procedure and self-explanations are most promising practice to worked example.
Second, previous research has proposed that adding graphics into instructional materials may enhance learning (Anglin et al., 2004; Carney & Levin, 2002; Clark & Lyons, 2004; Mayer et al., 1996; Mayer & Gallini, 1990; Peeck, 1993; Smaldino et al., 2007). Hegarty and Just (1993) and Pociask and Morrison (2008) found out learners did better in the performance test and reported a lower level of cogitative load by using text-plus-graphic presentation format. However, this study revealed that presentation format did not significantly affect students’ learning performance (posttest, cognitive load, time spent on the posttest and instructional efficiency). It was expected that participants who viewed text-plus-graphic presentation format could perform better than participants who viewed text-only presentation format. However, the expectation was not supported by this study. Failing to have significant results may possibly relate to the individual difference (e.g., prior knowledge or visual ability) (Butcher, 2006; Hegarty et al., 1991; Petre & Green, 1993). In addition, if more participants get invited in the study, the result may be different, because one of the descriptive data revealed that among the instructions the low prior knowledge level group who received the text-plus-graphic worked example instruction reported the least cognitive load invested on the posttest; the medium prior knowledge level group who viewed the text-only worked example instruction reported the least cognitive load invested on the posttest; the high prior knowledge level group who studied the text-only worked example reported the least cognitive load invested on the posttest. Text-plus-graphic presentation format may benefit novices more than experts.
Third, previous studies addressed that prior knowledge may affect students’ learning performance, because students who have more relevant knowledge can generate appropriate responses faster to solve problems (Cooper & Sweller, 1987; Schnottz & Kurschner, 200; Sweller et al., 1998; van Merriënboer et al., 2003). This study revealed that prior knowledge level did significantly impact students’ learning performance (posttest, cognitive load, time spent on the posttest and instructional efficiency). It was expected that participants with higher prior knowledge level could scored higher, reported less cognitive load, spent less time on the posttest and got higher instructional efficiency than participants with lower prior knowledge level. The expectation was supported by some findings of the study. According to the results, participants with higher prior knowledge level did score higher, report less cognitive load and get higher instructional efficiency than participants with lower prior knowledge level. However, the researcher found that high prior knowledge level group actually spent significantly more time on the posttest than the lower prior knowledge level group, which is conflicted with previous studies (Cooper & Sweller, 1987; Sweller & Cooper, 1985). The possible explanation for this finding may be related to the lower prior knowledge group’s learning frustration during the experiment. They may not know how to answer the questions then chose to click through the posttest and thus spent less time on the posttest. In contrast, high prior knowledge level group may spend more time on learning the materials in order to achieve higher performance. In addition, since the result of time issue did not consistent with the findings of other performances, two issues have been raised up. One issue was related to the rating scale used in this study, because the self-reported data was
more subjective. One who had high prior knowledge may report high cognitive load and one who had low prior knowledge may report low cognitive load during the task. The other issue was related the instructional efficiency. The formula of instructional efficiency does not include the time invested. van Gog and Paas (2008) have mentioned if the researcher restricted the time spent on the task, then they recommended to incorporate both performance, time-on-task, and mental effort invested in the test into the instructional efficiency measure. In other words, if the time spent on the task could be counted into the instructional efficiency measure, it may be able to get more accurate results.

Fourth, previous studies addressed that there may be an associate relationship among worked examples, presentation formats and prior knowledge levels (Kalyuga et al, 1998; Hegarty et al., 1991). (a) For the relationship between worked examples and prior knowledge, according to Crissman (2006) and Kalyuga et al. (2001), it was expected that worked examples benefited participants with lower prior knowledge levels than participants with higher prior knowledge levels. However, this expectation was not supported by the study. The results showed the low prior knowledge level group and the medium prior knowledge level group performed better on the posttest by using the general statement instruction. In contrast, the high prior knowledge level group performed better on the posttest by using the worked examples.

The possible explanation for this finding may be because participants with lower prior knowledge level may get used to follow information in a conventional bullet writing style and participants with high prior knowledge may get used to the problem solving
process. Therefore, it may be the reason why the high prior knowledge group got higher posttest scores by using worked examples, since the worked examples provided in the study started with an internet disconnection problem following by troubleshooting steps and final answer. (b) For the relationship between presentation format and prior knowledge, according to Kalyuga et al. (1988), it was expected that participants with lower prior knowledge level performed better by using the text-plus-graphic presentation format and participants with higher prior knowledge level preferred the text-only presentation format. However, the expectation was not supported by this study. Failing to have significant results may possibly relate to the individual difference (e.g., prior knowledge or visual ability) (Butcher, 2006; Hegarty et al., 1991; Petre & Green, 1993). (c) For the relationship between worked example and presentation format, according to Hegarty and Just (1993), it was expected that participants can learn better by using text-plus-graphic worked example than text-only worked example. However, the expectation was not supported by this study. Failing to have significant results may possibly relate to individual differences as well (e.g., prior knowledge or visual ability) (Butcher, 2006; Hegarty et al., 1991; Petre & Green, 1993). (d) For the relationship among worked example, presentation format and prior knowledge, according to Kalyuga et al. (1988), it was expected that the higher knowledge level group performed better by using text-only worked example and lower prior knowledge group performed better by using text-plus-graphic worked example. The expectation was supported by one of findings of the study, because there is only a significant interaction effect among these three factors on one of the learning performance (cognitive load).
According to the results, when worked example instruction was provided, the medium prior knowledge level group and the high prior knowledge level group reported lower cognitive load by viewing the text-only presentation format than the text-plus-graphic presentation format; in contrast, the low prior knowledge level group reported lower cognitive load by viewing the text-plus-graphic presentation format than the text-only presentation format. To illustrate further, when worked example instruction was provided, the lower prior knowledge may prefer to view the text-plus-graphic presentation format, because they may need more detailed and integrate information, in contrast, the higher prior knowledge may not need the same detailed information because they already have relevant knowledge in mind. It was so called expert reversal effect (Kalyuga, Ayres, Chandler, & Sweller, 2003).

Summary of Additional Results about Learning Gain

According to the results of learning gain, there is no significant mean difference for the learning gain between pre-learning performance and post-learning performance among the pre-service teachers who view different instructions. In addition, there is no significant mean difference for the learning gain between pre-learning performance and post-learning performance among the pre-service teachers who view different presentation formats. There is also no significant interaction among instructions and presentation formats in the learning gain between the pre-service teachers’ pre-learning performance and post-learning performance. The possible explanation for these results may relate to the limited instruction time. Since the instruction was a short lesson of disconnected internet troubleshooting process and students needed to master all the
materials and concepts under time pressure, which made them difficult to digest the information at once. Probably, extending the instruction time or conducting repeated experimental sessions may get more accurate results.

**Summary of Additional Results about Gender**

There were some additional findings about gender; first of all, one of the additional findings indicated that male group had a significantly higher posttest scores and instructional efficiency than the female group. The possible explanation of this finding may be related to the subject matter, since the content of the instructional materials was about technical computer knowledge which may be gender biased with this particular sample population. Second, another result showed that compared to the pre-cognitive load invested, male participants reported less cognitive load invested on the posttest by studying the worked example instruction than the general statement instruction; in contrast, female participants reported less cognitive load invested by studying the general statement instruction than the worked example instruction. The possible explanation for this result could relate to instructional preference between male and female groups, but it also could possibly relate to the physical traits of working memory between male and female group. According to Speck et al. (2000), there was a gender difference in brain activation during working memory tasks. In Speck’s study, the task performance data demonstrated higher accuracy and slightly slower reaction times for the female subjects. The findings revealed that gender may be an important issue when designing worked examples.
Summary of Additional Results about Class Year

There was one additional finding about class year. According to the results, when the general statement was provided, the sophomore group and the junior group scored better by viewing the text-plus-graphic presentation format than the text-only presentation format; in contrast, the senior group scored better by viewing the text-only presentation format than the text-plus-graphic presentation format. When worked example instruction was provided, the sophomore group and the junior group scored better by viewing the text-only presentation format than the text-plus-graphic presentation format; in contrast, the senior group scored better by viewing the text-plus-graphic presentation format than the text-only presentation format. Class year is more complex concept than the prior knowledge, because it could relate the age, relevant experience or knowledge. It is hard to explain this finding, but it reminds the design to consider class year while designing worked example instruction.

