2007

The Effect of Different Types of Worked Examples on Student Learning and Transfer of a Problem Solving Task

Xiaoxia Huang
THE FLORIDA STATE UNIVERSITY
COLLEGE OF EDUCATION

THE EFFECT OF DIFFERENT TYPES OF WORKED EXAMPLES
ON STUDENT LEARNING AND TRANSFER OF A PROBLEM-SOLVING TASK

BY

XIAOXIA HUANG

A Dissertation submitted to the
Department of Educational Psychology and Learning Systems
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

Degree Awarded:
Fall Semester, 2007
The members of the Committee approve the dissertation of Xiaoxia Huang defended on June 8, 2007.

________________________________________
Robert Reiser
Professor Directing Dissertation

________________________________________
Neil Charness
Outside Committee Member

________________________________________
Marcy Driscoll
Committee Member

________________________________________
Zane Olina
Committee Member

Approved:

________________________________________
Aki Kamata, Chair, Department of Educational Psychology and Learning Systems

The Office of Graduate Studies has verified and approved the above named committee members.
ACKNOWLEDGEMENT

It has finally come to the time when I can formally say thank you to all the people who have helped and supported me during my journey in completing this dissertation.

First of all, I would like to express my deepest appreciation to Dr. Robert Reiser, my advisor, for the guidance, advice, and encouragement that he has provided throughout my PhD studies. Dr. Reiser has been my advisor since I first entered the program and has always been an excellent role model for me. His wisdom as well as his passion and commitment to the field have greatly inspired me throughout these years. Furthermore, his expertise in research, his dedication to his students, and his insightful feedback has greatly benefited me in every aspect of my dissertation. He truly has made this journey less stressful for me.

I would also like to thank my committee members, Dr. Zane Olina, Dr. Marcy Driscoll, and Dr. Neil Charness, for their willingness to serve in my committee, and for their valuable feedback to my dissertation. I am fortunate to have them in my committee. I would like to especially thank Dr. Olina, who generously spent her time providing suggestions and discussing her ideas regarding the design of the study. Her thoughtful questions and comments have always made me think deeper. I am also indebted to her for generously giving me the permission to develop the instructional materials of the study based on the materials that she created before.

I am grateful to Ms. Carla Zoda, Ms. Beverly Rogers, Ms. Lauren Mathis, and their students at Swift Creek Middle School for their willingness to participate in the study. Their support and commitment were crucial.

I would like to extend my gratefulness to all the faculty members in Instructional Systems at Florida State University for the quality instruction and training that I received. I also wish to thank all my friends and my peer students who supported me in one way or another. Especially, I would like to thank Huei-yu Chen, my “dissertation companion”, who has made this journey less lonely and more fun. I would also like to thank Cliff Fyle and Wayne Slabon for their helpful comments on the design of the instructional materials.

I dedicate this dissertation to my parents in China for their unconditional love and confidence in me. I would also like to dedicate this dissertation to my brother and sisters for their continued support and encouragement.
# TABLE OF CONTENT

LIST OF TABLES ........................................................................................................................................ VI

LIST OF FIGURES ....................................................................................................................................... VIII

ABSTRACT ................................................................................................................................................ IX

CHAPTER 1 INTRODUCTION........................................................................................................................ 1

  Context of Problem ................................................................................................................................... 1
  Purpose of the Study ................................................................................................................................. 5

CHAPTER 2 REVIEW OF THE LITERATURE ............................................................................................ 7

  Overview of Cognitive Load Theory ....................................................................................................... 7
    Extremely Limited Working Memory ..................................................................................................... 9
    Essentially Unlimited Long Term Memory .......................................................................................... 9
    Schema Acquisition & Automation ...................................................................................................... 10
  Worked Examples Effect ........................................................................................................................ 12
    Reduce Extraneous Cognitive Load ..................................................................................................... 13
    Facilitation of Schema Construction ................................................................................................. 13
  Limitations of standard worked examples ............................................................................................ 14
  Increasing Germane Cognitive Load: Two Strategies in Overview ....................................................... 14
  Research on Self-explanations .................................................................................................................. 15
    Self-explanation Effect .......................................................................................................................... 15
    Elicited Self-explanation ....................................................................................................................... 17
    Optimize Self-explanation Prompt ....................................................................................................... 19
  Instructional Explanation Overview ....................................................................................................... 21
  Self-explanation versus Instructional Explanation: Two Strategies Compared ...................................... 22
  Self-explanation Prompts and Instructional Explanations: Two Strategies Combined ......................... 25
  Conclusion ................................................................................................................................................ 27

CHAPTER 3 METHOD ............................................................................................................................... 29

  Participants .............................................................................................................................................. 29
  Task and Materials .................................................................................................................................. 29
  Independent Variables ............................................................................................................................. 32
  Dependent Measures ............................................................................................................................... 37
  Procedure .................................................................................................................................................. 40
  Quantitative Research Design & Data Analysis ...................................................................................... 44
  Qualitative Research Design & Data Analysis ....................................................................................... 45

CHAPTER 4 DATA ANALYSES AND RESULTS ...................................................................................... 47

  Quantitative Data Analyses and Results ................................................................................................. 47
    Learning .................................................................................................................................................. 47
LIST OF TABLES

Table 4.1 Mean Scores and Standard Deviations on Achievement Test ........................................48

Table 4.2 Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-
explanation Prompts in Learning ………………………………………………………………………49

Table 4.3 Mean Scores and Standard Deviations on Transfer …………………………………………..50

Table 4.4 Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-
explanation Prompts in Transfer ………………………………………………………………………51

Table 4.5 Mean Scores and Standard Deviations on Cognitive Load during Practice ........……53

Table 4.6 Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-
explanation Prompts in Cognitive Load during Practice …………………………………………..53

Table 4.7 Mean Scores and Standard Deviations on Cognitive Load during the Achievement
Test ……………………………………………………………………………………………………………54

Table 4.8 Mean Scores and Standard Deviations on Cognitive Load during the Transfer Test …55

Table 4.9 Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-
explanation Prompts in Perceived Cognitive Load for Learning ……………………………………55

Table 4.10 Summary of Two-Way Analysis of Variance for Instructional Explanations x
Self-explanation Prompts in Perceived Cognitive Load for Transfer …………………………………56

Table 4.11 Means and Standard Deviations on Time on Task during Practice ……………………57

Table 4.12 Summary of Two-Way Analysis of Variance for Instructional Explanations x
Self-explanation Prompts in Time on Task during practice ………………………………………..57

Table 4.13 Mean Scores and Standard Deviations for Time on Task during the Achievement
and Transfer test ……………………………………………………………………………………………58

Table 4.14 Summary of Two-Way Analysis of Variance for Instructional Explanations x
Self-explanation Prompts in Time on Task during the Achievement and Transfer Test …………59

Table 4.15 Mean Responses to Student Attitude Survey by Group ………………………………..60

Table 4.16 Mean Scores and Standard Deviations for Motivation Subscale ……………………..61

Table 4.17 Mean Scores and Standard Deviations for Task Difficulty Subscale …………………61

Table 4.18 Mean Scores and Standard Deviations for Invested Effort Subscale …………………62
Table 4.19  Mean Scores and Standard Deviations for Program Features Subscale ................. 62

Table 4.20  Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Motivation Subscale ................................................................. 63

Table 4.21  Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Task Difficulty Subscale .......................................................... 63

Table 4.22  Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Invested Effort Subscale ......................................................... 64

Table 4.23  Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Program Features Subscale ......................................................... 64

Table 4.24  Mean Scores and Standard Deviations for Practice Performance .................. 65
LIST OF FIGURES

Figure 3.1 Example of the first part of a lesson .................................................................31
Figure 3.2 Content structure of the modified student guide *Hip Commas* ......................32
Figure 3.3 Example of Standard Worked Example .............................................................34
Figure 3.4 Example of WE with self-explanation prompts ...................................................35
Figure 3.5 Example of WE with instructional explanations ................................................35
Figure 3.6 Example of Conventional Problem ...................................................................36
Figure 3.7 Graphic overview of Procedure ........................................................................43
Figure 3.8 Overview of the Research Design ......................................................................44
Figure 3.9 Coding scheme for think-aloud protocols ...........................................................45
Figure 4.1 Instructional explanations by self-explanation prompts Interaction on learning ....49
Figure 4.2 Instructional explanations by self-explanation prompts interaction on transfer ....51
Figure 5.1 Strategy evaluation matrix in Schraw (1998) .......................................................89
ABSTRACT

The purpose of this study was to investigate the effect of different types of worked examples on student learning, transfer, cognitive load, and attitude. In a context of learning two comma rules, four types of worked examples were examined: standard worked examples, worked examples with self-explanation prompts, worked examples with instructional explanations, and worked examples with a transitional combination of instructional explanations and self-explanation prompts. In addition, a control group, the conventional problem condition, was included.

Two hundred and five 7th and 8th grade students enrolled in nine Language Arts classes in a middle school in northwestern Florida were randomly assigned to one of the five conditions. All students studied a five-lesson self-paced instructional program on using two comma rules over a period of seven days. On each day of the first five days, students studied one lesson and completed a corresponding condition-dependent practice exercise. On the sixth day, students completed a final practice exercise. Students in each of the worked example conditions received example-problem pairs during each practice, with examples varying depending on the conditions, while students in the control group received problems without any worked examples. All students completed a pretest one week before the study and a posttest and attitude survey on the seventh day of the study.

Student learning, transfer, cognitive load, and attitude were measured. Learning was measured by an achievement test consisting of 18 individual sentences without any commas inserted. Transfer was measured by a 3-paragraph prose passage punctuated only with periods. Students were required to place commas whenever appropriate by applying the two comma rules. Cognitive load was measured by a single item 9-point rating scale developed by Paas and van Merriënboer (1994), and attitude was measured by a 12-item survey.

In addition to the quantitative measures mentioned previously, a think-aloud protocol was used to examine how learners studied the different types of worked examples. Four students with average ability were selected to think aloud while studying the program. Each of them participated in five think-aloud sessions, one for each of the five lessons that were part of the instructional program.
Analysis of the data found that when self-explanation prompts were not provided, students who received instructional explanations performed better on both learning and transfer test than students who did not receive instructional explanations. In addition, it was found that students presented with self-explanation prompts reported higher cognitive load and spent more time during practice than students who did not receive such prompts; while students presented with instructional explanations reported lower cognitive load than those who did not receive such explanations during practice.

The factors that may have contributed to the results are discussed. Where appropriate, results from the qualitative data analysis are used to support the discussion points. Limitations and implications for research and practice are also provided.
CHAPTER 1

INTRODUCTION

Context of Problem

How to effectively design instruction so as to enhance student learning has been a concern in literature on learning, instruction, and instructional design. Consistent with the belief that “practice makes perfect”, traditional instructional approach tends to provide students with a large number of problems to solve as a way to enhance learning. Many educators and researchers have used this approach and believed that students would learn how to solve problems by being given plenty of problems to solve (Van Engen, 1959).

However, since the 1980s, this heavy emphasis on problem solving has been challenged as an ideal approach to gain initial problem-solving skill by some researchers (Sweller & Cooper, 1985). Studies on novice-expert distinctions (Larkin, MaDermott, Simon, & Simon, 1980; Chi, Glaser, & Rees, 1982) have revealed that experts use previously acquired schemas when solving a problem, while novice learners tend to use general search strategies, such as means-ends analysis. Novice means-ends analysis, however, has been claimed as an insufficient and ineffective learning device for different domains, such as solving puzzle problems (Mawer & Sweller, 1982; Sweller, Mawer, & Howe, 1982), mathematics problems (Cooper & Sweller, 1987; Larkin, 1980; Owen & Sweller, 1985; Sweller, 1988; Sweller & Cooper, 1985), and elementary computer programming problems (van Merriënboer & Krammer, 1990; van Merriënboer & Paas, 1990).

Why is means-ends analysis considered as ineffective for learning? First of all, although it facilitates the attainment of the problem goal, means-ends analysis often prevents problems solvers from paying attention to a problem’s essential structural characteristics (Sweller, 1988; Sweller et al. 1982). In other words, it fails to optimize the acquisition of schemas – a key ingredient of expert problem-solving performance and a key learning mechanism (Sweller, 1988) - because problem solvers’ attention would be
devoted to the attempt of diminishing differences between the problem and the goal states for a particular problem, thus leaving little room for schema acquisition (Sweller, Chandler, Tierney, & Cooper, 1990; Sweller & Cooper, 1985).

Furthermore, research in the area of cognitive load theory has shown that means-ends analysis tends to impose unnecessary cognitive load on problem solvers’ limited cognitive processing capacity because they need to attend to the problem state, the goal, the differences between the two states, and the related problem-solving operators at the same time (Kalyuga, Chandler, Tuovinen, & Sweller, 2001; Owen & Sweller, 1985; Sweller, 1988; Sweller et al., 1982). Since conventional problem solving practice tends to lead novice learners to use general means-ends analysis strategy that interferes with learning, some researchers have proposed to substitute conventional problems with other learning strategies (Sweller, 1988).

Worked examples have been suggested as an instructional device to address the problems associated with traditional practice (Sweller et al., 1990). Worked examples typically contain a problem state, step-by-step solutions, and the goal state, which are intended to provide learners an expert model for solving a particular type of problem (Atkinson, Derry, Renkl, & Wortham, 2000). It is known that conventional instructions usually use only a small number of worked examples after the initial introduction of the content. Proponents of worked examples suggested that much more worked examples should be present in order to facilitate learning.

Sweller (1988, 1994) proposed the use of worked examples based on his cognitive load theory, the rationale being that having novice learners study worked examples rather than solving conventional problems will help to reduce the extraneous cognitive load resulting from the unnecessary search strategies associated with conventional problem solving (Sweller et al., 1990). In addition, by presenting the expert solution steps, worked examples provide the information necessary for optimum schema acquisition (Sweller & Cooper, 1985). In short, it has been found that by studying worked examples, learners’ attention is directed to problem states and the associated operators that both facilitate schema acquisition and reduce extraneous cognitive load. As a result of this, learning is enhanced (Sweller et al., 1990). Furthermore, studies have shown other benefits of worked examples. Firstly, using worked examples leads to the efficiency of instruction
(Paas & van Merriënboer, 1994; Zhu & Simon, 1987). Zhu and Simon’s (1987) study shows clearly that students given only examples and problems to work on completed a math course within 2 years that would have taken 3 years if using standard traditional instruction. Secondly, learners prefer to study worked examples rather than the written procedural instruction. It has been found that students tend to ignore the written instructions while spend much more time studying examples (Anderson, Greeno, Kline, & Neves, 1981; LeFevre & Dixon, 1986; Pirolli & Anderson, 1985). It is worth mentioning, however, that research indicates that worked examples must be well-designed (e.g., avoiding the split-attention effect and the redundancy effect) so as not to negate their instructional benefits (Tarmizi & Sweller, 1988; Ward & Sweller, 1990).