Implications of Study

The present study has the following implications for instructional designers:

1. Since the findings of the study revealed that prior knowledge, gender and class year had some impacts on the effectiveness of worked examples, while designing worked example instruction, individual differences needs to be considered.

2. Additionally, the expert reversal effect (Kalyuga et al, 2001) was confirmed by one of findings in the study. When worked example instruction was provided, the higher prior knowledge level groups reported lower cognitive load by viewing the text-only presentation format; in contrast, the low prior knowledge level group reported lower
cognitive load by viewing the text-plus-graphic presentation format. It indicated novices may need more detailed guidance in worked example instruction.

3. Since one of findings in the study discovered that the low prior knowledge level group reported lower cognitive load by viewing the text-plus-graphic worked examples instead of text-only worked examples. It indicated that integrating text and graphics in worked examples may help novice learn better.

4. The findings of the study showed that high prior knowledge level group performed better on the posttest by using worked examples than general statements. It indicated that worked examples may not only benefit novices as previous studies addressed (Crissman, 2006; Kalyuga, et al., 1998), they may also work for experts.

**Limitations of the Study and Recommendations for Future Research**

The limitations of this study and future recommendations are discussed as follows:

1. Since a web-based experiment may lose some control in the experiment (Schmidt, 1997) and have a high drop-out rate (Reips, 2002a), the performance test used in this study only had 10 items, which reduced the reliability of the instruments. The future studies could consider increasing the number of items the performance test to gain a higher reliability (Light, et al., 1990).

2. In addition, from participant responses to the open-ended question, 9 participants reported the learning materials were hard and they needed more time to learn. Therefore, the future studies could consider separating the learning content and conducted a series of experiments to get more robust learning effects.
3. The concept of cognitive load in this study was defined in general and did not divide into three categories: intrinsic cognitive load, extraneous cognitive load and germane cognitive load. It was hard to determine whether participants devoted germane cognitive load for a deeper thinking or not during the experiment. Therefore, future studies could consider investigating any particular cognitive load of these three to get more accurate results.

4. The cognitive load scale used in this study was a self-reported rating scale. It may be subjective and impact the results. Because one who had high prior knowledge may report high cognitive load and one who had low prior knowledge may report low cognitive load during the test. Therefore, the future studies could consider other measures, such as dual-task performance.

5. The instructional efficiency formula used in this study only focused on the test performance and mental load invested, which did not consider the time issue and instructional condition. van Gog and Paas (2008) have mentioned if the researcher restricted the time spent on the task, then they recommended to incorporate both performance, time-on-task, and mental effort invested in the test into the instructional efficiency measure. In addition, they also revised the original formula of instructional efficiency (Efficiency = $Z_{\text{Performance}} - Z_{\text{Mental Load}} / \sqrt{2}$) to the one focusing on the instructional condition more (Efficiency = $Z_{\text{Ptest}} - Z_{\text{Elearning}} / \sqrt{2}$). The future studies could consider adopting the new formula for calculating the instructional efficiency.

6. The worked example design in this study focused on the integration of text and graphics, since the findings of study did not show the strong relationship between worked
examples and learning performance, the future studies could consider adding any of the following techniques to enhance the effectiveness of worked examples: (a) practice problems, (b) fading procedure, (c) self-explanations, (d) verbal instruction and (e) subgoals (Crissman, 2006; Shen, 2006).
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Review, 17*(2), 147-177.

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Instruction, 7*, 1-39.

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database. (UMI No. 3199988)


APPENDIX A

PERMISSION FOR USING IGI COPYRIGHTED FIGURE
Dear E-Ling Hsiao, I have been forwarded your request to use an IGI copyrighted figure in your upcoming dissertation. IGI is pleased to grant you this permission provided you cite it with the source where it appears in the IGI publication and that you add the following words “Reprinted with permission of the publisher.” Thanks, and good luck with your thesis.

Jan Travers

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Vice President
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E-mail: travers@igi-global.com
www.igi-global.com

APPENDIX B

QUESTIONS ON THE PRETEST AND POSTTEST
<table>
<thead>
<tr>
<th>Question Items</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is a Network Card?</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1) A piece of hardware for the network communication *.</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2) A piece of hardware for audio signals.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) A piece of hardware for media storage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Router is used for</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>1) Connect local network and ISP’s network*.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Connect computers and cable television infrastructure.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Connect two modems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Cable modem is used for</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>1) Sending data signal over the optical fibers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Sending data signal over the cable television infrastructure*.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Sending data signal over the DSL phone line.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. What is an ISP Company?</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>1) Hardware repair/support company.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Software company.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Internet service company*.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. What does an IP address mean?</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>1) A unique computer address*.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) A hardware or physical address.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) A domain name.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Sarah finds that she cannot connect to the internet. When she types in IPCONFIG on the command prompt screen, she finds that she does not have an IP address assigned. What problem does she have?</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>1) She may have a problem with the router.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) She may have a problem with the network card*.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) She may have a problem with the cable modem.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Mary finds that she cannot connect to the internet, but she has all cords plugged in correctly, what she should do next and why?</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>1) Type in IPCONFIG on the command prompt screen to make sure she has an IP address*.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Type in PING on the command prompt screen to make sure she has a reply from the router.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Type in IPCONFIG on the command prompt screen to make sure she has a reply from the modem.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. David finds that he cannot connect to the internet, he is sure that he has a working router, so he types in PING 169.168.1.1 (Default Gateway IP Address) on the command prompt screen and he does not get any reply. What problem do you think he has?</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>1) He may have a problem with the cable modem.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) He may have a problem with the router*.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) He may have a problem with the DNS server.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Dan finds that he cannot connect to the internet, he is sure that his network card, router and cable modem have no problem. However,</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>
when he types in PING 199.188.164.8 (external site) on the command prompt screen, he still cannot get any reply, so what he should do next and why?
1) Double check the cords to see if they are plugged in correctly.
2) Connect his ISP Company directly, because its DNS server may be down.
3) Restart the modem, router and computer. If it does not work, contact his ISP company. His ISP’s network may be down*.

10. Jean finds that she cannot connect to the internet, she is sure that her network card, router and cable modem are working fine, but when she type in PING www.home.com on the command prompt screen, she is not able to get a response. What problem does she have now?
1) Connect her ISP Company directly, because its DNS server may be down*.
2) Restart the modem, router and computer. If it does work, contact her ISP company. Her ISP’s network may be down.
3) She may have a bad router.