In spite of the documented advantages of worked examples, research has also found limitations associated with them. As mentioned previously, conventional worked examples provide learners with a problem formulation and complete solution steps, which resemble the product an expert has produced at each step for a given problem. These types of worked examples have been referred to as product-oriented worked examples (van Gog, Paas, and van Merriënboer, 2004). One shortcoming of this standard type of worked examples, even when they are well-designed, is that learners have been found to have difficulty solving problems slightly different from what they have been presented with. It has been argued that learners have difficulty transferring the skills they learn when exposed to worked examples of this type because such examples do not describe the underlying process information related to the solution steps, which some researchers feel is necessary for facilitating student understanding of the problem-solving model illustrated in the examples (Atkinson et al., 2000). In other words, since standard worked examples provide only a “finished product” for a problem, with no information on how or why the problem was solved in a particular way, these examples fail to allow for the development of appropriate schemata for “performance, learning, and reasoning” (van Gog et al., 2004, p86). It has been argued that as a result, these examples fail to facilitate deep understanding and transfer (Chi & Bassok, 1989; Sweller & Cooper, 1985; van Gog et al., 2004).

Because of the problem with the standard worked examples mentioned above, i.e., lack of information in the unexplained solution steps, researchers have expressed a
concern about how worked examples can be improved so that learners can process them more thoroughly to achieve learning transfer. Several strategies have been suggested for use to overcome the claimed limitations of standard worked examples.

One of the strategies suggested has been to design worked examples so as to foster learner use of a metacognitive skill known as *self-explanation* at each step in the worked examples presented (Chi & Bassok, 1989; Renkl & Atkinson, 2003; Renkl, Stark, Gruber, & Mandl, 1998). Self-explanation is a “constructive inferencing activity” where a learner is attempting to “make sense of new information” by explaining to him/herself (Chi, 2000, p164). The suggestion that learning might be enhanced by fostering learner self-explanation was put forward based on the studies which found that learners who were better able to explain to themselves the reasons for employing particular solution steps profited more from worked examples than learners less capable of doing so. Because not all learners are spontaneous self-explainers (Renkl, 1997), it has been suggested that prompting students to self-explain while they study worked examples would facilitate their learning (Chi & Bassok, 1989; Renkl, 1997; Renkl et al., 1998).

Another strategy that has been investigated has been to provide worked examples with *instructional explanations*, expert information that is provided to learners, rather than information that is self-generated in response to a self-explanation prompt (Renkl, 2002). This suggestion was put forward because it was believed that instructional explanations provide novice learners with “expert” opinions on explaining the worked-out steps which are usually correct and complete, therefore, should be able to enhance learner understanding of the worked examples.

As can be seen, researchers who propose either the instructional explanation strategy or the self-explanation strategy have realized the same need for students to understand the unexplained solution steps in standard worked examples; however, they differ in *how* the problem should be addressed. Still another suggested strategy is to combine both self-explanations and instructional explanations in worked examples (Hilbert, Schworm, & Renkl, 2004). This strategy is suggested with the purpose to further improve the effect of self-explanations in worked examples. Studies have shown that the quality of learner self-explanations is sometimes unsatisfactory because learners may produce incomplete or incorrect self-explanations which negate to some extent the self-
explanations effect. In view of this, researchers have suggested to combine instructional explanations with self-explanations because the former will serve as a guidance or scaffold for novice learners to elicit correct and complete self-explanations (Hilbert et al., 2004; Renkl, 2002).

Although the aforementioned strategies have been proposed as means of enhancing the value of worked examples, little research has examined the relative merits of these approaches. The paucity of research in this area leads to these questions: What type of support and guidance should we provide to help students to process worked examples so as to optimize their learning? Is learning and transfer better facilitated by providing learners with instructional explanations, self-explanation prompts, or a combination of the two? This study was designed to address these questions.

**Purpose of the Study**

The primary purpose of the study was to examine the effects of various types of worked examples regarding comma usage on student learning, transfer, cognitive load, time on task, and attitude. Four different types of worked examples were compared: standard worked examples, worked examples with self-explanation prompts, worked examples with instructional explanations, and worked examples with a combination of instructional explanations and self-explanation prompts. These four types are described below.

*Standard worked examples* were simply worked-out examples unaccompanied by self-explanation prompts or instructional information explaining the solution process depicted in the worked example.

*Worked examples with self-explanation prompts* included questions related to the steps depicted in the worked examples, so as to prompt students to explain to themselves how solutions to a specific problem were arrived at.

*Worked examples with instructional explanations* provided expert information explaining to the learners how solutions to a specific problem were arrived at.

*Worked examples with a combination of instructional explanations & self-explanations prompts* provided instructional explanations for the first half of worked
examples while prompted students to self-explain for the second half of worked examples, which was a transitional combination of the two types of information.

In addition to the four treatment conditions described above, there was a control condition, the *Conventional problem* condition. Students in this treatment condition received conventional types of problems to solve; they were not presented with any worked examples.

With regard to the dependent variables, *learning* was measured by an achievement test assessing student ability to place commas in individual sentences. *Transfer* was measured by a transfer test assessing student ability to place commas in a coherent text. *Cognitive load* was measured by a 9-point rating scale created by Paas & van Merriënboer (1994) that asked student to rate the amount of mental effort they invested in completing each practice activity, the achievement test, and the transfer test. Student *attitude* toward the instruction and learning content was measured by a Likert-type survey instrument as well as by student interviews. The amount of time students spend on each practice activity, the achievement test, and the transfer test was also measured.
CHAPTER 2

REVIEW OF THE LITERATURE

This chapter consists of a review of selected research concerning, in general, cognitive load theory and worked examples, as these two concepts provide a general framework where the present study is situated. Research related to the instructional strategies of self-explanation prompts and/or instructional explanation is also included as they are the two main variables explored in the present study. More specifically, this review starts with a historical overview of cognitive load theory and its associated core concepts, and then moves to a review of studies on worked examples, one line of research related to cognitive load theory and the main focus of the present study. Review of research in the area of worked examples is approached in the following sequence: it starts with research documenting the worked example effect, followed by research pointing to the limitations of standard worked examples. Finally, studies concerning strategies proposed to improve standard worked examples, i.e., instructional explanation and/or self-explanation, are reviewed.

Overview of Cognitive Load Theory

Cognitive load theory (Sweller, 1988, 1994) is an instructional theory gaining currency in instructional design field. It is a branch of cognitive learning theory that was conceptualized by Sweller in the early 1980s. The main purpose of this theory is to provide a framework for effective instructional design (Sweller, van Merriënboer, & Paas, 1998) with the consideration of the way cognitive resources are allocated and utilized (Chandler & Sweller, 1991).  
Cognitive load theory is built upon information-processing models. Most information processing models can be traced back to Atkinson and Shiffrin’s (1968) model of memory which categorizes memory system into sensory stage, short-term stage, and long-term stage. This model proposes that the information is transformed from one
stage to the next in sequence. However, within information processing models, schemata
theory (originated from Bartlett’s concept of *schemata*, 1932, 1958) and Miller’s (1956)
research (i.e., limited working memory capacity) may be considered as the genesis of
cognitive load theory. Sweller builds his theory upon concepts of short- and long-term
memory, as well as schema acquisition and automation. More specifically, cognitive load
theory emphasizes “the role of working memory in the learning process” (Cooper, 1998,
Principles of Cognitive Load Theory section, ¶1) and highlights working memory limits
as factors determining the effectiveness of instructional design (Sweller et al, 1998).

 Nonetheless, the most direct influence that has affected the conception of
cognitive load theory may have come from expert-novice research in the late 1970s and
early 1980s in the problem solving domain (Chi et al., 1982; Larkin et al., 1980). As
Sweller & Chandler (1991) claimed, cognitive load theory was proposed not as a general
theory of learning such as Anderson’s (1983) ACT* framework, but as “a narrower
theory designed solely to generate novel instructional procedures. . . . to facilitate the
transformation of novice problem solvers into experts” (Sweller & Chandler, 1991,
p356). It seemed that not until early 1990s has cognitive load theory been used in
domains other than problem solving (see Sweller & Chandler, 1991).

 Research on expertise in problem solving in the late 1970s and early 1980s
generally concluded that experts solve problems using previously acquired schemas while
novices using means-ends analysis. According to Sweller & Chandler (1991), this finding
suggested that means-ends analysis may facilitate problem solving but not necessarily
learning in terms of construction of appropriate problem structure (schema) because it
directs learner attention to “the complex mechanics of the means-ends process that is
necessary to attain the problem goal, rather than at the relations between previous moves
necessary to learn the rule” (p352).

 Based on this finding, Sweller and Chandler (1991) claimed that it was a key
question in cognition and instruction to convert “means-ends using novices” into
“schemas using experts” (Sweller & Chandler, 1991). Cognitive load theory was
proposed to suggest that quality instructions should prevent means-ends strategy and
direct learner attention to the problem structure, which would then lead to reduced
cognitive load and help facilitation of schema acquisition.
Several instructional effects were grouped under the framework of cognitive load theory as a result of a series of experiments conducted by Sweller and his colleagues in 1980s and early 1990s, which include the goal-free effect, the worked example effect, the split-attention effect, and the redundancy effect. Sweller (1994) claimed that instructional strategies that fail to engage students in activities directing at schema acquisition and automation tend to be defective because these techniques often require an over-limit processing capacity. This shows that one main concern of cognitive load theory is to improve the quality of instructional design with the consideration of the role and constraints of working memory (Cooper, 1998).

There are several core concepts associated with cognitive load theory. Generally speaking, these concepts may be approached from two aspects: human cognitive architecture and information structure (Sweller et al, 1998). Related to human cognitive architecture aspect are concepts of short- and long-term memory, as well as schema acquisition and automation (Valcke, 2002). Related to the information structure aspect are concepts of intrinsic cognitive load, extraneous cognitive load, and germane cognitive load.

**Extremely Limited Working Memory**

Working memory is a system where conscious processing of information occurs (Sweller et al., 1998). Miller’s (1956) research has shown that working memory can hold only up to 7±2 chunks of information simultaneously. This research finding on limited working memory capacity is a major foundation of cognitive load theory. Cooper (1998) claims that the key principle of cognitive load theory is that instructional design quality would be improved if the role and limitations of working memory were considered with greater concern. Sweller et al. (1998) make more direct statements about the role of working memory limitation, i.e., “any instructional design that flouts or merely ignores working memory limitations inevitably is deficient. It is this factor that provides a central claim of cognitive load theory” (p253).

**Essentially Unlimited Long Term Memory**

Although cognitive load theory emphasizes the role of working memory, it acknowledges other cognitive structures such as long term memory as well. Long term
memory is where schemas (see below) are stored on a relatively permanent basis after information being attended to and processed by working memory. According to cognitive load theory, one function of learning is to hold schemas of varying degrees of automacity in long-term memory (Sweller & Chandler, 1994). This has been supported by empirical studies (e.g., Charness, 1976). De Groot (1966) and Chase & Simon (1973) (as cited in Sweller, 1988) document that differences between chess masters and novices lie in their different long-term rather than working memory structures. According to cognitive load theory, in order for quality instruction to happen, it is important to consider how to transform information in working memory to schemas in long-term memory.

**Schema Acquisition & Automation**

Schema is “a cognitive construct that organizes the elements of information according to the manner with which they will be dealt” (Sweller, 1994, p296). Cognitive load theorists consider learning as construction of schemas and that schemas stored in long term memory constitute an individual’s knowledge base (Sweller, 1988). Consistent with this view, schema theory is put as an “essential prerequisite” to cognitive load theory (Sweller and Chandler, 1991, p357).

Sweller (1994) claims that schema acquisition and schema automation are two critical learning mechanisms for any intellectual activities. Both schema acquisition and automation substantially reduce working memory load. By chunking individual elements into a single unit, schemas increase the amount of information that can be retained in working memory and thus free capacity for other functions. Improving or even by-passing the working memory limit is one major function of schema acquisition and automation (Sweller, 1994). On the other hand, intellectual performance cannot attain its full potential until schema automation is reached. Considerable cognitive effort will be needed to perform a complex intellectual skill when it is first acquired, but the skill may require minimal effort for performance when it becomes automatic with time and practice (Sweller, 1994).

Sweller’s inclusion of the concepts of schema acquisition and schema automation in the theory seems to be also the influence of expertise research in the 1980s, which documented the importance of schemas. Schema theory was the main theory in the early 1980s that was used to explain novice-expert differences in problem-solving skill.
(Sweller & Chandler, 1991). Expertise research suggests that schema is a major factor that distinguishes experts from novices. A vital quality of skilled performance is a large amount of schemas in long term memory (Sweller, 1994). These schemas play a critical role when experts approach and solve problems. Novices, however, tend to resort to means-ends analysis due to the lack of appropriate schemas (Sweller, 1988).

**Three Sources of Cognitive Load**

Cognitive load refers to “the total amount of mental activity imposed on working memory at an instance in time” (Cooper, 1998, Cognitive Load Theory section, ¶1). Cognitive load theory distinguishes three sources of cognitive load, i.e., *intrinsic* cognitive load, *germane* cognitive load, and *extraneous* cognitive load. Intrinsic cognitive load concerns the inherent complexity of learning content, which was considered a fixed source of load (Sweller et al., 1998). Both germane cognitive load and extraneous cognitive load are related to how instruction is presented and can be manipulated by instruction. Cognitive load theory proposes an addictive relationship among the three types of cognitive load, and that the total load could not exceed the working memory limit in order for learning to occur (Sweller et al., 1998).

The three sources of cognitive load were not all proposed at the same time, but evolved over time. It seems that in early works of Sweller and his colleagues, the main concern of cognitive load theory was to reduce extraneous cognitive load (Sweller & Chandler, 1991). The concept of intrinsic cognitive load appeared in Sweller (1994), where he explicitly distinguished intrinsic cognitive load from extraneous cognitive load, suggesting that total cognitive load consists of at least these two separate factors.

Sweller (1994) further suggests that the effects of cognitive load theory may apply only when intrinsic load is high. That is, this theory may be irrelevant for instruction with low intrinsic cognitive load. A concept closely related to intrinsic cognitive load is *element interactivity*. An element is defined as “anything that has been or needs to be learned, most frequently a schema” (Sweller et al. 1998, p259). Intrinsic cognitive load is considered high when several elements have to hold or interact in working memory simultaneously. On the contrary, if each element can be learned in isolation, then intrinsic cognitive load is low (Sweller et al., 1998).
The concept of germane cognitive load evolved with the development of the theory. Sweller et al (1998) distinguishes germane cognitive load from extraneous cognitive load, suggesting that germane cognitive load is related to demands placed on working memory capacity imposed by mental activities contributing to the schema construction, while extraneous cognitive load is caused by mental activities that do not contribute to learning. They further proposed that if total cognitive load does not exceed working memory limit, learners’ attention could be directed to processes relevant to learning or schema construction, i.e., germane cognitive load. Appropriately designed instruction should reduce extraneous cognitive load while increasing germane cognitive load within total load limit.

**Worked Examples Effect**

Since the 1980s, it has been suggested that instruction should use much more worked examples than that which was previously suggested. Worked examples typically contain a problem statement, step-by-step solutions, and the final solution statement as in an expert’ problem-solving model (Atkinson et al., 2000). Sweller (1988, 1994) proposes the use of worked examples based on his cognitive load theory. The purpose of this instructional device is to reduce extraneous cognitive load and facilitate schema construction in the initial cognitive skill acquisition stage. In a series of studies, Sweller and his colleagues found that students learned more from studying worked examples than from solving conventional problems. This superiority of worked examples over problem solving has been referred to as the *worked example effect*. According to cognitive load theory, learning from worked examples is important in the initial stages of cognitive skill acquisition as depicted in Anderson’s ACT* framework (Anderson, 1983), but may not be beneficial during the following learning stages. Numerous studies have provided evidence that worked examples are more effective than problem solving. The following part discusses in more detail the reported benefits of studying worked examples.
Reduce Extraneous Cognitive Load

The primary reason for encouraging the use of worked examples is to reduce novice learners’ extraneous cognitive load. Studies (Chi et al., 1982) have shown that novice learners tend to use means-ends analysis in problem solving, while expert learners usually ignore the goal state and focus on generating solutions based on the givens. Sweller and his colleague claim that means-ends analysis may hamper learning because it tends to result in extraneous cognitive load for the novices. Having novice learners study worked examples rather than solve conventional problems will help reduce the extraneous cognitive load resulting from unnecessary search associated with conventional problem solving.