*sign stands for the answer key
APPENDIX C

KNOWLEDGE INVOLVED IN THE PRETEST AND POSTTEST
<table>
<thead>
<tr>
<th>Question Items</th>
<th>Knowledge Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is a Network Card?</td>
<td>• Relevant knowledge involved: 1) network card.</td>
</tr>
<tr>
<td>1) A piece of hardware for the network communication *.</td>
<td></td>
</tr>
<tr>
<td>2) A piece of hardware for audio signals.</td>
<td></td>
</tr>
<tr>
<td>3) A piece of hardware for media storage.</td>
<td></td>
</tr>
<tr>
<td>2. Router is used for ____________.</td>
<td>• Relevant knowledge involved: 1) router; 2) local network; 3) ISP's network.</td>
</tr>
<tr>
<td>1) Connect local network and ISP’s network*.</td>
<td></td>
</tr>
<tr>
<td>2) Connect computers and cable television infrastructure.</td>
<td></td>
</tr>
<tr>
<td>3) Connect two modems.</td>
<td></td>
</tr>
<tr>
<td>3. Cable modem is used for ____________.</td>
<td>• Relevant knowledge involved: 1) cable modem; 2) optical fibers; 3) cable television infrastructure; 4) DSL phone line; 5) Data Signal: Information transfer.</td>
</tr>
<tr>
<td>1) Sending data signal over the optical fibers.</td>
<td></td>
</tr>
<tr>
<td>2) Sending data signal over the cable television infrastructure*.</td>
<td></td>
</tr>
<tr>
<td>3) Sending data signal over the DSL phone line.</td>
<td></td>
</tr>
<tr>
<td>4. What is an ISP Company?</td>
<td>• Relevant knowledge involved: 1) ISP company.</td>
</tr>
<tr>
<td>1) Hardware repair/support company.</td>
<td></td>
</tr>
<tr>
<td>2) Software company.</td>
<td></td>
</tr>
<tr>
<td>3) Internet service company*.</td>
<td></td>
</tr>
<tr>
<td>5. What does an IP address mean?</td>
<td>• Relevant knowledge involved: 1) IP address; 2) domain name.</td>
</tr>
<tr>
<td>1) A unique computer address*.</td>
<td></td>
</tr>
<tr>
<td>2) A hardware or physical address.</td>
<td></td>
</tr>
<tr>
<td>3) A domain name.</td>
<td></td>
</tr>
<tr>
<td>6. Sarah finds that she cannot connect to the internet. When she types in IPCONFIG on the command prompt screen, she finds that she does not have an IP address assigned. What problem does she have? 1) She may have a problem with the router. 2) She may have a problem with the network card*. 3) She may have a problem with the cable modem.</td>
<td>• Relevant knowledge involved: 1) IPCONFIG; 2) Command prompt screen; 3) IP address; 4) router; 5) Network card; 6) Cable modem. • Decision involved: When you use IPCONFIG on the command prompt screen, what does that mean to you? • Procedure involved: 1) How to use IPCONFIG to find out the IP Address? 2) The complete procedure of troubleshooting disconnected internet connection.</td>
</tr>
</tbody>
</table>
| 7. Mary finds that she cannot connect to the internet, but she has all cords plugged in correctly, what should she do next and why? 1) Type in IPCONFIG on the command prompt screen to make sure she has an IP address*. 2) Type in PING on the command prompt screen to make sure she has a reply from the router. 3) Type in IPCONFIG on the command prompt screen to make sure she has an IP address. | • Relevant knowledge involved: 1) IPCONFIG; 2) Command prompt screen; 3) IP address; 4) Router; 5) Cable modem. • Decision involved: When you find out all cords plugged in correctly, but you cannot connect to the internet, what is your fist step to
screen to make sure she has a reply from the modem.

8. David finds that he cannot connect to the internet, he is sure that he has a working router, so he types in PING 169.168.1.1 (Default Gateway IP Address) on the command prompt screen and he does not get any reply. What problem do you think he has?
1) He may have a problem with the cable modem.
2) He may have a problem with the router*.
3) He may have a problem with the DNS server.

9. Dan finds that he cannot connect to the internet, he is sure that his network card, router and cable modem have no problem. However, when he types in PING 199.188.164.8 (external site) on the command prompt screen, he still cannot get any reply, so what should he do next and why?
1) Double check the cords to see if they are plugged in correctly.
2) Connect his ISP Company directly, because its DNS server may be down.
3) Restart the modem, router and computer. If it does not work, contact his ISP company. His ISP’s network may be down*.

10. Jean finds that she cannot connect to the internet, she is sure that her network card, router and cable modem are working fine, but when she type in PING www.home.com on the command prompt screen, she is not able to get a response. What problem does she have now?
1) Connect her ISP Company directly, because its DNS server may be down*.
2) Restart the modem, router and computer. If it
does work, contact her ISP company. Her ISP’s network may be down.
3) She may have a bad router.

any reply, what does that mean to you?
• Procedure involved: 1) How to use Ping to check the external site with name? 2) The complete procedure of troubleshooting disconnected internet connection.
APPENDIX D

PILOT STUDY – INVITATION LETTER
Dear XXX,

Good day!! I am inviting you to join an online experiment. The purpose of this experiment is to examine the effectiveness of different worked examples. The content of this experiment is about IP addresses and the conversion between binary form and decimal form. After this experiment, you will know more about IP addresses. The maximum time needed for this experiment is about half an hour. If you are willing to attend this experiment, please click on the hyperlink below, or cut and paste the entire URL into your browser. Please use the 6-digit digital key assigned to access the experiment.

http://www.elinghsiao.net/online/de178_r9.asp

Your 6-digit digital key: JSQT0O

We would appreciate a response by March 1, 2008.

Your input is very important for instructors to construct better instructions for students. All your records will be kept confidential (The data collected is only used for this study and raw data will be deleted after the dissertation is completed)

If you have any questions, do not hesitate to contact me at 408-386-1887 or email me at eh247904@ohio.edu or Dr. David Richard Moore at moored3@ohio.edu

Sincerely,

E-Ling Hsiao
Ph.D student, Instructional Technology
Department of Educational Studies
College of Education
eh247904@ohio.edu
http://www.elinghsiao.net
APPENDIX E

PILOT STUDY - CONSENT FORM
Title of Research: The Effectiveness of Worked Examples Associated with Presentation Format and Prior Knowledge Principal Investigator: E-Ling Hsiao
Department: Educational Studies (Instructional Technology Program)
Before agreeing to participate in this research study, it is important that you read the following explanation of this study. This following statement describes the purpose, procedures, risks and discomforts, benefits, confidentiality and compensation of this study.

• **Purpose of this study**
The purpose of this study is to examine the effectiveness of different worked example formats, including text only, diagram only and text plus diagram.

• **Explanation of procedures**
1. Background information: The first session of this study is 4 background information questions, including your major, gender, class year and age.
2. Pretest: After providing the background information, you are asked to complete a 10-question pretest. The pretest is used to understand your baseline knowledge about IP addresses.
3. Instruction: After the pretest, there will be two instructional sessions about IP addresses showing up. You have 10 minutes to review these two sessions. In these sessions, you can hit the “Back” button to review the information back and forth until you understand the content of instruction.
4. Post-test: At the end, please complete the 10-question post-test within 8 minutes.

• **Risks and Discomforts**
There aren't any risks or discomforts associated with this experiment.

• **Benefits**
1. By participating in this experiment you will know more about IP address.
2. By participating in this experiment you will know how to convert IP address between binary form and decimal form.
3. After the dissertation is completed, you can have one digital copy of brief research report and the best instructional version of worked example we find in this study.
4. The results of this study can contribute to educators' understanding of instructional design. Students can benefit from better instructional designs.

• **Confidentiality and Records**
In this experiment, the system will record the following information: 1. submitted time; 2. login IP; 3. background information you provided; 4. time you spent on each sessions; 5. scores on pretest and post-test; 6. scores on mental load scales. 7. the comments you provided; 8. the e-mail account you provided. All information you provided will be kept confidential. Only the principal researcher in this study can accept the raw data. The raw data will be deleted after the dissertation is completed. This dissertation will be completed by September 2008.

• **Compensation**
There will be no compensation for this study.
• Contact Information If you have any questions regarding this study, please contact E-Ling Hsiao at eh247904@ohio.edu or Dr. David Richard Moore at moored3@ohio.edu. If you have any questions regarding your rights as a research participant, please contact Jo Ellen Sherow, Director of Research Compliance, Ohio University, (740) 593-0664.

• I certify that I have read and understand this consent form and agree to participate as a subject in the research described. I agree that known risks to me have been explained to my satisfaction and I understand that no compensation is available from Ohio University and its employees for any injury resulting from my participation in this research.
• I certify that I am 18 years of age or older. My participation in this research is given voluntarily. I understand that I may discontinue participation at any time without penalty or loss of any benefits to which I may otherwise be entitled.