Facilitation of Schema Construction

As a consequence of reduced extraneous cognitive load from worked examples, learners would have more cognitive resources freed for schema construction (Sweller & Chandler, 1991). According to cognitive load theory, schemas acquisition is a key learning mechanism, while means-ends analysis is insufficient for, and may be incompatible with, learning (Sweller, 1988). Worked examples are believed to facilitate schema construction by helping novice learners to focus on problem states and their associated moves and thus become aware of essential structures of the problems (Sweller & Chandler, 1991).

Other benefits of using worked examples have also been reported (see Chi & Bassok, 1989). For example, studies have shown that learners prefer to study worked examples. Anderson et al. (1981) show that students tend to spend much more time on studying examples and actually learned knowledge of the examples. Pirolli and Anderson (1985) find that novice learners in the early stages tend to rely on examples when learning computer programming skills. LeFevre and Dixon (1986) have reached a similar conclusion that students prefer to use the information in the examples while pay little attention to the written instructions for a procedural task. Another finding is that using worked examples leads to the efficiency of instruction. Zhu and Simon’s (1987) study shows a clear advantage of worked examples in that students given only examples and problems to work on completed a math course within 2 years that would have taken 3 years if using standard traditional instruction.
Limitations of standard worked examples

In spite of the documented advantages of worked examples, research has also found limitations associated with them. As mentioned previously, traditional worked examples contain a given state, solution steps, and the desired goal state (Renkl 2002, van Gog et al., 2004, van Merriënboer 1997). These examples resemble “the ‘products’ experts produce at each step” when solving a particular problem (Van Gog et al., 2004, p86). However, one shortcoming of this type of worked example is its ineffectiveness in facilitating learning transfer due to the fact that standard worked examples do not provide rationales underlying the sequence of solution steps (van Gog et al., 2004). Chi & Bassok (1989) have demonstrated how inadequately explained the worked-out solutions are, using the examples from a physics textbook. According to them, students learned from standard worked examples only “a sequence of actions” which are basically “syntactic or algorithmic rules” that do not allow for transfer (p261). They then concluded that the effect of worked examples would be hindered if the conditions underlying the action steps are not explicitly stated. Many other researchers have expressed similar concerns regarding the unexplained solution steps in worked examples. For example, it has been pointed out that due to the lack of explication of the underlying rationale, students may not be able to comprehend the “problem-solving model” demonstrated in the worked examples, and therefore have difficulty solving problems slightly different from the examples (Atkinson et al., 2000).

Increasing Germane Cognitive Load: Two Strategies in Overview

To overcome the aforementioned limitation of unexplained solution steps in worked examples, it is important to help students learn with “understanding”. The main strategies striving for that goal concern two types of explanations: self-explanations (Chi & Bassok, 1989; Chi, Bassok, Lewis, Reimann, & Glaser, 1989) and instructional explanations (Renkl, 2002). Self-explanation activities foster students to actively think about unexplicated aspects of a problem that are essential to understanding (Mwangi & Sweller, 1998). Chi et al. (1989) stated that, considering the fact that examples usually
contain a succession of unexplained steps, self-explanations are vital because “students learn and understand an example via the explanations they give while studying it” (p148). On the other hand, some researchers think that providing students with the expert explanations for the unexplicated solution steps should help address the limitation of standard worked examples because instructional explanations would direct learner’s attention to appropriate aspects of instruction (van Gog et al, 2004). Put another way, both strategies were proposed for students to learn with understanding of the solution steps, the difference is how the problem should be addressed: to have the learners generate the unexplained information or to provide the learners with this information.

From the cognitive load theory point of view, either asking students to self-explain the solution steps or providing expert information to elucidate the solution steps can induce germane cognitive load (Gerjets, Scheiter, & Catrambone, 2006). This is important for learning because students do not necessarily spontaneously involve themselves in relevant cognitive activities (i.e., germane cognitive load) when studying standard worked examples, despite that the extraneous cognitive load associated with conventional problem solving may be reduced (Moreno, 2006). Another issue to keep in mind is that although both types of explanations were proposed as strategies to induce germane cognitive load, the role they actually play may not necessarily be as expected, due to the interacting effect of learner characteristics. For example, for learners with high prior knowledge, instructional explanations may become redundant information.

The next part of this literature review will discuss self-explanation strategy and instructional-explanation strategy separately.

**Research on Self-explanations**

**Self-explanation Effect**

Research on self-explanations was originated by Chi and her colleagues. Self-explanation is a meta-cognitive skill and has been defined as a “constructive inferencing activity” where a learner is “generating explanations to oneself” (Chi, 2000, p165). In the context of studying worked examples, self-explanation has been defined as “generating explanations to oneself to clarify an example’s worked out solution” (Conati & Vanlehn,
Three important processing characteristics of spontaneous self-explanation have been identified (Chi, De Leeuw, Chiu, & LaVancher, 1994). First, it is a constructive activity for new knowledge. Second, it encourages the integration of new information with prior knowledge, which, however, may result in incorrect knowledge. Nonetheless, Chi and her colleagues argued that this incorrect knowledge may be beneficial to the learners because it provides a learning experience, and the incorrect explanation can be corrected later when the learners encountered the correct information where contradictions arise. Third, it occurs in a “continuous, ongoing, and piecemeal fashion” (p.472) which often lead to partial and incomplete self-explanation. This partial self-explanation may be better at repairing learners’ erroneous initial mental model. Chi et al. (1989, p.149) mentioned the importance of self-explanations for transfer when studying worked examples:

In order to learn with understanding, a student needs to overcome the incompleteness of an example by drawing conclusions and making inferences from the presented information (Wickelgren, 1974). To do so, a student needs to provide explanations (either overtly or covertly) for why a particular action is taken. Only then will the student be able to apply the acquired procedure to non-isomorphic problems that do not match exactly the conditions of the example solution.

Empirical research has confirmed the benefits of spontaneous self-explanations. Chi et al. (1989) is considered a classical study in the area (Renkl, 1999). They examined the processes of ten students studying three worked examples related to Newton’s laws of motion via think-aloud protocols, as well as how the process related to the subsequent problem solving. The result from this study is enlightening. They found that the number of self-explanations students spontaneously generated positively correlated with their problem solving success. That is, students who self-explained more also benefited more from learning worked examples. This phenomenon has been referred as self explanation effect in the literature.

Many studies have provided evidence supporting the self-explanation effect, including studies not focusing on learning from worked examples (Bielaczyc, Pirolli, & Brown, 1995; Chi et al., 1994; Neuman & Schwarz, 1998). These studies usually focused
on the comparison of “spontaneous” self-explainers versus “nonspontaneous” self-explainers and confirmed that students who spontaneously self-explained while studying either scientific texts or worked examples demonstrated better learning performance (Chi & Bassok, 1989; Chi et al., 1989; Chi et al. 1994; Renkl, 1997).

**Elicited Self-explanation**

Although self-explanations were suggested as an effective means of studying worked examples and fostering transfer, most students, unfortunately, are not spontaneous self-explainers. Instead, they are “passive” or “superficial” self-explainers who do not demonstrate effective learning behaviors without external support (Renkl, 1997). Therefore, researchers suggested providing *prompts* to elicit students to actively engage in self-explanation activities (Chi, 1996; Chi & Bassok, 1989; Renkl, 1997; Renkl et al., 1998). Chi (1996) has claimed that “[s]ince the construction of self-explanations, directed by oneself without any guidance from another, is an effective means of learning, then it seems that the construction of explanation, elicited by others, may have the same beneficial effect…” (p35).

Many empirical research studies have investigated the effect of prompts for self-explanations and demonstrated proof of their benefits for either studying texts or solving problems in well-structured domains. Chi et al. (1994) investigated the effect of the prompts for self-explanation on learning from an expository text regarding the circulatory system with eight-graders. The experimental group was prompted to explain each sentence based on their own understanding, whereas the control group received no prompts but read the text twice instead to equal time on task. The prompting of their study consisted of general prompts (i.e., general instruction provided at the beginning of the reading and verbal instruction/reminder to self-explain every sentence) and specific function prompts (i.e., asked the students to explain the function of each component of the circulatory system when the discussion of the component occurred). It was found that that the prompted group answered more questions correctly during the assessment phrase than the unprompted group, especially for the more difficult questions. Similarly, Aleven & Koedinger (2002) found that high school students who received self-explanation prompts from an intelligent Geometry tutor at each of their problem-solving step during
the practice achieved a significantly greater learning gain for both learning and transfer tests than their peers who were not prompted for self-explanation.

In the context of learning with worked examples, however, the results did not unanimously show the benefits of elicited self-explanations (Atkinson, Renkl, & Merrill, 2003; Nathan, Mertz, & Ryan, 1994). Renkl et al. (1998) seemed to be the first to experimentally test elicited self-explanation effect on learning from examples. They compared elicited self-explanations and spontaneous self-explanations with students who studied nine worked examples on calculation of compound interest and real interest. Learners in the spontaneous self-explanations condition were asked to verbalize their thoughts while studying the examples, whereas learners in the elicited self-explanations conditions were trained to self-explain and elicited to fill in the rationale of worked-out steps in the examples. They found that the elicitation of self-explanations fosters both near (particularly for learners with low prior knowledge) and far learning transfer compared with the self-explanations completely generated by students themselves. Nathan et al. (1994) also showed evidence supporting the benefits of elicited self-explanations in the domain of algebra for learning with worked examples. Their college-level participants that were trained to self-explain each solution step of an worked example during the learning phase performed significantly better in the subsequent story-problem translation tasks than those who did not self-explain, although there was only a marginal effect of self-explanations for the algebra manipulation tasks that were more procedural. Atkinson et al. (2003) echoed the results of the above studies in that they found that both university students and high school students who were prompted to select the probability principle for each solved solution step of probability word problem examples during the learning phase performed better for both near-transfer and far-transfer tests than their counterparts who received no prompts. However, the finding from Mwangi & Sweller (1998, Experiment 3) is inconsistent with the findings mentioned above. Their study with Year 4 students learning worked examples of word problems failed to find the beneficial effects of self-explanation prompts. Similarly, the finding from Conati & Vanlehn (2000) did not support the effect of self-explanation prompts. Their university students studied worked examples on Newton’s Law, either with the prompts for self-explanations or without such prompts. Students who were prompted to
self-explain did not perform better in the posttest compared with the students who did not receive such prompts. In addition, Olina et al.’s (2005) study of middle school students learning worked examples of comma rules did not confirm the beneficial effects of self-explanation prompts.

**Optimize Self-explanation Prompt**

The mixed findings on the effect of elicited self-explanations could be related to the way self-explanations were elicited, which may influence the quality of student self-explanations. Many earlier studies in the area have used prompts that are general or nonspecific. It is argued that such prompts may not result in self-explanations of optimal quality either because learners are not able to self-explain for certain solution steps or because the elicited self-explanations are incomplete or incorrect (Berthold & Renkl, 2005). It should be noted that one question that researchers disagree upon is whether incomplete or incorrect self-explanation is beneficial to learning. Chi et al. (1994) considered incompleteness or incorrectness as one of the characteristics of spontaneous self-explanations. According to these researchers, partial or even incorrect spontaneous self-explanations can be beneficial because it provides a learning experience, and the incorrect explanation can be corrected once contradictions occur in cases when the learners encountered the correct information provided later during the learning stage. However, other researchers hold a different view regarding this issue. Conati & Vanlehn (2000) pointed out that “this argument applies only to students that can monitor their understanding and we know that these students are a minority. The other students may seldom detect the inconsistencies generated by their incorrect self-explanations” (p393). Therefore, they proposed that more scaffolds will need to be provided in the prompts in order to facilitate learning. Conati & Vanlehn’s (2000) argument is consistent with Chi et al.’s (1989) finding that poor students were oftentimes not accurate at recognizing their comprehension failures. Therefore, for novice learners, more structured prompts should be a better strategy.

Conati & Vanlehn’s (2000) point of view was supported by some other researchers. An analysis of student self-explanation data in Olina et al (2005, 2006) found that the quality of elicited self-explanations were far from satisfactory. Students with
poor meta-cognitive strategies produced self-explanations that were incomplete, incorrect, irrelevant, or even meaningless, which might have explained at least in part the failure of self-explanation prompts in their study. One conclusion they drew was that more structured prompts would be needed in order to provide effective guidance for students to produce high-quality self-explanations. Like many earlier studies in the area, the prompts used in Olina et al. (2005) were general open questions (“Explain why you chose your answer”), which might not be structured enough for the students to construct effective self-explanations in a way that their understanding of the learning topic would be facilitated. This line of thought was consistent with other researchers in the area. For example, Atkinson et al. (2003) mentioned that the reason that Hausmann & Chi (2002) failed to find the positive effect of self-explanations may be because their self-explanation prompts were not specific enough. Furthermore, Chi & Bassok (1989) suggested that shaping student’s self-explanations by more specific prompts could help poor students to produce self-explanations of higher quality. Renkl (2002) also claimed that although elicited self-explanation were more effective than non-prompts in facilitating learning, “much could and should be done to improve the quality and correctness of the learners’ self-explanations further” (p534).

It seems that two methods can be used to optimize the effect of self-explanation prompts. One is to make the prompts themselves more structured in form of multiple-choice (Bunt, Conati, & Muldner, 2004) or fill-in-the-blanks (Conati & Vanlehn, 2000) types of questions, rather than using open-ended general questions such as “Please explain your answer”. The other method is to supplement the prompts with additional instructional explanations or guidance (Berthod & Renkl, 2005; Renkl, 2002; Schworm & Renkl, 2002; Hilbert et al., 2004). The findings of the Berthold & Renkl (2005) study provided empirical evidence that instructional guidance integrated with self-explanation prompts benefited the learner. Similarly, Renkl (2002) also showed that providing students with instructional explanations during the self-explanation activities had a positive impact on learning. The two studies and other empirical studies regarding the effect of the latter strategy will be discussed in the Section “Instructional Explanations and Self-explanation Prompts: Two Strategies Combined” in this chapter.
Based on the research findings above, although there is disagreement regarding the effect of partial and incorrect self-explanations, it seems that eliciting complete and correct self-explanations could further facilitate student learning and understanding during the initial learning stage. In view of this, the present study intended to incorporate the two strategies mentioned above separately in the hope of eliciting higher-quality self-explanations and compare their respective effects on student performance. Another reason that this study intended to focus on structured/scaffolded prompts is related to cognitive load. It is believed that more structured prompts will help to reduce extraneous cognitive load that may be perceived by novice learners. For low-ability students or poor self-explainers, just asking them to self-explain without further support may result in extraneous cognitive load when they are unable to explain the solution steps on their own (Chi et al., 1989; van Gog et al., 2004), while providing this type of support should, theoretically, help to minimize extraneous cognitive load. It seems that little empirical data have been obtained yet with regard to the effect of the two strategies on student perceived cognitive load. The findings from this study may help contribute to that aspect of the literature.