After reading the above explanation, please type in your initials and 6-digits digital key assigned to you and your oak e-mail to indicate your consent and press the "Yes, I consent" button. The system will lead you to the experiment. If you check "No, I do not wish to participate," it means you do not wish to participate in this study, the system will stop automatically. Cartwright, H. M. (1998) Long-distance experiments: The use and control of scientific equipment through the Internet, in New Network-based Media in Education, University of Maribor, Slovenia, 102-106.
APPENDIX F

PILOT STUDY – PERFORMANCE TEST
Performance Test - Text Information

Background Information
- What is your gender?
  □ Male □ Female
- Your class year
  □ Freshman □ Sophomore □ Junior □ Senior □ Graduate
- Your Age

Pre-test:
1. Present "22" in binary format
   A.00010110 B.00010111 C.00010010
2. Present "17" in binary format
   A.00010001 B.00010011 C.00010000
3. Present "129" in binary format
   A.10000011 B.10000001 C.10000010
4. Present "01010000" in decimal format
   A.74 B.76 C.80
5. Present "00001100" in decimal format
   A.12 B.14 C.16
6. Present "88" in binary format
   A.01011100 B.01011000 C.01011101
7. Present "00101000" in decimal format
   A.32 B.36 C.40
8. Present "01010110" in decimal format
   A.84 B.86 C.88
9. Present "00001010" in binary format
   A.8 B.9 C.10
10. Present "31" in binary format
    A.00011110 B.00011111 C.00011101

Posttest
1. Present "00001010" in decimal format
   A.9 B.10 C.11
2. Present "01010110" in decimal format
   A.84 B.86 C.88
3. Present "00101000" in decimal format
   A.32 B.36 C.40
4. Present "88" in binary format
   A.01011100 B.01011001 C.01011100
5. Present "00001100" in decimal format
   A.8 B.10 C.12
6. Present "31" in binary format
   A.00011110 B.00011111 C.00011101
7. Present "22" in binary format
8. Present "17" in binary format
   A. 00010001 B. 00010011 C. 00010000

9. Present "129" in binary format
   A. 10000011 B. 10000001 C. 10000010

10. Present "01010000" in decimal format
    A. 80 B. 86 C. 90

Performance Test - Screen Shot
APPENDIX G

PILOT STUDY – INSTRUCTIONS
What is IP address?

Every machine on the Internet has a unique identifying number, called an IP address. To make it easier for us to remember, IP addresses are normally expressed in decimal format and separated by periods, like "216.27.61.137." These four numbers in an IP address are called octets. The octets can be split into two sections: Net ID and Host ID. The Net ID always contains the first octet. It is used to identify the network that a computer belongs to. Host ID identifies the actual computer on the network. The Host ID always contains the last octet.

Because computers communicate in binary form, each octet has eight positions in binary form, like "11011000.00011011.00111101.10001001." By adding all the positions together, IP addresses have 32-bit numbers in total. Each of the eight positions can have two different states (1 or 0), so the total number of possible combinations per octet can be up to 256.

How to convert IP address from decimal format to binary format?

Take "45" as an example: 45 -->00101101

How to convert IP address from binary format to decimal format?

Take "00101101" as an example: 00101101-->45
1. What is IP address?

Every machine on the Internet has a unique identifying number, called an IP address. To make it easier for us to remember, IP addresses are normally expressed in decimal format and separated by periods, like "216.27.61.137." These four numbers in an IP address are called octets. The octets can be split into two sections: Net ID and Host ID. The Net ID always contains the first octet. It is used to identify the network that a computer belongs to. Host ID identifies the actual computer on the network. The Host ID always contains the last octet. Because computers communicate in binary form, each octet has eight positions in binary form, like "11011000.00011011.00111101.10001001." By adding all the positions together, IP addresses have 32-bit numbers in total. Each of the eight positions can have two different states (1 or 0), so the total number of possible combinations per octet can be up to 256.

2. How to convert IP address from decimal format to binary format? Take "45" as an example:

**Step 1:**
Subtract the largest possible power of two.
In this case, the closet number is 5th power of two (32). Keep subtracting the next largest possible power from 13. The next possible power of two are 3rd powers of two (8), 2nd powers of two (4), 0th power of two (1).

**Step 2:**
As we mentioned, each octet in IP Address has eight positions. We can set 7th powers of two to 0th power of two in an order from left to right. Mark the position of the number subtracted in this case as "1" and put the rest of positions as "0." The answer is "00101101."

3. How to convert IP address from binary format to decimal format? Take "00101101" as an example:
Step 1:
We can set 7th powers of two to 0th power of two in an order from left to right. Pay attention to the positions of "1." In this case, "1"s are located in 5th, 3rd, 2nd, 0th.
Step 2:
Calculate the decimal value of each location. 5th power of two is equal to 32. 3rd power of two is equal to 8, 2nd power of two is equal to 4, 0th power of two is equal to 1. Add these values up. The answer is "45."
1. What is IP address?

Every machine on the Internet has a unique identifying number, called an IP address. To make it easier for us to remember, IP addresses are normally expressed in decimal format and separated by periods, like "216.27.61.137." These four numbers in an IP address are called octets. The octets can be split into two sections: Net ID and Host ID. The Net ID always contains the first octet. It is used to identify the network that a computer belongs to. Host ID identifies the actual computer on the network. The Host ID always contains the last octet.

Because computers communicate in binary form, each octet has eight positions in binary form, like "11011000.00011011.00111101.10001001." By adding all the positions together, IP addresses have 32-bit numbers in total. Each of the eight positions can have two different states (1 or 0), so the total number of possible combinations per octet can be up to 256.

2. How to convert IP address from decimal format to binary format? Take "45" as an example:

```
Step 1:

    45
   - 32
    - 13
     - 8
      - 5
       - 4
        - 1
```

3. How to convert IP address from binary format to decimal format? Take "00101101" as an example:

```
<table>
<thead>
<tr>
<th>2</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>Binary Evaluate</th>
</tr>
</thead>
<tbody>
<tr>
<td>128</td>
<td>64</td>
<td>32</td>
<td>16</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>Decimal Value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Decimal Number</td>
</tr>
</tbody>
</table>
```
Step 1:

<table>
<thead>
<tr>
<th>128</th>
<th>64</th>
<th>32</th>
<th>16</th>
<th>8</th>
<th>4</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Decimal Value

Decimal Number

Step 2:

32
+ 8
---
40
+ 4
---
44
+ 1
---
45
1. **What is IP address?**

   Every machine on the Internet has a unique identifying number, called an IP address. To make it easier for us to remember, IP addresses are normally expressed in decimal format and separated by periods, like "216.27.61.137." These four numbers in an IP address are called octets. The octets can be split into two sections: Net ID and Host ID. The Net ID always contains the first octet. It is used to identify the network that a computer belongs to. Host ID identifies the actual computer on the network. The Host ID always contains the last octet. Because computers communicate in binary form, each octet has eight positions in binary form, like "11011000.00011011.00111101.10001001." By adding all the positions together, IP addresses have 32-bit numbers in total. Each of the eight positions can have two different states (1 or 0), so the total number of possible combinations per octet can be up to 256.

2. **How to convert IP address from decimal format to binary format?** Take "45" as an example:

   **Step 1:**

   We can first subtract the largest possible power of two, and keep subtracting the next largest possible power from the remainder.
3. How to convert IP address from binary format to decimal format? Take "00101101" as an example:

### Step 1:

<table>
<thead>
<tr>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
<th>Binary</th>
<th>Evaluate</th>
<th>Decimal Value</th>
<th>Decimal Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>128</td>
<td>64</td>
<td>32</td>
<td>16</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mark 1s in each column where this is possible and 0s where it is not. The final answer we get is "00101101."

### Step 2:

Fill 1's and 0's in "00101101" into this chart and mark the decimal values they present.
Step 2:

\[32 + 8 = 40\]

\[4 + 1 = 5\]

Add the decimal values marked together. The final answer is "45".
APPENDIX H

PILOT STUDY - RATING OF THE DIFFICULTY OF THE MATERIALS
Rating of the Difficulty of the Materials - Text Information

Rating of the Difficulty of the Materials on each question page:

• This question is ____ for me.

1-9 points from extremely easy to extremely difficult.

Rating of the Difficulty of the Materials - Screen Shot
APPENDIX I

FORMAL STUDY - INVITATION LETTER
Dear XXX,
Good day!! I am inviting you to join an online experiment. The purpose of this experiment is to examine the effectiveness of different worked examples. The content of this experiment is about IP addresses and the conversion between binary form and decimal form. After this experiment, you will know more about IP addresses. The maximum time needed for this experiment is about half an hour. If you are willing to attend this experiment, please click on the hyperlink below, or cut and paste the entire URL into your browser. Please use the 6-digit digital key assigned to access the experiment.
http://www.elinghsiao.net/online/de178_r9.asp

Your 6-digit digital key: JSQT0O
We would appreciate a response by March 1, 2008. Your input is very important for instructors to construct better instructions for students. All your records will be kept confidential (The data collected is only used for this study and raw data will be deleted after the dissertation is completed)

If you have any questions, do not hesitate to contact me at 408-386-1887 or email me at eh247904@ohio.edu or Dr. David Richard Moore at moored3@ohio.edu

Sincerely,
E-Ling Hsiao
Ph.D student, Instructional Technology
Department of Educational Studies
College of Education
eh247904@ohio.edu
http://www.elinghsiao.net
APPENDIX J

FORMAL STUDY - CONSENT FORM
Before agreeing to participate in this research study, it is important that you read the following explanation of this study. This following statement describes the purpose, procedures, risks and discomforts, benefits, confidentiality and compensation of this study.