**Instructional Explanation Overview**

As mentioned previously, rather than prompting students to generate explanations for the unexplained solution steps by themselves, another strategy proposed to improve the effect of standard worked examples is providing instructional explanations to students. No standard definition has been provided for instructional explanations in worked examples. Basically, it is considered as explanations provided by an expert or a more knowledgeable person (Renkl, 2002). Some researchers have used terms such as *author-generated* explanations/elaborations or *experimenter-generated* explanations/elaborations, in contrast to those produced by the learner. Although different terms have been used, the operational definitions of these terms in the literature were very similar; therefore, research using these terms is included in this review. However, the original terms used in those studies are kept in this discussion.
Instructional explanations are considered more consistent with the traditional form of instruction. However, compared with studies on self-explanations, relatively few studies have examined the effect of instructional explanations in worked examples (Lee & Hutchison, 1998; Renkl, 2002). Renkl (2002) mentioned that the major reason might be because some studies have shown that instructional explanations were less effective than self-explanations on learning and transfer either for problem solving (Brown & Kane, 1988; Rittle-Johnson, 2006) or for studying worked examples (Schworm & Renkl, 2002). In fact, most studies that examined instructional explanations focused on either the comparison of, or supplement this strategy with, self-explanations. Therefore, research on instructional explanations will be discussed in the following two parts of this review of literature.

**Self-explanation versus Instructional Explanation: Two Strategies Compared**

Generally speaking, a self-explanation strategy seems to be considered as more favorable than an instructional explanation strategy, which may be attributed to the generation effect (Jacoby, 1978) found in early research. Generation effect refers to the phenomenon that information generated by oneself is better recalled than information provided by others (Renkl, 2002). Partly because of this finding, an instructional explanation strategy was thought as inferior to a self-explanation strategy, whether it is about learning facts or not. Another reason that self-explanation was regarded as superior to instructional explanation may be related to the conception that the former is a “constructive” (Chi, 2000) learning activity while the latter is usually thought of as related to “passive” learning.

Renkl (2002) has compared the advantages and disadvantages of instructional explanation and self-explanation in worked examples. On one hand, he pointed out three problems with self-explanation that may negate its effects. Some of them may have been tackled previously in the chapter. The purpose of restating here is to provide a briefly summary. The first problem concerns the quality of self-explanations. The second concerns “comprehension impasses” (p535) students may have when they are presented with new information, and the third is related to students’ illusion of understanding due to
the meta-cognitive problem of monitoring their comprehension. On the other hand, Renkl pointed out three problems with instructional explanations. First, instructional explanations oftentimes are not adapted to learners’ existing knowledge. Second, it’s hard to guarantee appropriate timing for instructional explanations in a way that learners could benefit from them because it’s been found that learners would not benefit from instructional explanations until they integrate them into an ongoing activity. The third is related to the generation effect mentioned above: information generated by oneself is better recalled than information provided by others.

Empirical studies comparing an instructional explanation strategy and a self-explanation strategy in problem-solving contexts tend to support that the latter is more effective than, or, at least as effective as, the former strategy. Brown & Kane (1988) studied preschool children learning examples of biological mechanism and found that self-explanation prompts were more effective than instructional explanations on transfer of a general rule to new instances of the concept. In addition, Chi’s (1996) case study of a tutor coaching a college student on solving a mechanics problem also showed benefits of self-explanation on learning (removing misconceptions) over “long-winded didactic explanations” (p11). Rittle-Johnson (2006) partially supported the above findings in his study concerning, although not directly comparing, the effect of direct instruction and self-explanation prompts on conceptual and procedural learning, as well as procedural transfer. In a context of 3-5 graders solving mathematical equivalence problems, he found that self-explanation prompts resulted in both better procedural learning and better transfer, although no effect on conceptual learning was found. As far as direct instruction is concerned, he found only a marginal effect on procedural learning. On the other hand, while findings from Reder, Charney & Morgan (1986) did not confirm the above findings, their study found that both instructional explanation (author-generated elaboration) and self-explanation (self-generated elaboration) facilitated skill performance for students who learned a procedure task of using a personal computer.

Findings obtained from empirical studies in the area of worked examples research seem less clear. Catrambone & Yuasa’s (2006) study of the effect of instructional explanations and self-explanation prompts in worked examples on a procedure skill of writing database queries found no difference between the two types of explanation on
learning. However, they found that although the self-explanation prompts group spent more time on the learning stage, the time on subsequent performance was reduced when compared with the students in the instructional explanations group. Gerjets, Scheiter, & Catrambone (2006) also found that neither instructional explanations nor self-explanation prompts facilitated learning and transfer in two separate studies. In one experiment, they compared the effect of highly-, medium-, and low-elaborated instructional explanations in molar and modular worked examples on college student learning, transfer, and cognitive load of calculation of the probability of complex events. Although they found that students in the highly-elaborated worked example condition perceived lower cognitive load than those in the low-elaborated worked examples, this difference did not lead to the superior performance of the highly elaborated group for either type of the worked examples. In another experiment, they found that although prompting students to self explain resulted in increased learning time, this did not lead to improved performance. On the contrary, prompting hurt learning with modular examples. That means that the prompts neither result in the performance superiority nor the efficiency benefit. No difference on perceived cognitive load was found regarding the prompts for self-explanations. The authors attribute the non-significant difference to learner’s prior knowledge and the design issues of the worked examples. Similarly, Olina et al. (2005) found no effect for either instructional explanations or self-explanation prompts. In this study, they compared the effect of instructional explanations versus self-explanation prompts on learning & transfer performance as well as on perceived mental effort in a 3 (conventional problems vs. worked examples with instructional explanations vs. worked examples with self-explanation prompts) x 2 (high-achieving students vs. low-achieving students) research design. During the learning phase, 147 ninth-graders studied two comma rules in four lessons over a period of four days. Treatments differed in that after all the lessons were completed, students received various types of practice exercises. The researchers did not find significant differences between the conditions on learning, transfer, and perceived cognitive load.
Self-explanation Prompts and Instructional Explanations: Two Strategies Combined

In reviewing the advantages and disadvantages of instructional explanations and self-explanations strategies, Renkl (2002) suggested to combine the two types of explanation in a way that their respective advantages could be brought together. This view is consistent with the recommendations to optimize the effect of self-explanation prompts via instructional scaffolding during the student self-explanation process (Bethold & Renkl, 2005). In a computer-based learning environment related to probability calculation, Renkl’s (2002) students initially studied some complete worked examples; they were then presented with incomplete worked examples where a question mark was prompted at the last solution step so that students had to calculate the probability value on their own. The question mark in the incomplete worked examples can be regarded as a prompt for self-explanation. During the process of this self-explanation activity, the experimental group of students had the option to access on-demand instructional explanations in form of probability principles as well as additional detailed information if desired, while the control group had no such option. It was found that, in general, instructional explanations facilitated far transfer. This finding showed that combining instructional explanation and self-explanation strategies could have a beneficial effect on learning. Berthold & Renkl’s (2005) study also supports the effect of guiding student self-explanation via instructional explanations. In this study, Berthold & Renkl constructed scaffolded self-explanation prompts by providing gradually-withdrawn instructional guidance in the self-explanation prompts, and they compared this strategy with open self-explanation prompts in the context of college students studying multi-representational worked examples on probability theory. Open self-explanation prompts were more general questions (e.g., “Why do you calculate the total acceptable outcomes by multiplying?”) with the purpose to induce self-explanations, but the self-explanation process itself was not guided. The scaffolded prompts were provided in a way similar to “completion” activities where “fill-in-the-blank” explanations were used for the first worked examples, and the support was gradually reduced until the learners received open self-explanation prompts. It was found that the scaffolded self-explanation prompts were
more effective than open self-explanation prompts on conceptual knowledge, although no
difference was found in their effects on procedural knowledge.

However, research findings have not been consistent with regard to the effect of
combining instructional explanations and self-explanation prompts. Contrary to the
findings of Renkl (2002), Schworm & Renkl (2002) found that instructional explanations
may be detrimental to learning (both near and far transfer) when combined with self-
explanation prompts in solved example problems. Their study employed a 2 x 2
(presence or absence of instructional explanations x presence or absence of self-
explanations prompts) design in a computer-based learning environment where teachers
learned how to use worked examples. Instructional explanations were presented in form
of correct answers to the self-explanations prompts and were accessible at the same time
when self-explanations were prompted. That is, for a specific example, learners could get
access to the instructional explanations without actively self-explaining the worked
examples. This design format was considered by the authors as a factor contributing to
the failure of the combined strategy because the self-explanation prompts reduced the
self-explanation activity. In order to further examine the issue of combining the two types
of explanations so that to bring their respective advantages, Hilbert et al. (2004)
conducted a study in the same computer-based learning environment as that in Schworm
& Renkl (2002), and they manipulated the way the two explanations methods were
combined. Rather than having instructional explanations available during the self-
explanation activities, the former was presented “asynchronously” with the latter, which
was realized by a transition from instructional explanations during the first learning stage
that, compared with the “synchronous” combination of self-explanation prompts and
instructional explanations in Schworm & Renkl (2002), the transitional combination had
two advantages. First, it prevented students from looking up the instructional
explanations before they tried to complete the self-explanation activities. Second, it did
not cause extraneous cognitive load in the form of the redundancies between the two
instructional methods. They then compared the effect of this combined strategy with that
of self-explanation prompts with students in either a didactically-oriented educational
program or a subject matter-oriented program. It was found that the transitional combined
strategy was as effective as providing self-explanation prompts alone for students in the subject matter-oriented program but not for students in the didactically-oriented program, although both groups of students perceived the combined condition more useful.

Based on the findings discussed above, it seems that the effect of combining instructional explanations and self-explanation prompts on learning with worked examples remains unclear. The results are interesting and worth further investigation. Theoretically, a well-designed combination condition of the two types of explanation should produce a beneficial effect on learning because it should supposedly improve the quality of self-explanations by minimizing incomplete or incorrect self-explanation via the guidance or scaffolding of instructional explanations. One likely explanation for the mixed results obtained could be related to how the two types of strategies are combined (Schworm & Renkl, 2002). The existing findings seem to suggest that a transitional combination is more effective than a synchronous combination of the two strategies. However, more research will be needed in order to confirm the effects of the transitional combination strategy. On the other hand, it may also be interesting to compare the more structured self-explanation prompts with the combination strategy since there are studies documenting their beneficial effects, but no direct comparison of the two have been made.

**Conclusion**

The review of relevant literature found that although different instructional strategies, i.e., instructional explanations, self-explanation prompts (open or structured), or a combination of the two, were proposed to improve the effect of worked examples, few studies (Schworm & Renkl, 2002) have examined the relative merits of these strategies. Instead, the majority of research in the area was conducted comparing either standard worked examples with one of the aforementioned strategies, or comparing just two of those strategies. It seemed that more research will be needed to examine all three different strategies in order to better understand the role of adding instructional explanation and/or self-explanation to standard worked examples. In particular, there are only few studies that have investigated the effect of combining instructional explanations
and self-explanation prompts, and the results are not conclusive due to the fact that how the two types of information are combined may influence the learning outcome. Studies in different domains and with different groups of learners will be needed in order to have a more accurate evaluation of the effect of the combination strategy. Furthermore, although Hilbert et al (2004) claimed that the transitional combination would reduce extraneous cognitive load, they did not provide empirical evidence on this as student perceived cognitive load was not directly measured. Indeed, only few studies (Olina et al., 2005; Gerjets et al., 2006) in the area have measured student cognitive load to empirically test the assumptions of the effect of these strategies on cognitive load (e.g., instructional explanations and self-explanations would increase germane cognitive load).

The presented study was proposed in the hope of contributing to the literature by attempting to address some of the aforementioned issues. This study examines the relative effects of the different strategies, i.e., instructional explanations, self-explanation prompts, and a combination of instructional explanations and self-explanation prompts, on student learning, transfer, and cognitive load. Time on task and student attitude are also measured to have a more complete picture of their effects. In addition, the review of the literature had impact on the design of this study in the following ways:

1. For the worked examples with both instructional explanations and self-explanation prompts condition, the present study employs a transitional combination from instructional explanations for the first half of worked examples to self-explanation prompts for the second half of worked examples, rather than providing both types of information at the same time.

2. For the worked examples with self-explanation prompts condition, structured prompts in form of multiple choice questions, rather than general open-ended questions, were used in order to more effectively guide the student self-explanation process.
CHAPTER 3

METHOD

Participants

Participants in this study were 205 seventh- and eighth-grade students enrolled in nine Language Arts classes in a middle school in northwestern Florida. These classes were taught by three female teachers, each with at least two years of teaching experience. Initially, 212 students participated in the study. The data collected from six of the students were not included due to the fact that these students missed most class sessions when the experimental treatments were imposed. Another student was also deleted from the data analysis because he did not take the transfer test, and he spent very little time (less than 2 minutes) working on the various portions of the instructional program and the achievement test.

The gender distribution for the final sample of 205 students showed that the sample was almost equally divided between males and females. The reported ethnicity of participants was as follows: 71% white, 19% black, 9% other ethnicity, and 1% students reported no ethnicity.

Task and Materials

Students who participated in this study were expected to learn how to use two comma rules so as to correctly punctuate sentences. One rule was the FANBOYS rule, which indicates that when a coordinating conjunction joins two independent clauses, a comma should be inserted before the conjunction. The other rule was the Introductory Element rule, which indicates that a comma should be inserted after an introductory word, phrase, or clause in a sentence.

The instructional material that was employed was a modified version of the Hip Commas program, a print-based instructional program originally developed by Olina et
al. (2006). The modified version of the program consisted of five lessons, each of which focused on one of the skills listed below:

- Lesson 1: Identifying subjects and predicates;
- Lesson 2: Identifying clauses;
- Lesson 3: Identifying the type of clauses (dependent or independent clause);
- Lesson 4: Applying the FANBOYS rule when appropriate;
- Lesson 5: Applying the Introductory Element rule when appropriate.

As noted above, the primary purpose of this series of lessons was to teach students how to use two comma rules, the FANBOYS rule and the Introductory Elements rule, to correctly punctuate sentences. In light of this, the first three lessons were intended to provide the prerequisite knowledge for mastering the two comma rules, and the last two lessons were designed to provide students with instruction and practice in actually using the rules.

Each of the five lessons consisted of two parts. The first part of each lesson consisted of a brief explanation of the skill being taught, accompanied by several examples. This part of each lesson was the same for all of the treatment groups. Figure 3.1 is an example of the first part of one of the lessons.

In four of the five treatment conditions, the second part of each of the five lessons was a practice activity that consisted of a series of four worked examples paired with conventional problems. The nature of the worked examples varied by treatment group (see Appendices A-E for an example exercise for each condition). In addition, there was one treatment group that did not receive any worked examples in the second part of each lesson. They simply received conventional practice problems as their practice activity. These variations are described in the Independent Variables section of this chapter.

In addition to the five lessons described above, there was a final activity which involved giving students additional practice performing each of the comma rules. The nature of this final practice activity also varied by treatment condition and is described in the Independent Variables section of this chapter. Figure 3.2 provides an overview of the structure of the entire instructional program.
STEP 1 Identify Subjects and Predicates

"SP" is the first line in the song. S means "subject". A subject is the word (noun or pronoun) in a sentence that tells what or whom the sentence is about. A subject can be a person, place, or thing.