- **Purpose of this study**
  The purpose of this study is to examine the effectiveness of different worked example formats, including text only, diagram only and text plus diagram.

- **Explanation of procedures**
  1. Background information: The first session of this study is 4 background information questions, including your major, gender, class year and age.
  2. Pretest: After providing the background information, you are asked to complete a 10-question pretest. The pretest is used to understand your baseline knowledge about IP addresses.
  3. Instruction: After the pretest, there will be two instructional sessions about IP addresses showing up. You have 10 minutes to review these two sessions. In these sessions, you can hit the “Back” button to review the information back and forth until you understand the content of instruction.
  4. Post-test: At the end, please complete the 10-question post-test within 8 minutes.

- **Risks and Discomforts**
  There aren't any risks or discomforts associated with this experiment.

- **Benefits**
  1. By participating in this experiment you will know more about IP address.
  2. By participating in this experiment you will know how to convert IP address between binary form and decimal from.
  3. After the dissertation is completed, you can have one digital copy of brief research report and the best instructional version of worked example we find in this study.
  4. The results of this study can contribute to educators' understanding of instructional design. Students can benefit from better instructional designs.

- **Confidentiality and Records**
  In this experiment, the system will record the following information: 1. submitted time; 2. login IP; 3. background information you provided; 4. time you spent on each sessions; 5. scores on pretest and post-test; 6. scores on mental load scales; 7. the comments you provided; 8. the e-mail account you provided. All information you provided will be kept confidential. Only the principal researcher in this study can accept the raw data. The raw data will be deleted after the dissertation is completed. This dissertation will be completed by September 2008.

- **Compensation**
  There will be no compensation for this study.
• Contact Information If you have any questions regarding this study, please contact E-Ling Hsiao at eh247904@ohio.edu or Dr. David Richard Moore at moored3@ohio.edu. If you have any questions regarding your rights as a research participant, please contact Jo Ellen Sherow, Director of Research Compliance, Ohio University, (740) 593-0664.

• I certify that I have read and understand this consent form and agree to participate as a subject in the research described. I agree that known risks to me have been explained to my satisfaction and I understand that no compensation is available from Ohio University and its employees for any injury resulting from my participation in this research.
• I certify that I am 18 years of age or older. My participation in this research is given voluntarily. I understand that I may discontinue participation at any time without penalty or loss of any benefits to which I may otherwise be entitled.

After reading the above explanation, please type in your initials and 6-digits digital key assigned to you and your oak e-mail to indicate your consent and press the "Yes, I consent" button. The system will lead you to the experiment. If you check "No, I do not wish to participate," it means you do not wish to participate in this study, the system will stop automatically. Cartwright, H. M. (1998) Long-distance experiments: The use and control of scientific equipment through the Internet, in New Network-based Media in Education, University of Maribor, Slovenia, 102-106.

Content Form - Screen Shot
APPENDIX K

FORMAL STUDY - PERFORMANCE TEST
### Performance Test – Text Information

#### Background Information
1. What is your gender?
   - [ ] Male  [ ] Female

2. Your class year
   - [ ] Freshman  [ ] Sophomore  [ ] Junior  [ ] Senior  [ ] Graduate

3. Your Age

4. Your Major

#### Question Items

<table>
<thead>
<tr>
<th>Question</th>
<th>Pretest Order</th>
<th>Posttest Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is a Network Card?</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2. Router is used for__________</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>3. Cable modem is used for__________</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4. What is an ISP Company?</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>5. What does an IP address mean?</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

- **Relevant knowledge involved**: 1) network card.
- **Relevant knowledge involved**: 1) router; 2) local network; 3) ISP's network.
- **Relevant knowledge involved**: 1) cable modem; 2) optical fibers; 3) cable television infrastructure; 4) DSL phone line; 5) Data Signal: Information transfer.
- **Relevant knowledge involved**: 1) ISP company.
- **Relevant knowledge involved**: 1) IP address; 2) domain name.
Difficult questions

6. Sarah finds that she cannot connect to the internet. When she types in IPCONFIG on the command prompt screen, she finds that she does not have an IP address assigned. What problem does she have? (Answer: 2)

1) She may have a problem with the router.
2) She may have a problem with the network card. *
3) She may have a problem with the cable modem.

· Relevant knowledge involved: 1) IPCONFIG; 2) Command prompt screen; 3) IP address; 4) router; 5) Network card; 6) Cable modem.
· Decision involved: When you use IPCONFIG on the command prompt screen, what does that mean to you?
· Procedure involved: 1) How to use IPCONFIG to find out the IP Address? 2) The complete procedure of troubleshooting disconnected internet connection.

7. Mary finds that she cannot connect to the internet, but she has all cords plugged in correctly, what she should do next and why?

1) Type in IPCONFIG on the command prompt screen to make sure she has an IP address. *
2) Type in PING on the command prompt screen to make sure she has a reply from the router.
3) Type in IPCONFIG on the command prompt screen to make sure she has a reply from the modem.

· Relevant knowledge involved: 1) IPCONFIG; 2) Command prompt screen; 3) IP address; 4) Router; 5) Cable modem.
· Decision involved: When you find out all cords plugged in correctly, but you cannot connect to the internet, what is your fist step to check the problem?
· Procedure involved: 1) How do the cords connected together? 2) How to use IPCONFIG to check your own IP Address? 3) The complete procedure of troubleshooting disconnected internet connection.

8. David finds that he cannot connect to the internet, he is sure that he has a working router, so he types in PING 169.168.1.1 (Default Gateway IP Address) on the command prompt screen and he does not get any reply. What problem do you think he has?

1) He may have a problem with the cable modem.
2) He may have a problem with the router. *
3) He may have a problem with the DNS server.

· Relevant knowledge involved: 1) PING; 2) Command prompt screen; 3) Default Gateway IP Address; 4) Router; 5) Cable modem; 6) DNS server.
· Decision involved: When you use PING on the command prompt
9. Dan finds that he cannot connect to the internet, he is sure that his network card, router and cable modem have no problem. However, when he types in PING 199.188.164.8 (external site) on the command prompt screen, he still cannot get any reply, so what should he do next and why?

1) Double check the cords to see if they are plugged in correctly.
2) Connect his ISP Company directly, because its DNS server may be down.
3) Restart the modem, router and computer. If it does not work, contact his ISP company. His ISP’s network may be down.

- Relevant knowledge involved: 1) PING; 2) Command prompt screen; 3) Network card; 4) Router; 5) Cable modem; 6) DNS server; 7) ISP company.
- Decision involved: When you use PING on the command prompt screen to find out an external site and cannot get any reply, what does that mean to you?
- Procedure involved: 1) How to use Ping to check the external site? 2) The complete procedure of troubleshooting disconnected internet connection.

10. Jean finds that she cannot connect to the internet, she is sure that her network card, router and cable modem are working fine, but when she type in PING www.home.com on the command prompt screen, she is not able to get a response. What problem does she have now?

1) Connect her ISP Company directly, because its DNS server may be down.
2) Restart the modem, router and computer. If it does work, contact her ISP company. Her ISP’s network may be down.
3) She may have a bad router.

- Relevant knowledge involved: 1) PING; 2) Command prompt screen; 3) Network card; 4) Router; 5) Cable modem; 6) DNS server; 7) ISP company.
- Decision involved: When you use PING on the command prompt screen to find out an external site (Alternative Name) and cannot get any reply, what does that mean to you?
- Procedure involved: 1) How to use Ping to check the external site with name? 2) The complete procedure of troubleshooting disconnected internet connection.
1. What is a Network Card?

- A piece of hardware for the network communications.
- A piece of hardware for audio signals.
- A piece of hardware for media storage.

This question is _______ for me.

[Scale from 1 to 9]

Time left available: 3 minutes.

*Please be patient to complete the pretest. Thanks!*
APPENDIX L

FORMAL STUDY - RATING OF THE DIFFICULTY OF THE MATERIALS
Rating of the Difficulty of the Materials - Text Information

Rating of the Difficulty of the Materials on each question page:

- This question is ____ for me.

1-9 points from extremely easy to extremely difficult.

Rating of the Difficulty of the Materials - Screen Shot
APPENDIX M

FORMAL STUDY – INSTRUCTIONS
A successful internet connection is usually composed of the following components:

1. **Network Card**: A network card is a piece of hardware designed to allow computers to communicate over a network. Network card has one Ethernet port used to connect to a router.

2. **Router**: Router is a device used to connect at least two networks, like your local network and ISP’s network. A 5-Port router has five ports: One is used to connect the cable modem; the other ports are used to connect computers.

3. **Cable modem**: A cable modem is a device that provides access to a data signal sent over the cable television infrastructure. Cable modem has one Ethernet port used to connect to a router and one cable hole used to connect the ISP’s network.

4. **ISP server**: An Internet service provider (ISP) is a business or organization that provides consumers or businesses access to the Internet and related services.

A successful internet connection allows you to connect to the world of information. However, if you find that you cannot connect to the internet, you can follow the following procedure to solve the problem easily:

1. **Check cords**: Check all the related cords to see if they are plugged properly. For example, make sure the Ethernet able are plugged in the network card’s Ethernet port.

2. **Run command prompt screen**: Command prompt screen is the command line interpreter on windows operating systems. You can use it to find the IP address. Please hit “Start” button → select “run” option → type in “cmd” in the dialog box.

3. **Check network card**: Please check the network card signal and type in `IPCONFIG` on the command prompt screen to see if the network card is OK. `IPCONFIG` is a command on the command prompt screen used to display the IP address information. An IP address (Internet Protocol address) is a unique computer address used to identify and communicate with other computers in the network.
   - **Correct Situation**: You should have IP address like 192.168.1.100 in the following message.
     
     **Message**:
     
     IP Address.................: 192.168.1.100
     Subnet Mask...............: 255.255.255.0
     Default Gateway.........: 192.168.1.1
     DNS Servers..............: 63.150.73.182
   
   - **Problematic Situation**: If you don't have something like 192.168.x.x, it means you are not getting IP address assigned and needs to be resolved first. You can:
     1) Check if you have correct setting on IP address.
     2) If you make sure you have correct setting on IP address, you are still not able to have an IP address on the command prompt screen, which means you may have a bad network card. Please replace the network card.

4. **Check router**: Type `PING 192.168.1.1` (Default Gateway IP address) on the command prompt screen to detect if the router is OK. PING is a command on the
command prompt screen used to display the IP address information. Gateway is a
node on a network that serves as an entrance to another network. In homes, the
gateway is the ISP that connects the user to the internet.

► Correct Situation: If you get a reply like the following message, then your
connection to the router is working.

Message:
Pinging 192.168.1.1 with 32 bytes of data:
Reply from 192.168.1.1: bytes= 32 time <1ms TTL=255
Reply from 192.168.1.1: bytes= 32 time <1ms TTL=255
Reply from 192.168.1.1: bytes= 32 time <1ms TTL=255
Reply from 192.168.1.1: bytes= 32 time <1ms TTL=255

► Problematic Situation: If you don't get a reply, then you have problem with the
router.

► You can:
   1) Double check your network card, cable, port on the router.
   2) You might also see if any other computers on the network have the same
      problem.
   3) If other computers have the same problem, you may have a bad router.

6. Check cable modem: Type PING 199.188.164.8 (external site) on the command
prompt screen to check if the cable modem is OK. PING is a command on the
command prompt screen used to display the IP address information.

► Correct Situation: If you get a reply like the following message, then you have
a connection to the internet.

Message:
Pinging 199.188.164.8 with 32 bytes of data:
Reply from 199.188.164.8: bytes= 32 time <1ms TTL=63
Reply from 199.188.164.8: bytes= 32 time <1ms TTL=63
Reply from 199.188.164.8: bytes= 32 time <1ms TTL=63
Reply from 199.188.164.8: bytes= 32 time <1ms TTL=63

► Problematic Situation: If you don’t get a reply, you may have a problem with the
cable modem.

► You can:
   1) Turn the power off your cable modem and router. Plug the modem back in a
      wait a minute or so. Plug the router back in and wait a minute or so. Then restart
      your computer.
   2) If the above solution cannot solve your problem, then you can contact the
      ISP Company.

7. Check DNS server: Type PING www.yahoo.com (external site by Name) on
the command prompt screen to check if the DNS server is OK. DNS serves as the "phone
book" for the Internet by translating human-readable computer hostnames, e.g.
www.yahoo.com, into the IP addresses, e.g. 23.23.23.23.

► Correct Situation: If you get a reply like the following message, then you have
a connection to the internet.

Message:
Pinging www.yahoo.com [23.23.23.23] with 32 bytes of data:
Problematic Situation: If you don’t get a reply, you may have a problem with the DNS server.

You can:

1) Check if you have a DNS server IP address on the command prompt screen.
2) Contact your ISP Company and let them know their DNS server has problems.

Text-Plus-Graphic General Statement Version

A successful internet connection is usually composed of the following components:

1. Network Card: A network card is a piece of hardware designed to allow computers to communicate over a network. Network card has one Ethernet port used to connect to a router.

2. Router: Router is a device used to connect at least two networks, like your local network and ISP’s network. A 5-Port router has five ports: One is used to connect the cable modem; the other ports are used to connect computers.

3. Cable modem: A cable modem is a device that provides access to a data signal sent over the cable television infrastructure. Cable modem has one Ethernet port used to connect to a router and one cable hole used to connect the ISP’s network.

4. ISP server: An Internet service provider (ISP) is a business or organization that provides consumers or businesses access to the Internet and related services.

A successful internet connection allows you to connect to the world of information. However, if you find that you cannot connect to the internet, you can follow the following procedure to solve the problem easily:
Troubleshooting procedure for internet connection
(use mouse to move over the buttons)

Check all the related cords to see if they are plugged properly.

Time left available: 9 minutes

- Please be patient to read through the instruction. Thanks!!
- Troubleshooting procedure for internet connection (use mouse to move over the buttons)

Step 1: Check cords
Step 2: Run command prompt screen
Step 3: Check network card
Step 4: Check router
Step 5: Check cable modem
Step 6: Check DNS server

Please check the network card signal and type in `IPCONFIG` on the command prompt screen to see if the network card is OK. `IPCONFIG` is a command on the command prompt screen used to display the IP address information. An **IP address** (Internet Protocol address) is a unique computer address used to identify and communicate with other computers on the network.

- Correct Situation: You may have an IP address in the following message.

  IP Address: 192.168.1.100
  Subnet Mask: 255.255.255.0
  Default Gateway: 192.168.1.1
  DNS Servers: 63.150.73.182

- Problematic Situation: If you don’t have something like the above message, it means you are not getting an IP address assigned and needs to be resolved first. You can:
  1. Check if you have a correct setting on IP address.
  2. If you make sure you have correct setting on IP address, you are still not able to have an IP address on the command prompt screen, which means you may have a problem with the network card.

Time left available: 8 minutes

- Please be patient to read through the instruction. Thanks!!

---

- Troubleshooting procedure for internet connection (use mouse to move over the buttons)

Step 1: Check cords
Step 2: Run command prompt screen
Step 3: Check network card
Step 4: Check router
Step 5: Check cable modem
Step 6: Check DNS server

Type `PING 192.168.1.1` (Default Gateway IP address) on the command prompt screen to detect if the router is OK. PING is a command on the command prompt screen used to display the IP address information. **Gateway** is a node on a network that serves as an entrance to another network. In homes, the gateway is the ISP server that connects the user to the internet.

- Correct Situation: If you get a reply like the following message, then your connection to the router is working.

  Pinging 192.168.1.1 with 32 bytes of data:
  Reply from 192.168.1.1: bytes=32 time=1ms TTL=255

- Problematic Situation: If you don’t get a reply, then you have a problem with the router. You can:
  1. Double check your network card, cords, ports on the router.
  2. You might also see if any other computers on the network have the same problem. If other computers have the same problem, you may have a problem with the router. You can reset the router’s setting. If it doesn’t work, you may have a bad router.