Example 1: The night was cold.
Subject: The night
This sentence tells something about the night. The night is the subject.

Example 2: My mother ansues.
Subject: My mother
This sentence tells something about my mother. My mother is the subject.

A sentence can contain a subject with more than one noun or pronoun joined by "and" or "or".

Example 3: My mother and I sleep a lot.
Subject: My mother and I
This sentence tells something about my mother and I. My mother and I is the subject. Notice how both nouns have pronoun possessive after them.

In this booklet, we will always underline subjects with a double line.

The "P" in the first line of the song means "predicate". A predicate consists of the verb(s) plus the following words associated with the verb(s) that come after a subject. It tells what the subject is, does, has, or feels.

Example 1: My mother dances.
Predicate: dances
This is the predicate because it tells us what my mother does.

Example 2: The night was cold.
Predicate: was cold
This is the predicate because it describes the night.

A sentence can have a predicate with more than one verb joined by "and" or "or".

Example 3: The guests sang and danced in the flower garden.
Predicate: sang and danced
This is the predicate because it describes what the guests did. The predicate has two verbs joined by and: sang and danced.

In this booklet, we will always underline predicates with a single line.

Now, you know all about subjects and predicates. Your teacher will tell you when to start Exercise 1 to practice identifying subjects and predicates.

Figure 3.1 Example of the first part of a lesson
Figure 3.2 Content structure of the modified student guide *Hip Commas*

*Note 1.* For the worked examples conditions, practice activities 2-5 consisted of 4 pairs of worked examples and practice problems. The final practice consisted of 6 such pairs.  
*Note 2.* For the conventional problems condition, practice activities 2-5 consisted of 8 conventional problems. The final practice consisted of 12 conventional problems.

As an activity to help motivate students to proceed through these lessons, a hip-hop style song that briefly described each of the five steps for applying the two comma rules was included in each lesson. The lines in the song describing a particular skill were presented and defined at the beginning of the lesson involving the corresponding skill. The song itself was also played in each lesson, and a competition on the recall of the meaning of the key lines was scheduled toward the end of the program. The integration of the hip-hop song in the program was to serve as both a motivational device and a mnemonic for helping students acquire the desired skills. See Appendix F for the complete lines of the Comma Hip-Hop Song.

**Independent Variables**

As stated earlier, the primary purpose of this study was to investigate the effects of the various types of explanations included with worked examples. With this purpose
in mind, the study was designed to examine the effects of the presence or absence of two types of explanations - (1) *instructional explanations* that were intended to explain to students why particular steps were taken; and (2) *self-explanation prompts* that were intended to prompt students to recognize the underlying reasons why a particular step was taken. In order to examine the effects of these variables, a 2 (presence or absence of instructional explanation) x 2 (presence or absence of self-explanation prompts) factorial design was employed. The four resulting treatment conditions were:

- standard worked examples (WE) without any instructional explanations or self-explanations prompts;
- WE with self-explanation prompts;
- WE with instructional explanations; and
- WE with both instructional explanations and self-explanation prompts.

In addition, this study included a control group that did not receive any worked examples; instead they were simply asked to solve conventional practice problems. These various treatment conditions were incorporated into the practice activity that was part of four of the aforementioned five lessons, plus the final practice activity. Detailed information regarding each treatment condition is presented below.

**Standard WE.** In this treatment condition, worked examples consisted of individual sentences with the essential features of the structure of each sentence clearly identified. For example, as shown in the left hand side of Figure 3.3, the standard worked-example for *identifying the number of clauses* in a sentence (practice activity 2) simply contained a sentence with ‘subject’ and ‘predicate’ labeled for each subject and predicate (solution steps) and with each clause identified in brackets (the final solution).
As with the other three treatment conditions, each worked example was paired with a conventional problem that was similar in structure. That is, the first sentence in each pair was a condition-specific worked example, while the second sentence in the pair was a conventional problem that students were expected to solve (see the right hand side of Figure 3.3). There were four such pairs for lessons 2 – 5, plus six such pairs for the final practice activity.

**WE with self-explanations.** Worked examples with self-explanations were the standard WE described above with the self-explanation prompts placed immediately above each individual sentence. Self-explanation prompts were provided in the form of multiple-choice questions with the purpose of getting the students to recognize the steps necessary to perform a particular skill and then consciously apply those steps to the examples given to understand why the final solution was arrived at. See the left hand side of Figure 3.4 below for an example of worked examples with self-explanation prompts. The two questions that appear above the worked example are the self-explanation prompts.

---

**Figure 3.3 Example of Standard Worked Example**

<table>
<thead>
<tr>
<th>Study this</th>
<th>Then do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>subject predicate &lt;br&gt; [You can preview the class schedule for the fall but &lt;br&gt; predicate &lt;br&gt; cannot register yet].</td>
<td>Put brackets around each clause in the sentence below. Like the example sentence in the box on the left to help you! &lt;br&gt; I should remove the blackberry pie from the oven and eat it later.</td>
</tr>
</tbody>
</table>
WE with instructional explanations. Worked examples with instructional explanations were the standard WE with instructional explanations provided immediately above each individual sentence. The instructional explanation provided information explaining why particular steps were taken. See the left hand side of Figure 3.5 below for an example of a worked example with an instructional explanation.

![Figure 3.4 Example of WE with self-explanation prompts](image)

![Figure 3.5 Example of WE with instructional explanations](image)
In this treatment condition, the first two of the four pairs of sentences were of the instructional explanation variety while the next two pairs were of the self-explanations prompts variety, which was a transitional combination of the two types of strategies.

Conventional problem-solving: conventional problems consisted of ‘bare’ individual sentences and directions that asked students to identify particular features of each sentence. The features students had to identify depended on the skill taught in a particular lesson. For example, the conventional problem for identifying the number of clauses in the sentence asked students to double underline each subject and single underline each predicate and then put each clause in brackets (See Figure 3.6 below).

**Instruction**: Identify the number of clauses in each sentence below by:

a) underlining all subjects with a **double line** and all predicates with a **single line**,

b) putting each clause in brackets.

1. **You can preview the class schedule for the fall but cannot register yet.**

Figure 3.6 Example of Conventional Problem

As noted above, for the worked examples conditions, practice activities 2-5 in this study consisted of four pairs of practice problems, while the final practice activity consisted of 6 pairs of practice problems. Students in the conventional problem condition received 8 sentences for each of practice activities 2-5, and 12 sentences for the final practice activity.
Dependent Measures

The dependent variables of this study were learning, transfer, cognitive load, attitude, and time on task. In addition, student practice performance and the quality of self-explanations were examined to see how they were related to the subsequent learning and transfer tests. Detailed information as to how each of the variables was measured is described below.

**Learning.** Learning was measured by an achievement test created by Olina et al (2006). It consisted of 18 individual sentences without any commas inserted. For each sentence, either the FANBOYS rule, the Introductory Elements rule, or neither rule applied. None of the sentences required the use of both rules and no sentence required more than one comma. Students were required to place commas whenever appropriate for each of the sentences, or check a box next to the sentence to indicate that neither of the rules applied. One point was assigned to each sentence that students punctuated correctly. Given that the test consists of 18 sentences, the maximum score on this test was 18 points.

**Transfer.** Transfer was measured by an 18-sentence, 3-paragraph prose passage punctuated only with periods. Students were required to place commas whenever appropriate by applying the FANBOYS rule and the Introductory Elements rule. For some sentences, only one of the two comma rules applied, while for the other sentences, both or neither rules applied. One point was assigned if students punctuated a sentence correctly. The maximum score for this transfer test was 18 points.

Both the achievement test and the transfer test were adopted from Olina et al (2006). The two tests were bundled as one single test. Two identical versions of the test were used. Half of the students received version A as the pretest and version B as the posttest and vice versa for the other half of the students.

**Practice performance.** Practice performance was measured by the average score students received for practice activities 2-5 and the final practice. For the worked example conditions, one point was assigned to each paired problem that a student solved correctly. Therefore, there was a maximum of 4 points for practice activities 2-5 respectively, and a maximum of 6 points for the final practice activity. For the control
condition, the maximum score for each of the practice activities 2-5 was 8 points and for the final practice was 12 points.

**Self-explanation Correctness.** For the worked example conditions that involved self-explanation activities (i.e., WE with self-explanation condition and WE with the transitional combination of instructional explanation & self-explanation prompts condition), the number of self-explanation prompts that students responded to correctly was examined to see how these explanations relate to the subsequent performance. A two-point scale was used to score the self-explanations. For WE with self-explanation prompts condition, students were able to earn a maximum of 4 points for their self-explanations in practice activities 2-5, and a maximum of 6 points for their self-explanations in the final practice activity. In the transitional combination condition, the maximum score for student self-explanations in practice activities 2-5 was 2 points, while in the final practice activity it was 3 points, as they only needed to self-explain the first half of the practice items for each practice activity. Percentage scores were used in order to compare scores across the two conditions.

**Cognitive load.** Perceived cognitive load was measured by a single item 9-point rating scale (ranging from 1, representing *very, very low mental effort*, to 9, representing *very, very high mental effort*) developed by Paas and van Merriënboer (1994). Students were asked to use this scale to indicate the amount of mental effort they spent on (1) the practice activities at the end of each lesson, (2) the achievement test and (3) the transfer test. Previous studies have shown that this instrument is a reliable measure of perceived cognitive load (Paas, Van Merriënboer, & Adam, 1994). The test-retest reliability of this instrument in the present study was .81, which was measured using the Cronbach’s alpha.

**Attitude.** Student attitude was measured by a 12 item survey, developed by Olina et al (2006), that required students to indicate, on a four point scale, the extent to which they agreed or disagreed with each of 12 statements (See Appendix G). The first three items on the survey measured student motivation. Items 4-6 measured student perceptions of the difficulty of applying the two comma rules. Items 7-9 measured student perceptions regarding the amount of invested effort they spent on the practice exercises and on learning about the two comma rules. The last three items measured student perceptions regarding the instructional features of the instructional program.
**Time on task**: students recorded for themselves the start time and end time for each practice activity, the achievement test, and the transfer test.

**Process of Learning with Different Types of Worked Examples.** A think-aloud protocol was used to study the thinking processes of a selected pool of participants when they studied the instructional program, especially the process of how they studied the worked examples. The main purpose of using think-aloud for this study was to gain a better and more direct understanding of students’ experience with different types of worked examples during practice. The experimenter was especially interested in finding out the answers to the following questions using the think-aloud method: 1) How do students study the different types of worked examples? Are instructional explanations and self-explanation prompts useful? 2) How do students approach the example-problem pairs? What were the strategies that they use? Do they compare the paired problems with the examples and do they follow the examples to solve the problems?

As mentioned previously, four students deemed of average ability verbalized their thoughts when studying the instructional program. Each of these four students worked individually with the experimenter as the student went through the program, thinking aloud as the student did so. Each of the four students participated in six think-aloud sessions, one for each of the six lessons that were part of the instructional program. Data collected on day 1 were not used because no worked examples were involved in practice exercise 1. However, each of the four students was still asked to think aloud on that day in order for them to get accustomed to this protocol. The procedure of each think-aloud session followed that as discussed in van Someren et al. (1994) and Ericsson and Simon (1993). At the beginning of the first think-aloud session, the student received a few minutes of training using a warm-up activity consistent with the corresponding condition the student was assigned to. During the instruction, students were told to verbalize whatever was in their mind when they studied the program, without worrying about whether their thoughts were complete or comprehensible to the others (e.g., “Please study Lesson 2 and complete the following practice activity. Try to say everything that goes through your mind while you do so”). The real session did not start until a student felt comfortable enough to verbalize his/her thoughts for the task. Subsequent think-aloud sessions involved the same procedure except that no training was provided at the start of
these sessions. During the think aloud process, the author did not interfere except to say “Please keep talking” when the student stopped talking for 15 seconds.

**Classroom observations.** Classroom observations were conducted to gain a better understanding of the students’ experience with the program. The purpose of the classroom observations was mainly two-fold: 1) to see how students behave in the classroom when engaging in the program, and 2) to see if the teachers follow the Teacher Guide appropriately. A classroom observation checklist was used for all observations (see Appendix H). Brief field notes were also taken for each observed class session. Both classroom observation checklists and field notes were analyzed to identify patterns.

**Procedure**

**Pretest.**

One week before conducting the study, a 15-minute pretest was administered by the participating teachers at the beginning of one of their regular classes. Participants were randomly assigned within each class to the five treatment groups: standard WE, WE with self-explanations, WE with instructional explanations, WE with the transitional combination of instructional & self-explanations, and the conventional problem-solving (the control group). The purpose of the pretest was to ensure that the students’ level of prior knowledge was the same across treatment conditions.

At the same time, the author asked the participating teachers to select a pool of students from the sample for the qualitative part of the study. Four students in total were selected, following the three criteria below. First, the students were supposed to be average in language ability. Second, in order to minimize disruptive effects of the think aloud process, the students were supposed to be articulate (van Someren, Barnard, & Sandberg, 1994). Third, the students were supposed to be representative of the sample in terms of gender and ethnicity. In view of this, two girls and two boys were selected, with one of the students being a black student.

**Instruction**

The instruction began one week after the pretest and extended over a period of seven days. The specific instructional activities that took place each day are described below.
Day 1. Lesson 1, *Identifying Subject and Predicate*, was covered on the first day. At the beginning of the class, the teachers introduced the learning topic for the week by telling the students that they would be learning about two comma rules during the coming week. To motivate the students to proceed through the instructional program, the teachers then played the Hip Comma song and informed them that they would be hearing the song throughout the week and a competition on recalling the meaning of the key lines would be scheduled on the last day of the week. The teachers then distributed the *Hip Commas* instructional program and practice activity 1 to the students and guided them to start working on their own on Lesson 1 and the practice activity 1. All students received eight conventional problems for practice activity 1, where they practiced identifying subjects and predicates in sentences. The teachers collected the completed practice activity 1, as well as the Student Guide. The author received the completed practice activity 1 for grading.

Day 2. The second day covered Lesson 2, *Identifying Clause*. At the beginning of the class, students received their graded practice activity 1 together with the correct answer sheet. They were given a few minutes to review their answers and compare them with the correct answers. The teachers addressed their questions, if any. After that, students watched an animated PowerPoint presentation with narration that demonstrated how to study the pairs of worked examples and practice problems. (See Appendix I for the script of the animated presentation). After the presentation, the teachers distributed the Student Guide and the practice activity 2 for students to start learning and practicing clause identification. All students rated their perceived cognitive load at the end of practice activity 2. The teachers collected the completed practice activity 2 and Student Guide at the end of the class. The author received the completed practice activity 2 for grading.

Day 3. On the third day, students learned and practiced *Identifying the Type of Clause*. At the beginning of the class, students received their graded practice activity 2 together with the correct answer sheet. They were given a few minutes to review their answers and compare with the correct answers, and the teachers addressed their questions, if any. Students received their Student Guide and the practice activity 3 on identification of the type of clause. They were reminded of the PowerPoint presentation
they had watched on the previous day regarding what they would need to do for studying the pairs of worked examples and practice problems. All students rated their perceived cognitive load at the end of the practice activity 3. The teachers collected the completed practice activity 3 and Student Guide at the end of the class. The author received the completed practice activity 3 for grading.

**Day 4.** On the fourth day, students learned and practiced *Applying FANBOYS rule*. At the beginning of the class, students received their graded practice activity 3 together with the correct answer sheet. They were given a few minutes to review their answers and compare with the correct answers. The teachers addressed their questions, if any. Students then received their Student Guide and the practice activity 4. After studying the Lesson 4 instruction, they completed the practice activity 4. Again, students were reminded of what they needed to do for the practice activities. All students rated their perceived cognitive load at the end of the practice activity 4. The teachers collected the completed worksheet 4 and Student Guide at the end of the class. The author received the completed practice activity 4 for grading.

**Day 5.** On the fifth day, students learned and practiced *Applying the Introductory Element rule*. At the beginning of the class, students received the graded practice activity 4 together with the correct answer sheet. They were given a few minutes to review their answers and compare with the correct answers, and the teachers addressed their questions, if any. Again, students were reminded of what they needed to do for the practice activities. All students rated their perceived cognitive load at the end of the practice activity 5. The teachers collected the completed worksheet 5 and Student Guide at the end of the class. The author received the completed practice activity 4 for grading.

**Day 6.** On the sixth day, after spending a few minutes reviewing their graded practice activity 5, students received an additional practice activity to practice both FANBOYS rule and the Introductory Element rule. Students in the worked example groups received 6 pairs of sentences. Students in the control group received the same sentences, but presented as conventional problems and without being paired. All students rated their perceived cognitive load at the end of the practice activity. The teachers collected the completed final practice and Student Guide at the end of the class. The author received the completed final practice for grading.
Figure 3.7 Graphic overview of Procedure

**Attitude Survey & Posttest.**

On the seventh day of the study, students received the graded final practice activity with the correct answer sheet. They were given a maximum of 5 minutes to
review their answers and compare with the correct answers, and the teachers addressed their answers, if any. After that, students received a 15-minute posttest that includes both the achievement test and the transfer test. All students were asked to rate their perceived cognitive load at the end of the achievement test as well as at the end of the transfer test. Finally, students completed the 12-item survey measuring their attitude towards the instruction.

Quantitative Research Design & Data Analysis

As mentioned earlier, the research design included a 2 (presence or absence of self-explanations in worked examples) x 2 (presence or absence of instructional explanations in worked examples) factorial design resulting in four worked example treatment conditions in addition to a control group involving conventional problem solving (see Figure 3.8). It was a true experimental design, as participants were randomly assigned to the five conditions. To test the hypotheses proposed in Chapter 1, both descriptive and inferential statistics were employed to analyze the quantitative data that were collected on the proposed outcome measures: 1) learning; 2) transfer; 3) perceived cognitive load; 4) time on task; and 5) attitude.

<table>
<thead>
<tr>
<th>Worked Examples</th>
<th>Self-explanations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
</tr>
<tr>
<td>Instructional explanations</td>
<td>Present</td>
</tr>
<tr>
<td></td>
<td>Absent</td>
</tr>
</tbody>
</table>

+ Conventional Problem Solving

Figure 3.8 Overview of the Research Design
A 2x2 factorial design was used to compare the effects of the four different types of worked examples. Two-way ANOVA was used to analyze the data among the four worked example conditions. To compare the control group (conventional problems) with the other four groups, a one-way ANOVA was used to analyze the data.

**Qualitative Research Design & Data Analysis**

Student think-alouds were tape recorded and transcribed verbatim. The transcriptions were then segmented into unit of ideas, and numbers were assigned to each idea for the ease of coding. Then each segment was coded following a pre-developed coding scheme (see Figure 3.9). Some of the categories in the coding scheme were adapted from Chi et al. (1989) and Renkl (1997), and some other categories were developed by the author based on a task analysis of how the students studied the example-problem pairs. Where necessary, several segments were aggregated by episode or solution steps. The main purpose of the think-aloud protocol analysis was to better understand the student learning process with the different types of worked examples.

<table>
<thead>
<tr>
<th>Coding categories re students’ processes for studying example-practice pairs</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-monitoring-positive</td>
<td>“Ok, maybe if I found the subject and the predicate that’ll help me.”</td>
</tr>
<tr>
<td>Self-monitoring-negative</td>
<td>“Now I’m just sort of rambling…”</td>
</tr>
<tr>
<td>Self-explanations for practice problems</td>
<td>“ok, um, there is only...// the subject is I, // should remove...the blackberry pie from the oven and enjoy it later is the predicate. // So the clause is the whole sentence//”</td>
</tr>
<tr>
<td>Attend to example sentence</td>
<td>“You you can preview the class schedule for the fall but cannot register yet”. //</td>
</tr>
<tr>
<td>Note the essential sentence structure in example</td>
<td>Subject you, // predicate can preview the class schedule for the fall but cannot register. //</td>
</tr>
</tbody>
</table>

Figure 3.9 Coding scheme for think-aloud protocols
<table>
<thead>
<tr>
<th>Coding categories re students’ processes for studying example-practice pairs</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attend to instructional explanations</td>
<td>“In the example sentence below, there is one subject-predicate pair. Therefore, there is one clause” //</td>
</tr>
<tr>
<td>Attend to self-explanation questions</td>
<td>“In the example sentence below, how many subject-predicate pairs are there?” //</td>
</tr>
<tr>
<td>Explain the choice of self-explanation prompts</td>
<td>“One subject, one predicate, therefore, there’s one”. //</td>
</tr>
<tr>
<td>Attend to problem-solving instruction</td>
<td>“Put brackets around each clause in the sentence below. Use the example sentence in the box on the left to help you” //</td>
</tr>
<tr>
<td>Compare the problem with paired example</td>
<td>“I’m going to look back at the study part so I can do…”</td>
</tr>
</tbody>
</table>

Figure 3.9 Continued
CHAPTER 4

DATA ANALYSES AND RESULTS

Quantitative Data Analyses and Results

As noted in Chapter 1, the general research questions this study intended to investigate were: 1) Do worked examples improve learning and transfer as compared to conventional problems?; and 2) Do explanations, either instructional explanations, self-explanation prompts, or the transitional combination of the two, improve the effect of standard worked examples?. The dependent variables examined in this study included: (a) learning; (b) transfer; (c) cognitive load during practice, learning and transfer; (d) time on task for practice and on the posttest test; and (e) student attitude.

In order to examine the first research question, a series of one-way ANOVAs were conducted. In addition, the effects of the four different worked example approaches were examined using a series of 2 (presence or absence of self-explanation prompts) x 2 (presence or absence of instructional explanations) ANOVAs.

Prior to conducting the aforementioned analyses, preliminary analyses were carried out to check for outliers and to ensure that the assumptions for the parametric statistics used in this study were met. Independence of observations, homogeneity of variance, and normal distribution assumptions were examined. Generally speaking, most assumptions were satisfied, and no outliers were excluded from the study. In addition, there were no differences between the groups with respect to the pretest scores. For more detailed information with regard to the preliminary analyses, refer to Appendix J.

Presented below are the results of the study. These results are organized according to dependent variable, and then further organized according to the two research questions mentioned above.

**Learning**

**Conventional Problems Condition vs. Worked Examples Conditions.** Learning was measured by the achievement test consisting of 18 individual sentences where...
students were asked to insert commas as necessary. A one-way between-group ANOVA revealed that the average score of the students in the four worked example conditions ($M = 11.62, SD = 2.82$) was not significantly different from the average score of the students in the conventional problems group ($M = 11.63, SD = 3.13$), $F(1, 183) = .01, p = .927$.

Comparison Between Various Worked Example Conditions. Following the one-way ANOVA analyses, a two-way between groups ANOVA, with instructional explanations and self-explanation prompts as the factors, was conducted to examine the relative effects of the four worked example approaches. The mean scores of the students in these conditions are presented in Table 4.1. The results revealed a significant interaction between instructional explanations and self-explanation prompts, $F(1, 144) = 5.90, p = .02$. No main effect was found for either instructional explanations, $F(1, 144) = 1.02, p = .356$, or for self-explanation prompts, $F(1, 144) = .001, p = .97$. The effect of instructional explanations and self-explanation prompts on learning was also examined using the pretest as a covariate, and the same result pattern was obtained (i.e., significant interaction effect without main effect). A visual representation of this interaction is provided in Figure 4.1. Follow-up simple main effects analysis showed that when self-explanation prompts were not provided, students who received instructional explanations learned more (as measured by the achievement test) than students who did not receive instructional explanations, $F(1, 144) = 5.8, p = .017$.

Table 4.1
Mean Scores and Standard Deviations on Achievement Test

<table>
<thead>
<tr>
<th>Worked Examples</th>
<th>Self-explanation prompts</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td></td>
<td>$M$ $SD$</td>
<td>$M$ $SD$</td>
</tr>
<tr>
<td>Instructional explanations</td>
<td>Present 11.33 (3.16)</td>
<td>12.44 (2.19)</td>
</tr>
<tr>
<td></td>
<td>Absent 11.80 (3.01)</td>
<td>10.89 (2.90)</td>
</tr>
<tr>
<td></td>
<td>Overall 11.71 (3.02)</td>
<td>11.68 (2.66)</td>
</tr>
</tbody>
</table>

Note: Maximum score = 18
Table 4. 2
Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Learning

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>η²</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional Explanations (IE)</td>
<td>1</td>
<td>.86</td>
<td>.01</td>
<td>.356</td>
</tr>
<tr>
<td>Self-explanation prompts (SE)</td>
<td>1</td>
<td>.001</td>
<td>.00</td>
<td>.97</td>
</tr>
<tr>
<td>IE x SE</td>
<td>1</td>
<td>5.90</td>
<td>.04</td>
<td>.02*</td>
</tr>
<tr>
<td>error</td>
<td>144</td>
<td>(7.81)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Values enclosed in parentheses represent mean square errors. *p<.05

Figure 4.1 Instructional explanations by self-explanation prompts interaction on learning
Transfer

Conventional Problems Condition vs. Worked Examples Conditions. Transfer was measured by a three-paragraph prose passage where students were required to place commas wherever appropriate. A one-way ANOVA revealed that the average score of the students in the conventional problems condition ($M=11.35, SD=3.13$) was not significantly different from the average score of the students in the four worked example conditions ($M=10.78, SD=3.5$), $F(1,184) = .68, p=.409$.

Comparison Between Various Worked Example Conditions. See Table 4.3 for the means and standard deviations for each of the worked example conditions. A two-way ANOVA of this data revealed a significant interaction between instructional explanations and self-explanation prompts, $F(1,145)=5.19, p=.024$. The effect of instructional explanations and self-explanation prompts on transfer was also examined using the pretest as a covariate, and the same result pattern was obtained (i.e., significant interaction effect without main effect). Figure 4.2 below is a visual representation of this interaction effect. The follow-up simple effect analysis showed that when self-explanation prompts were not provided, students who received instructional explanations performed better on the transfer test than students who did not receive instructional explanations [$F(1,145)=4.18, p=.04$]. The main effect for self-explanation prompts [$F(1,145)=.34, p=.56$] and for instructional explanations [$F(1,145)=.033, p=.86$] did not reach statistical significance. See Table 4.4 for a summary of the two-way ANOVA results on transfer.

Table 4.3
Mean Scores and Standard Deviations on Transfer

<table>
<thead>
<tr>
<th>Worked Examples</th>
<th>Self-explanation Prompts</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>SD</td>
</tr>
<tr>
<td>Instructional explanations</td>
<td>Present</td>
<td>10.41</td>
</tr>
<tr>
<td></td>
<td>Absent</td>
<td>11.10</td>
</tr>
<tr>
<td>Overall</td>
<td>10.93</td>
<td>(3.42)</td>
</tr>
</tbody>
</table>

*Note: Values enclosed in parentheses represent standard deviations. Maximum score =18*
Figure 4.2 Instructional explanations by self-explanation prompts interaction on transfer

Table 4.4
Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Transfer

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Between subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional Explanations</td>
<td>1</td>
<td>.34</td>
<td>.002</td>
<td>.56</td>
</tr>
<tr>
<td>(IE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-explanation prompts (SE)</td>
<td>1</td>
<td>.03</td>
<td>.000</td>
<td>.86</td>
</tr>
<tr>
<td>IE x SE</td>
<td>1</td>
<td>5.19</td>
<td>.04</td>
<td>.02</td>
</tr>
<tr>
<td>error</td>
<td>145</td>
<td>(12.22)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Values enclosed in parentheses represent mean square errors.
Cognitive Load During Practice

Cognitive load during practice was measured by having students respond at the end of each practice exercise to a one-item 9-point rating scale (ranging from 1, representing very, very low mental effort, to 9, representing very, very high mental effort) developed by Paas and van Merriënboer (1994). For each student, his or her self-reported cognitive load score on each of practice exercises 2 through 6 was averaged together to serve as an indicator of the student’s cognitive load during the practice exercises. Cognitive load during practice exercise 1 was not included because every student received the same version of this exercise regardless of the treatment condition the student was assigned to.

Conventional Problem Condition vs. Worked Examples Conditions. The mean cognitive load score on the practice exercises for students in the conventional problem condition was 4.72 (SD = 1.49), whereas the mean score for the students in the four worked example conditions was 4.38 (SD = 1.87). A one-way ANOVA revealed no differences between these average cognitive load ratings, $F(1,173) = .69, p = .41$.

Comparison Between Various Worked Example Conditions. Mean scores and standard deviations of cognitive load during practice for each of the worked example conditions are provided in Table 4.5. The results of a two-way ANOVA revealed significant main effects for both the instructional explanation factor, $F(1, 137) = .437, p = .04$, and the self-explanation factor, $F(1, 137) = 8.0, p = .01$. The results showed that 1) students presented with self-explanation prompts during practice reported higher cognitive load than those who did not receive such prompts; and 2) students presented with instructional explanations reported lower cognitive load than those who did not receive such explanations. No significant interaction was found, $F(1, 137) = .54, p = .46$. 

52
Table 4.5
Mean Scores and Standard Deviations on Cognitive Load during Practice

<table>
<thead>
<tr>
<th>Worked Examples</th>
<th>Self-explanation prompts</th>
<th></th>
<th>Overall</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Instructional explanations Present</td>
<td>4.61 (1.82)</td>
<td>3.95 (1.91)</td>
<td>4.28 (1.88)</td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>5.49 (1.87)</td>
<td>4.38 (1.87)</td>
<td>4.92 (1.94)</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>5.04 (1.89)</td>
<td>4.16 (1.89)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Maximum score = 9 (1 = very, very low mental effort, 9 = very, very high mental effort)

Table 4.6
Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Cognitive Load during Practice

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>η²</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional Explanations (IE)</td>
<td>1</td>
<td>4.37</td>
<td>.031</td>
<td>.039</td>
</tr>
<tr>
<td>Self-explanation prompts (SE)</td>
<td>1</td>
<td>7.96</td>
<td>.055</td>
<td>.005</td>
</tr>
<tr>
<td>IE x SE</td>
<td>1</td>
<td>.54</td>
<td>.004</td>
<td>.464</td>
</tr>
<tr>
<td>error</td>
<td>137</td>
<td>(3.49)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Values enclosed in parentheses represent mean square errors.

Cognitive Load During Learning and Transfer

Student cognitive load during learning was measured by having students respond at the end of the achievement test to the same one-item 9-point rating scale used during practice. In a similar manner, cognitive load during transfer test was measured by having students respond at the end of the transfer test to this one-item 9-point scale.