Time left available: 8 minutes

- Please be patient to read through the instruction. Thanks!!
Troubleshooting procedure for internet connection (use mouse to move over the buttons)

Type PING 192.168.164.8 (external site) on the command prompt screen to check if the cable modem is OK. PING is a command on the command prompt screen used to display the IP address information.

Correct Situation: If you get a reply like the following message, then you have a connection to the internet.
PING 192.168.164.8 with 32 bytes of data:
Reply from 192.168.164.8: bytes=32 time<1ms TTL=63

Problematic Situation: If you don’t get a reply, you may have a problem with the cable modem.

You can:
1) Turn the power off your cable modem and router. Plug the modem back in and wait a minute or so. Plug the router back in and wait a minute or so. Then restart your computer.
2) If the above solution cannot solve your problem, then you can contact the ISP Company.

---

Troubleshooting procedure for Internet connection (external site by Name) on the command prompt screen to check if the DNS server is OK. DNS serves as the "phone book" for the Internet by translating human-readable computer hostnames, e.g. www.yahoo.com, into the IP addresses, e.g. 23.23.23.23.

Correct Situation: If you get a reply like the following message, then you have a connection to the internet.
PING www.yahoo.com [23.23.23.23] with 32 bytes of data:
Reply from 23.23.23.23: bytes=32 time<1ms TTL=49

Problematic Situation: If you don’t get a reply, you may have a problem with the DNS server.

You can:
1) Check if you have a DNS server IP address on the command prompt screen.
2) Contact your ISP Company and let them know their DNS server has problems.

---

Time left available: 8 minutes

Please be patient to read through the instruction. Thanks!!
A successful internet connection is usually composed of the following components:

1. **Network Card**: A network card is a piece of hardware designed to allow computers to communicate over a network. Network card has one Ethernet port used to connect to a router.

2. **Router**: Router is a device used to connect at least two networks, like your local network and ISP’s network. A 5-Port router has five ports: One is used to connect the cable modem; the other ports are used to connect computers.

3. **Cable modem**: A cable modem is a device that provides access to a data signal sent over the cable television infrastructure. Cable modem has one Ethernet port used to connect to a router and one cable hole used to connect the ISP’s network.

4. **ISP server**: An Internet service provider (ISP) is a business or organization that provides consumers or businesses access to the Internet and related services.

John uses the internet to connect to the outside world. Someday he finds he is not able to connect to a site. He is upset, unfortunately he cannot get any help because it is midnight, ISP helpdesk is closed. He attempts to solve the problem by himself. He finds the following problem-solving procedure is helpful.

1. John checks all the related cords to see if they are plugged properly. He finds they are OK. For example, the Ethernet able are plugged in the network card’s Ethernet port correctly.

2. He decides to run command prompt to detect the possible disconnected factors. He presses the “Start” button and selects “run” option. When a window jumps out, he types in “cmd” in the dialog box. Command prompt screen is the command line interpreter on windows operating systems.

3. After he checks the network card signal, he types in `IPCONFIG` on the command prompt screen to check if the network card is OK. IPCONFIG is a command on the command prompt screen used to display the IP address information. He gets an IP address 192.168.1.100 in the following message. An IP address (Internet Protocol address) is a unique computer address used to identify and communicate with other computers in the network. This message means his network card has no problem and has an IP address assigned.

   **Message:**

   IP Address.............: 192.168.1.100
   Subnet Mask...........: 255.255.255.0
   Default Gateway.......: 192.168.1.1
   DNS Servers...........: 63.150.73.182

4. Then he continues to type in **PING 192.168.1.1 (Default Gateway IP address)** on the command prompt screen to check if the router is OK. PING is a command on the command prompt screen used to display the IP address information. Gateway is a node on a network that serves as an entrance to another network. In homes, the gateway is the ISP that connects the user to the internet. He gets a reply like the following message. This message means his router is working and
he does not need to double check his network card, cable, ports on the router or other computers.

Message:
Pinging 192.168.1.1 with 32 bytes of data:
Reply from 192.168.1.1: bytes= 32 time <1ms TTL=255
Reply from 192.168.1.1: bytes= 32 time <1ms TTL=255
Reply from 192.168.1.1: bytes= 32 time <1ms TTL=255
Reply from 192.168.1.1: bytes= 32 time <1ms TTL=255

5. Since his router has no problem at all, he is wondering that if his cable modem goes wrong or not. So he types **ping 199.188.164.8 (external site)** on the command prompt screen to check if the cable modem is OK. He gets a reply like the following message. This message means he has a good modem connected to the internet. He does not believe he needs to restart the modem, router and computer.

Message:
Pinging 199.188.164.8 with 32 bytes of data:
Reply from 199.188.164.8: bytes= 32 time <1ms TTL=63
Reply from 199.188.164.8: bytes= 32 time <1ms TTL=63
Reply from 199.188.164.8: bytes= 32 time <1ms TTL=63
Reply from 199.188.164.8: bytes= 32 time <1ms TTL=63

6. John is puzzled, because he has a good internet connection, but he does not understand why he cannot connect to yahoo when he type in its URL. He has another idea. He types **PING www.yahoo.com (external site by Name)** on the command prompt screen to check if the DNS server is OK. This time, he does not get a reply like the following message, so John knows he may have a problem with the DNS server. Therefore, he waits until next day and contacts his ISP Company to let them know their DNS server has problems. The ISP Company fixed the DNS server problem and John is able to surf the internet happily.

Message:
Pinging www.yahoo.com [23.23.23.23] with 32 bytes of data:
Reply from 23.23.23.23: bytes= 32 time <1ms TTL=49
Reply from 23.23.23.23: bytes= 32 time <1ms TTL=49
Reply from 23.23.23.23: bytes= 32 time <1ms TTL=49
Reply from 23.23.23.23: bytes= 32 time <1ms TTL=49
Reply from 23.23.23.23: bytes= 32 time <1ms TTL=49

..........................................................
A successful internet connection is usually composed of the following components:

1. Network Card: A network card is a piece of hardware designed to allow computers to communicate over a network. Network card has one Ethernet port used to connect to a router.

2. Router: Router is a device used to connect at least two networks, like your local network and ISP’s network. A 5-Port router has five ports: One is used to connect the cable modem; the other ports are used to connect computers.

3. Cable modem: A cable modem is a device that provides access to a data signal sent over the cable television infrastructure. Cable modem has one Ethernet port used to connect to a router and one cable hole used to connect the ISP’s network.

4. ISP server: An Internet service provider (ISP) is a business or organization that provides consumers or businesses access to the Internet and related services.

John uses the internet to connect to the outside world. Someday he finds he is not able to connect to a site. He is upset, unfortunately he cannot get any help because it is midnight, ISP helpdesk is closed. He attempts to solve the problem by himself. He finds the following problem-solving procedure is helpful.

*Problem statement:* John uses the internet to connect to the outside world. Someday he finds he is not able to connect to a site. He is upset, unfortunately he cannot get any help because it is midnight, his ISP help desk is closed. He attempts to solve the problem by himself. He finds the problem-solving procedure on the next screen is helpful.

*Important instruction for the next screen:* Please press "start" button to review the procedure on the next screen. On the next screen, a diagram is presented on the screen. Please use *mouse to move over the rectangle buttons* to review the troubleshooting process. When you get ready to take the posttest after reviewing the instruction, please press "*Ready for the posttest*" buttons.

I cannot connect to Internet!!
What should I do?

Time left available: 10 minutes

*Please be patient to read through the instruction. Thanks!*
John checks all the related cords to see if they are plugged properly. He finds they are OK.

John decides to run command prompt screen to detect the possible disconnected factors. He presses the "Start" button and selects "Run" option.

- Command prompt screen is the command line interpreter on windows operating systems.

- When a dialog box jumps out, he types in "cmd".
Troubleshooting procedure for internet connection
(use mouse to move over the buttons)

- Step 1: Check cords
- Step 6: Check DNS server
- Step 2: Run command prompt screen
- Step 5: Check cable modem
- Step 3: Check network card
- Step 4: Check router

After he checks the network card signal, he types in `IPCONFIG` on the command prompt screen to check if the network card is OK. `IPCONFIG` is a command on the command prompt screen used to display the IP address information. He gets an IP address 192.168.1.100 in the following message. An IP address (Internet Protocol address) is a unique computer address used to identify and communicate with other computers on the network. This message means his network card has no problem and gets an IP address assigned.