Conventional Problem Condition vs. Worked Examples Conditions. A one-way ANOVA revealed that, with regard to cognitive load during the achievement test, the
average cognitive load rating among students in the conventional problem solving group ($M=4.72$, $SD=2.18$) was not significantly different from that of students in the worked example groups ($M=5.07$, $SD=2.06$), $F(1, 180)=.91, p=.34$. Similarly, no difference was found on perceived cognitive load rating during the transfer test between the conventional problems approach ($M=5.38$, $SD=2.0$) and the worked example approaches ($M=5.26$, $SD=2.16$), $F(1, 180)=.08, p=.77$.

Comparison Between Various Worked Example Conditions. Mean scores and standard deviations of perceived cognitive load for each worked example condition are provided in Table 4.7 for the achievement test, and in Table 4.8 for the transfer test. A two-way ANOVA revealed neither treatment condition had a significant effect on perceived cognitive load on the achievement test, or on the transfer test. Moreover, there was no interaction effect between the factors of instructional explanations and self-explanation prompts on learning, $F(1,142)=.40, p=.53$, or on transfer, $F(1, 139)=.26, p=.61$. See Table 4.9 and Table 4.10 below for a summary of the two-way ANOVA results regarding cognitive load for learning and transfer, respectively.

Table 4.7
Mean Scores and Standard Deviations on Cognitive Load during the Achievement Test

<table>
<thead>
<tr>
<th>Worked Examples</th>
<th>Self-explanation prompts</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>Instructional explanations</td>
<td>Present</td>
<td>5.16</td>
</tr>
<tr>
<td></td>
<td>Absent</td>
<td>5.53</td>
</tr>
<tr>
<td>Overall</td>
<td>5.38</td>
<td>(2.07)</td>
</tr>
</tbody>
</table>

*Note. Maximum score =9 (1 = very, very low mental effort, 9 = very, very high mental effort)*
Table 4.8
Mean Scores and Standard Deviations on Cognitive Load during the Transfer Test

<table>
<thead>
<tr>
<th>Worked Examples</th>
<th>Self-explanation prompts</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td></td>
<td>M    SD</td>
<td>M    SD</td>
</tr>
<tr>
<td>Instructional</td>
<td>5.22 (2.03)</td>
<td>4.90 (1.89)</td>
</tr>
<tr>
<td>explanations</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td></td>
<td>5.76 (2.45)</td>
<td>5.14 (2.30)</td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.54 (2.26)</td>
<td>5.01 (2.09)</td>
</tr>
</tbody>
</table>

*Note. Maximum score = 9 (1 = very, very low mental effort, 9 = very, very high mental effort)*

Table 4.9
Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Perceived Cognitive Load for Learning

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>η²</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional Explanations</td>
<td>1</td>
<td>.29</td>
<td>.002</td>
<td>.59</td>
</tr>
<tr>
<td>(IE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-explanation prompts (SE)</td>
<td>1</td>
<td>2.61</td>
<td>.018</td>
<td>.11</td>
</tr>
<tr>
<td>IE x SE</td>
<td>1</td>
<td>.40</td>
<td>.003</td>
<td>.53</td>
</tr>
<tr>
<td>error</td>
<td>142</td>
<td>(4.37)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Values enclosed in parentheses represent mean square errors.*
Table 4.10
Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Perceived Cognitive Load for Transfer

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>η²</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional Explanations</td>
<td>1</td>
<td>1.38</td>
<td>.01</td>
<td>.24</td>
</tr>
<tr>
<td>(IE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-explanation prompts (SE)</td>
<td>1</td>
<td>1.94</td>
<td>.01</td>
<td>.17</td>
</tr>
<tr>
<td>IE x SE</td>
<td>1</td>
<td>.26</td>
<td>.002</td>
<td>.61</td>
</tr>
<tr>
<td>error</td>
<td>139</td>
<td>(4.73)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Values enclosed in parentheses represent mean square errors.

**Time on Task During Practice**

Mean practice time for practice exercises 2 through 6 was used as an indicator of time on task during practice. Practice time during practice exercise 1 was not included because every student received the same version of this exercise regardless of the treatment conditions the student was assigned to.

**Conventional Problem Condition vs. Worked Examples Conditions.** A one-way ANOVA between the conventional problems approach and the four worked example approaches revealed that the average time spent by the students in the conventional problems group (\(M=2.81\) minutes, \(SD=1.49\)) was not significantly different from the average time spent by the students in the worked example conditions (\(M=3.35\) minutes, \(SD=1.37\)), \(F(1, 138)=3.26, p=.07\).

**Comparison Between Various Worked Example Conditions.** Means and standard deviations of time on task for each worked example condition during practice are provided in Table 4.11 below. A two-way ANOVA on time on task during practice did not find a statistically significant interaction effect between instructional explanations and self-explanation prompts, \(F(1, 130)=.18, p=.67\). However, there was a main effect for self-explanation prompts, \(F(1, 130)=10.34, p=.002\); students who received self-explanation prompts spent significantly more time during practice than students who did not receive such prompts. The main effect for instructional explanations did not reach
statistical significance, $F (1, 130)=1.20, p=.28$. Table 4.12 below is a summary of the two-way ANOVA results with regard to time on task during practice.

Table 4.11
Means and Standard Deviations on Time on Task during Practice

<table>
<thead>
<tr>
<th>Worked Examples</th>
<th>Self-explanation prompts</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Instructional Explanations</td>
<td>3.56 (1.15)</td>
<td>2.85 (1.22)</td>
</tr>
<tr>
<td>Absent</td>
<td>3.95 (1.78)</td>
<td>3.02 (1.31)</td>
</tr>
<tr>
<td>Overall</td>
<td>3.75 (1.49)</td>
<td>2.93 (1.26)</td>
</tr>
</tbody>
</table>

Note. Time was measured in minutes.

Table 4.12
Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Time on Task during practice

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional Explanations (IE)</td>
<td>1</td>
<td>1.20</td>
<td>.01</td>
<td>.28</td>
</tr>
<tr>
<td>Self-explanation prompts (SE)</td>
<td>1</td>
<td>10.34</td>
<td>.09</td>
<td>.002</td>
</tr>
<tr>
<td>IE x SE</td>
<td>1</td>
<td>.18</td>
<td>.002</td>
<td>.67</td>
</tr>
<tr>
<td>error</td>
<td>130</td>
<td>(1.89)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Values enclosed in parentheses represent mean square errors.

**Time on Task on the Posttest (Achievement and Transfer tests Combined)**

Given that both the achievement test and the transfer test were handed out to students as one “package” of posttest materials, the amount of time each student spent on
the posttest was collected, but the amount of time the students spent on each of the two portions of that posttest (i.e., the achievement test and the transfer test) was not measured. Thus, the results reported below refer to time spent on the entire posttest, not on the individual parts.

Conventional Problem Condition vs. Worked Examples Conditions The average time spent on the posttest among students in the conventional problems group was 10.32 minutes ($SD=4.09$), whereas the average time spent among students in the four worked examples groups was 9.82 minutes ($SD=2.99$). A one-way ANOVA revealed that there was no significant difference in the average time spent on the posttest among students in these two conditions, $F (1, 166) =.69, p=.41$.

Comparison Between Various Worked Example Conditions. Means and standard deviations of time on task during the posttest for each of the four worked example conditions are provided in Table 4.13. A two-way ANOVA on time on task during the posttest revealed neither a main effect for instructional explanations, $F (1, 130) =.39, p=.53,$ nor for self-explanation prompts, $F (1, 130)=.84, p=.36,$ nor was there a significant interaction between the two variables, $F (1, 130)=.72, p=.40$. Presented in Table 4.14 below is a summary of the two-way ANOVA results with regard to time on task on the posttest.

<table>
<thead>
<tr>
<th>Worked Examples</th>
<th>Self-explanation prompts</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Instructional explanations</td>
<td>Present</td>
<td>10.00 (2.81)</td>
</tr>
<tr>
<td></td>
<td>Absent</td>
<td>9.20 (2.58)</td>
</tr>
<tr>
<td>Overall</td>
<td>9.55 (2.92)</td>
<td>10.06 (3.05)</td>
</tr>
</tbody>
</table>

*Note.* Time was measured in minutes.
### Table 4.14
Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Time on Task during the Achievement and Transfer Test

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional Explanations</td>
<td>1</td>
<td>.39</td>
<td>.003</td>
<td>.53</td>
</tr>
<tr>
<td>(IE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-explanation prompts</td>
<td>1</td>
<td>.84</td>
<td>.006</td>
<td>.36</td>
</tr>
<tr>
<td>(SE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IE x SE</td>
<td>1</td>
<td>.72</td>
<td>.005</td>
<td>.40</td>
</tr>
<tr>
<td>error</td>
<td>130</td>
<td>(8.97)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Values enclosed in parentheses represent mean square errors.

### Student Attitude

Student attitude was measured at the end of the Hip Hop program with a 12-item survey measuring (a) the motivation of students, (b) student perceptions about task difficulty, (c) the effort the students exerted, and (d) student reactions to features of the program.

**Conventional Problem Condition vs. Worked Examples Conditions.** Table 4.15 provides student mean responses to the attitude survey by treatment group. For each of the four aforementioned subscales, a one-way ANOVA was used to compare the average responses of the students in the conventional problems condition with the average responses of the students in the four worked examples conditions. To reduce the risk of type I error that may have resulted from conducting these multiple tests, alpha value was adjusted to the .017 level using the Dunn-Sidák method. The tests indicated no differences between the conventional problems group and the worked example groups on motivation $F(1, 168)=1.19$, $p=.28$, task difficulty, $F(1, 167)=.95$, $p=.33$, effort, $F(1, 170)=.90$, $p=.34$, and program features $F(1, 166)=.61$, $p=.43$.

**Comparison Between Various Worked Example Conditions.** Table 4.16 through Table 4.19 provide the mean responses and standard deviations on each subscale for each of the four worked example conditions.
### Table 4.15
Mean Responses to Student Attitude Survey by Group

<table>
<thead>
<tr>
<th>Survey items</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conventional</td>
</tr>
<tr>
<td>1. I liked studying about comma rules.*</td>
<td>2.47 (.75)</td>
</tr>
<tr>
<td>2. The <em>Hip Comma</em> program was interesting.</td>
<td>2.62 (.89)</td>
</tr>
<tr>
<td>3. I am confident that I can now apply the two comma rules to sentences.</td>
<td>2.94 (.61)</td>
</tr>
<tr>
<td>4. I had a hard time understanding how to apply comma rules to sentences.**</td>
<td>2.82 (.76)</td>
</tr>
<tr>
<td>5. To really learn how to apply comma rules to sentences, I had to work hard.**</td>
<td>2.76(.82)</td>
</tr>
<tr>
<td>6. Studying the <em>Hip Comma</em> program in class, by myself, was a difficult way to learn.**</td>
<td>3.09 (.83)</td>
</tr>
<tr>
<td>7. I carefully studied the explanations and examples.</td>
<td>3.12 (.73)</td>
</tr>
<tr>
<td>8. I completed the practice exercises to the best of my ability.</td>
<td>3.32 (.68)</td>
</tr>
<tr>
<td>9. I did my best to learn about comma rules.</td>
<td>3.15 (.82)</td>
</tr>
<tr>
<td>10. The explanations in the program were clear to me.</td>
<td>2.94 (.75)</td>
</tr>
<tr>
<td>11. The practice exercises helped me learn the comma rules.</td>
<td>2.97 (.78)</td>
</tr>
<tr>
<td>12. The tasks that I had to complete each day in the program were clear to me.</td>
<td>2.97 (.77)</td>
</tr>
</tbody>
</table>

* All items measured on a four-point scale: 4 (strongly agree), 3 (agree), 2 (disagree), and 1 (strongly disagree).

** Items 4, 5, 6 were reverse-scored.
Table 4.16
Mean Scores and Standard Deviations for Motivation Subscale

<table>
<thead>
<tr>
<th>Worked Examples</th>
<th>Self-explanation prompts</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Instructional</td>
<td>Present</td>
<td>2.78 (.54)</td>
</tr>
<tr>
<td>explanations</td>
<td>Absent</td>
<td>2.76 (.64)</td>
</tr>
<tr>
<td>Overall</td>
<td>2.77 (.59)</td>
<td>2.81 (.63)</td>
</tr>
</tbody>
</table>

*Note: All items measured on a four-point scale: 4 (strongly agree), 3 (agree), 2 (disagree), and 1 (strongly disagree).*

Table 4.17
Mean Scores and Standard Deviations for Task Difficulty Subscale

<table>
<thead>
<tr>
<th>Worked Examples</th>
<th>Self-explanation prompts</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Instructional</td>
<td>Present</td>
<td>2.33 (.67)</td>
</tr>
<tr>
<td>explanations</td>
<td>Absent</td>
<td>2.26 (.83)</td>
</tr>
<tr>
<td>Overall</td>
<td>2.29 (.75)</td>
<td>2.17 (.63)</td>
</tr>
</tbody>
</table>

*Note: All items measured on a four-point scale: 4 (strongly agree), 3 (agree), 2 (disagree), and 1 (strongly disagree).*
Two-way ANOVAs on each of the four subscales revealed no significant main effects for either the instructional explanations condition or the self-explanation prompts condition. Moreover, a significant interaction effect between the two factors did not occur in any of the four instances. Tables 4.20 to Table 4.23 provide detailed statistics resulting from the two-way ANOVA analyses.
Table 4.20
Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Motivation Subscale

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional Explanations</td>
<td>1</td>
<td>.067</td>
<td>.000</td>
<td>.80</td>
</tr>
<tr>
<td>(IE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-explanation prompts (SE)</td>
<td>1</td>
<td>.17</td>
<td>.001</td>
<td>.68</td>
</tr>
<tr>
<td>IE x SE</td>
<td>1</td>
<td>.000</td>
<td>.000</td>
<td>.99</td>
</tr>
<tr>
<td>error</td>
<td>136</td>
<td>(.38)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Values enclosed in parentheses represent mean square errors.

Table 4.21
Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Task Difficulty Subscale

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional Explanations</td>
<td>1</td>
<td>.38</td>
<td>.003</td>
<td>.54</td>
</tr>
<tr>
<td>(IE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-explanation prompts (SE)</td>
<td>1</td>
<td>1.08</td>
<td>.008</td>
<td>.30</td>
</tr>
<tr>
<td>IE x SE</td>
<td>1</td>
<td>.000</td>
<td>.000</td>
<td>.99</td>
</tr>
<tr>
<td>error</td>
<td>134</td>
<td>(.48)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Values enclosed in parentheses represent mean square errors.
Table 4.22
Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Invested Effort Subscale

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>( \eta^2 )</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional Explanations (IE)</td>
<td>1</td>
<td>.054</td>
<td>.000</td>
<td>.82</td>
</tr>
<tr>
<td>Self-explanation prompts (SE)</td>
<td>1</td>
<td>.001</td>
<td>.000</td>
<td>.98</td>
</tr>
<tr>
<td>IE x SE</td>
<td>1</td>
<td>.36</td>
<td>.003</td>
<td>.55</td>
</tr>
<tr>
<td>error</td>
<td>137</td>
<td>(.39)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Values enclosed in parentheses represent mean square errors.*

Table 4.23
Summary of Two-Way Analysis of Variance for Instructional Explanations x Self-explanation Prompts in Program Features Subscale

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>( \eta^2 )</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional Explanations (IE)</td>
<td>1</td>
<td>1.48</td>
<td>.011</td>
<td>.23</td>
</tr>
<tr>
<td>Self-explanation prompts (SE)</td>
<td>1</td>
<td>.43</td>
<td>.003</td>
<td>.51</td>
</tr>
<tr>
<td>IE x SE</td>
<td>1</td>
<td>.40</td>
<td>.003</td>
<td>.53</td>
</tr>
<tr>
<td>error</td>
<td>135</td>
<td>(.38)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Values enclosed in parentheses represent mean square errors.*

**Other Research Findings**

In addition to the effects of the treatment conditions on each of the dependent variables discussed previously, this study was also intended to examine 1) student practice performance across treatment conditions, as well as 2) the relationship between student self-explanation quality and the subsequent learning/transfer performance, with the aim to see if the results would help interpret the above findings.
**Practice performance.** Practice performance was measured by the mean percentage scores students received for practice activities 2-6. Mean Scores and Standard Deviations for Practice Performance are presented in Table 4.24 below. One-way ANOVA was used to detect differences between the treatment conditions, if any. As the assumption of homogeneity of variances was violated for this variable, the Brown-Forsythe modification of Levene test statistics, rather than the omnibus-F ration test, was used for the main ANOVA analysis.