<table>
<thead>
<tr>
<th>IP Address</th>
<th>192.168.1.100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subnet Mask</td>
<td>255.255.255.0</td>
</tr>
<tr>
<td>Default Gateway</td>
<td>192.168.1.1</td>
</tr>
<tr>
<td>DNS Servers</td>
<td>53.250.72.182</td>
</tr>
</tbody>
</table>

Why?

Troubleshooting procedure for internet connection
(use mouse to move over the buttons)

- Step 1: Check cords
- Step 6: Check DNS server
- Step 2: Run command prompt screen
- Step 5: Check cable modem
- Step 3: Check network card
- Step 4: Check router

Then he continues to type in `PING 192.168.1.1` (Default Gateway IP address) on the command prompt screen to check if the router is OK. PING is a command on the command prompt screen used to display the IP address information. Gateway is a node on a network that serves as an entrance to another network. In homes, the gateway is the ISP that connects the user to the internet. He gets a reply like the following message. This message means his router is working and he does not need to double check his network card, cords, ports on the router, other computers or reset the router's setting.

```
Pinging 192.168.1.1 with 32 bytes of data:
Reply from 192.168.1.1: bytes=32 time<1ms TTL=255
My router is OK!!
```
Troubleshooting procedure for internet connection
(use mouse to move over the buttons)

Step 1: Check cords
Step 2: Run command prompt screen
Step 3: Check network card
Step 4: Check router
Step 5: Check cable modem
Step 6: Check DNS server

Since his router has no problem at all, he is wondering that if his cable modem goes wrong or not. So he types PING 199.188.164.8 (external site) on the command prompt screen to check if the cable modem is OK. He gets a reply like the following message. This message means he has a good modem connecting to the internet. He does not believe he needs to restart the modem, router and computer.
Pinging 199.188.164.8 with 32 bytes of data:
Reply from 199.188.164.8: bytes=32 time<1ms TTL=63

My modem is OK!!

---

John is puzzled, because he has a good internet connection, but he does not understand why he cannot connect to yahoo when he type in its URL. He has another idea. He types PING www.yahoo.com (external site by Name) on the command prompt screen to check if the DNS server is OK. DNS serves as the "phone book" for the internet by translating human-readable computer hostnames, e.g. www.yahoo.com, into the IP addresses, e.g. 23.23.23.23. This time, he does not get a reply like the following message, so John knows he may have a problem with the DNS server. Therefore, he waits until next day and contacts his ISP Company to let them know their DNS server has problems. The ISP Company fixed the DNS server's problem and John is able to surf the internet happily.
Pinging www.yahoo.com [23.23.23.23] with 32 bytes of data:
Reply from 23.23.23.23:
bytes=32 time<1ms TTL=49

Thank you for your patience.
APPENDIX N

SUMMARY OF THE DEMOGRAPHIC INFORMATION
<table>
<thead>
<tr>
<th>Treatment</th>
<th>General Statement</th>
<th>Worked Example</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Text</td>
<td>Text+Graphics</td>
<td>Text</td>
</tr>
<tr>
<td>Prior Knowledge level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• High</td>
<td>12</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>• Medium</td>
<td>14</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>• Low</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Male</td>
<td>10</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>• Female</td>
<td>25</td>
<td>27</td>
<td>31</td>
</tr>
<tr>
<td>Class Year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Sophomore</td>
<td>18</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>• Junior</td>
<td>13</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>• Senior</td>
<td>4</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>
APPENDIX O

RESPONSES TO THE OPEN-ENDED QUESTION
<table>
<thead>
<tr>
<th>Instruction</th>
<th>Presentation Format</th>
<th>Prior Knowledge</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Statement</td>
<td>Text-only</td>
<td>Low</td>
<td>· I wish that I had a better understanding of this topic, but this is the first time that I have been instructed. I still feel that I need more instruction and would gladly take a course that taught such things.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>· This was very interesting and somewhat fun.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>· Good Job!</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
<td>· Good test. It was helpful learning information like that because it is something a person who uses computer often should know but usually don’t. I had heard of most of the words but never knew what they were or did. It was helpful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>· I did not really like this format. It was hard for me to remember the information I did not already know, so I just guessed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>· I think that if more emphasis is placed on definitions and steps (going over it more than once) I would have been able to remember more! I read through everything quickly and then when taking the test, forgot everything quickly as well!</td>
</tr>
<tr>
<td>Text-plus-graphic</td>
<td>Low</td>
<td></td>
<td>· It made me feel really stupid.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
<td>· This was enlightening. !</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>· I think this survey was very organized. I liked that it asked the reader the questions to see what</td>
</tr>
</tbody>
</table>
they already know, and then gave them the information. After reading the information you gave the same survey to see what they found out and learned.

· Good test, I think if the test takers knew the test was going to be repeated, they would probably pay better attention.

· very useful information!

· thanks

| High     | The longer questions were difficult I think. I do not have a great knowledge of internet protocol and things so it was difficult
|          | The directions were really wordy. It would be difficult to learn this way. I have always found that I learn better in a hands-on manner. |

<p>| Worked Example | Text-only | Low        | It was a little difficult to read and follow the instructions in order to learn more about the process. There was too much information to learn, possibly, which may affect your results. |
| Medium       | I find networking to be a hard subject to understand after the hardware. The trouble shooting for me is a hard thing to understand. Also the animation in the beginning was distracting. |
| High         | The time constraint was difficult. I read through the material quickly and I did not read it thoroughly. |
|             | Very good setup, explanation in steps was helpful but difficult to |</p>
<table>
<thead>
<tr>
<th>Text-plus-graphic</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I know very little/to nothing about how servers work.</td>
<td>Very difficult I felt like it was a different language</td>
<td>After completing this survey/experiment, I have learned that I do not know much about internet technology.</td>
</tr>
<tr>
<td></td>
<td>The information provided was somewhat difficult to comprehend but the explanation after the pre-test effective.</td>
<td>I feel as though the timer was intimidating. I think either longer time to take it, or no timer at all would have made this go more smoothly.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX P

LETTER FROM THE INSTITUTIONAL REVIEW BOARD (IRB)
Date: August 1, 2008

To: E-Ling Hsiao, Educational Studies (Instructional Technology)

From: Rebecca Gade, Assoc. Director, Research Compliance

Subject: IRB Expiration reminder

According to our records, you have a proposal that was approved by the Institutional Review Board (IRB) within the past year that is approaching its expiration date.

Proposal: 07X136, The Effectiveness of Worked Examples Associated with Presentation Format and Prior Knowledge: A Web-Based Experiment

Expiration Date: 10/17/2008

If your research is COMPLETED (including data analysis):

Please sign below and return this form to the compliance office or send an email to compliance@ohio.edu so that we can update our files accordingly.

\[ \int_{\text{Name}}^{\text{Date}} \]

If your research (including data analysis) is NOT COMPLETED:

This memo is to remind you that a periodic review by the IRB must occur and a new approval must be issued. In order to request a periodic review:

1. Download the periodic review form from the website: research.ohio.edu/compliance

2. Complete the form and return it to the Compliance Office in RTEC 117. You may email a scanned version of the completed form WITH signatures to compliance@ohio.edu

Please keep in mind:

- **Timing** - Periodic reviews can take as long as 5 weeks, so you are encouraged to submit this form well in advance of the expiration date of your proposal. If your proposal is a Full Committee proposal (indicated by a “F” in the third position of the proposal number, e.g., 01F099), then the periodic review must occur at a convened meeting of the IRB. Please check the web for meeting schedule/submission deadlines.

- **Approval Lapses** - If you have not been granted a new approval prior to the expiration of your old approval, all activities under that proposal must stop until such time that a new approval is obtained. If an approval is not granted prior to the Expiration Date, this constitutes a lapse in approval. In order for an approval to be reissued following a lapse, you must bring all signed consent forms to the Compliance Office for audit review.

cc: David Richard Moore