Brown-Forsythe statistics obtained from the ANOVA analysis showed that significant differences existed (p < .01) between the treatment conditions. The follow-up Games-Howell multiple comparisons revealed that the differences existed between the conventional problem approach versus each of the worked example approaches. In each case, students in each of the worked example conditions performed significantly better during practice than students in the conventional problem condition. There were no significant differences in the number of practice problems answered correctly among students in any of the four worked examples conditions.

<table>
<thead>
<tr>
<th>Types of Instruction</th>
<th>Mean Number of Practice Items Correct</th>
<th>Mean Percentage Correct</th>
<th>Standard Deviation (in percentage terms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WE with both instructional explanations and self-explanation prompts</td>
<td>16.81</td>
<td>.76</td>
<td>.17</td>
</tr>
<tr>
<td>WE with Instructional explanations</td>
<td>17.83</td>
<td>.81</td>
<td>.17</td>
</tr>
<tr>
<td>WE with self-explanation prompts</td>
<td>14.81</td>
<td>.67</td>
<td>.26</td>
</tr>
<tr>
<td>Standard WE</td>
<td>16.49</td>
<td>.75</td>
<td>.22</td>
</tr>
<tr>
<td>Conventional Problems</td>
<td>21.11</td>
<td>.48</td>
<td>.15</td>
</tr>
</tbody>
</table>

*Note. Number of practice items = 22 for each of the worked example conditions. Number of practice items=44 for conventional problems condition.*
**Correlation between self-explanation and performance.** The number of self-explanation prompts that students responded to correctly was examined in order to see if it was related to student performance on the achievement test and the transfer test.

Students in the treatment group that received instructional explanations along with self-explanation prompts were required to respond to self-explanation prompts for 11 items, so the maximum number of points that students in that condition could earn for their self-explanations was 11 points. Students in the treatment group that received self-explanation prompts but no instructional explanations were required to respond to self-explanation prompts for 22 items and thus could earn a maximum of 22 points for their self-explanations. Given that the number of points the two groups could receive was different, the mean percentage scores students received for their responses to the self-explanation prompts were compared. On average, students in the WE with both instructional explanations and self-explanation prompts condition received 53% of the possible points for their self-explanation prompts, whereas students in the WE with self-explanation prompts only condition received 68% of the points possible. It should be noted these average percentage scores were not compared across groups. Rather, each student’s percentage score was paired with his or her score on the achievement test and transfer test to arrive at correlations between the number of self-explanation prompts that students correctly responded to and performance on (a) the achievement test and (b) the transfer test.

As the assumption for normality was violated for the variable of self-explanation quality, Spearman’s Rank Order Correlation, the non-parametric alternative to Pearson’s product-moment correlation, was used to assess the relationship between the two specified variables. The results revealed that self-explanation quality was positively related to both student learning \[r=.56, n=60, p<.01\] and transfer \[r=.44, n=61, p<.01\].

**Qualitative Data Analyses and Results**

**Classroom Observations**

Classroom observations were conducted for 49 class sessions in total. Each class session was 42 minutes long, and the experiment was conducted during the first 20-30
minutes for each session. An observation rubric (See Appendix H) was used for all observations to see whether experimental procedures were appropriately carried out and how students reacted to the program in general. In addition, brief observation notes were taken to note the time for each main class activity and to record students’ noteworthy behaviors during the class sessions. No coding schema was developed for analyzing the data that were obtained based on the observation rubric and observation notes; rather, these data were scrutinized by the author to see if any pattern would emerge.

Generally speaking, it was observed that for the most part, all three teachers who participated in the study followed the procedures delineated in the Teacher Guide. However, there were at least two differences between teachers in the way in which they administered some aspects of the program. One inconsistency concerned the use of the hip hop comma song that was part of the program. The song was played on each day at the beginning of the class to serve as a mnemonic device to help students recall the comma rules. It seemed that some students liked the song and liked to sing along with it while the song was being played. Whereas two of the teachers encouraged their students to do so, the other teacher discouraged such behaviors by asking students to sit and listen quietly. The second inconsistency involved the amount of time one of the teachers allowed students to review their previous days practice exercises. Beginning with the fourth day of the experiment, this teacher seemed a bit rushed; for each of the remaining days of the study she provided less than the recommended amount of time for the students to review their previous-day practice exercises, giving them approximately 1-2 minutes per day, rather than the 5 minutes that had been planned for.

With regard to student reactions during the class sessions, they were generally attentive to the tasks they were supposed to do. However, it seemed that some of the students did not fully focus on the task when they were supposed to review their answers to the previous day’s practice exercise. Instead of carefully comparing their answers with the correct answers provided on a separate sheet, they seemed more interested in just counting the number of items that were marked as correct on their exercise worksheets. During this activity, it was observed that some students very quickly turned over each page of their scored practice items, looking just at the scoring rather than reviewing their answers. Even though some of their answers were marked as incorrect, those students
seemed not interested in knowing why their answers were wrong and how to correct them.

**Process of Learning with Different Types of Worked Examples**

Another qualitative data source for this study was the think-aloud protocols that were conducted with a small subset of the students. As noted in chapter 3, based on a set of pre-determined criteria, four students from the sample were selected and were asked to verbalize their thoughts while studying the program. All four students, Sarah, Alex, Roy, and Chris, were 8th graders enrolled in one of the nine Language Arts classes. The four students were randomly assigned to one of the four worked example conditions, and each of them participated in five think-aloud sessions, one for each of the five lessons that were part of the instructional program.

During the sessions, student verbal utterances were recorded using a digital voice recorder. Student physical behaviors, such as glancing at the paired example while solving the practice problem, were noted by the author on a notepad. In addition, short interviews were conducted with each of the four students after the final think-aloud session, which were also recorded. The think-aloud data were transcribed and coded following a coding schema developed by the author (see Chapter 3 for the details), who was responsible for conducting all of the think aloud sessions. The interview data were also scrutinized to see if any patterns emerged.

By using the think-aloud method, it was hoped to gain a better and more direct understanding of student experience with the different types of worked examples. More specifically, answers to the following questions were sought: 1) How do students study the different types of worked examples? How do they use the instructional explanations and/or self-explanation prompts? 2) How do students approach the example-problem pairs? What were the strategies that they use? Do they compare the paired problems with the examples and do they follow the examples to solve the problems? The information below addresses these questions.

Generally speaking, based on how they worked through the practice problems, all of the four students seemed to have no difficulty understanding how the “worked example-practice item” format of the practice problems was meant to be used (that is, study the materials on the left hand box, completing any questions listed there; then
respond to the questions in the right hand box, referring back to the left hand box as necessary). However, the manner in which the students actually studied the worked example-practice item pairs differed across individuals, as described below. Detailed information regarding the performance of each of these students on each of the practice items, as well as on the achievement and transfer pretests and posttests, is contained in Tables 4.25 - 4.30 (see Appendix K).

**Standard WE student.** Sarah was a Caucasian female student enrolled in an 8th grade Language Arts class. She received standard worked examples without any instructional explanations or self-explanation prompts.

How did Sarah use the worked examples? Oftentimes, even though she read the example sentences, it appeared that Sarah did not actually heed the other information (e.g., identification of independent and dependent clauses) that accompanied those sentences. Indeed, in 11 cases (out of the 22 practice items she had to respond to), Sarah appeared to quickly read the example sentence in the left box and then turn immediately to the right box to solve the practice problems, seeming to fail to spend enough time on the “solution steps” provided in the worked examples on the left.

In addition, Sarah’s score on the practice exercises was lower than that of any of the other three students involved in the think-aloud sessions. Only 55% of her responses (12 out of 22) to the paired practice problems were correct. Presented below are the types of errors Sarah made for the practice items she completed.

<table>
<thead>
<tr>
<th>Types of error</th>
<th>Number of accounts</th>
<th>Practice Exercise Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mistakenly identified object-functioning nouns as subject</td>
<td>3</td>
<td>Exercise 2: Identifying clause (a clause contains a subject-predicate pair)</td>
</tr>
<tr>
<td>Failed to recognize the conjunction “since” as part of an dependent clause</td>
<td>1</td>
<td>Exercise 3: Identifying dependent and independent clauses</td>
</tr>
<tr>
<td>Mistakenly identified an independent clause as a dependent clause</td>
<td>1</td>
<td>Exercise 3: Identifying dependent and independent clauses</td>
</tr>
<tr>
<td>Mistakenly thought that FANBOYS words would separate two clauses</td>
<td>2</td>
<td>Exercise 3: Identifying dependent and independent clauses</td>
</tr>
<tr>
<td>Failed to apply the FANBOYS rule</td>
<td>1</td>
<td>Exercise 4: Applying the FANBOYS rule</td>
</tr>
</tbody>
</table>
Out of the 10 cases where she solved a practice problem incorrectly, in eight instances Sarah seemed to just read the example sentences without carefully attending to the other information in the worked example. For example, in practice exercise 2 on identifying a clause, she correctly put each clause in brackets (final solution) as required; however, in 3 out of the 4 practice items in this exercise, she incorrectly identified each noun in the sentence, including those object-functioning nouns as subjects (solution steps). In all these cases, she read the worked examples quickly and then turned to the right box for the practice items, failing to attend to the solution steps information at all, as in one case, or attending to only part of the solution steps information, as in the other three cases. By so doing, it seemed that she failed to recognize the similarity between the worked examples and the paired practice problems. On the other hand, while solving the practice items, Sarah did refer back to the paired worked examples four times by quickly glancing at the left box. It was interesting to note, though, that in two of those cases, she did not solve the practice item correctly even though she refereed back to the paired worked examples.

WE with IE student. Alex was an African-American male student enrolled in an 8th grade Language Arts class. He received worked examples with instructional explanations.

Alex’s strategy for studying the worked examples with instructional explanations was quite interesting. In general, he appeared to study the worked examples carefully by attending to both the instructional explanations and the “solution steps” information in the worked examples. However, about 18% of the time (4 out of 22 cases), he seemed to totally ignore the instructional explanations provided above the worked examples. In those cases, he skipped instructional explanations and proceeded directly to the information contained in the worked examples themselves. He explained in the follow-up interview that he sometimes intentionally ignored that information “because it’s basically telling you the same thing as it does down here [meaning in the worked example itself]. It’s just putting it in shorter terms, so I read it down here instead of up there [meaning
the instructional explanations]. Whether this point of view is accurate or not will be discussed in the next chapter of this dissertation.

With regard to his behaviors while solving the practice problems in the example-problem pairs, Alex referred back to the paired worked examples in four cases and answered most (20 of 22) of the practice items correctly. For the two cases where he incorrectly solved the practice items, Alex made a similar type of mistake that Sarah made in her practice, which is related to the function of FANBOYS words. He had the misconception that the FANBOYS word “and” tended to join one independent clause and one dependent clause. In exercise 2 on identifying clauses, Alex mistakenly identified part of a predicate as a separate dependent clause based on the false reasoning that it started with the FANBOYS word “and”. He made the same mistake again for exercise 3 on identifying dependent and independent clauses. Despite the fact that it was stressed in the instructional explanations in the paired worked example that a FANBOYS word did not necessarily join two separate clauses, Alex did not attend to the instructional explanations when he was studying the paired worked example. Moreover, the feedback to his practice exercise 3 did not seem to work to correct this misconception because the same mistake was also observed during practice exercise 4 when he wrongly explained why no comma was needed for a one-clause sentence: “X (part of the predicate in the sentence starting with an “and”) is not an independent clause. It’s dependent, so there’s no comma needed”. In sum, the mistakes Alex made during practice problem solving seemed to be related to one misconception that was not corrected even though external help was provided.

**WE with SE prompts student.** Roy was a Caucasian male student enrolled in an 8th grade Language Arts class. He received worked examples with self-explanation prompts during practice.

How did Roy use the worked examples with prompts for self-explanation? Usually, as at least two prompts were provided above each worked example in most cases, he would start with the first prompt, and then went down to the worked example to look for the answer for this prompt, and then continued to the second prompt, went back to the worked example again to look for the answer for the second prompt, and so on. In other words, Roy frequently went back and forth between the self-explanation prompts
and the example sentence while studying the worked examples, especially for the final practice exercises where more prompts were provided for self-explanations. Take an instance of one worked example where four prompts (the first two prompts being related to the first part of the worked example, while the second two prompts being related to the second part of the worked example) were provided. When studying this worked example, Roy read the first prompt first. Seeing that this prompt was related to the first part of the example sentence, he went to the sentence below the prompt and read the first half of the sentence. He then went back to the first prompt again, reading the list of possible responses under the prompt, thinking about the answers for awhile, and selected one response. Following that, he moved on to the second prompt and selected one of the responses for this prompt. He then moved on to read the third prompt which was related to the second half of the sentence, he went back to the example sentence and read the second half of the sentence, and then went to the third prompt again and read the list of possible responses under that prompt, and then chose one response that he thought was correct.

As far as Roy’s self-explanation quality is concerned, he responded to all of the self-explanation prompts while studying the worked examples, and his responses to these prompts were all correct, except for one case where he failed to recognize one of the FANBOYS words in the example sentence when asked if there were any of these words in the sentence.

With regard to his behaviors while solving the practice problems in the example-problem pairs, Roy referred back to the paired worked examples five times and answered most (20 of 22) of the practice items correctly. For the two incorrectly solved practice items, one instance was when he mistakenly put a comma before a FANBOYS word which, however, did not join two independent clauses This type of mistake was also observed during Sarah’s and Alex’s practice problem solving. For the other instance, he failed to include the conjunction introducing a dependent clause as part of the clause.

**WE with IE/SE student.** Chris was a Caucasian female student who also enrolled in an 8th grade Language Arts class. She received worked examples with both instructional explanations and self-explanation prompts during practice.
Chris seemed to attend to both types of information provided for the worked examples. For each practice exercise, she read the instructional explanations for the first half of the worked examples and responded to the prompts for self-explanations for the second half of the worked examples. For a few instances, after reading the instructional explanations, she paraphrased the explanations and seemed to really try to comprehend the information contained there. However, the first time that Chris was presented with prompts for self-explanations, instead of the instructional explanations that she had seen for the first half of the worked examples, she expressed surprise at this transition ("On the left side, wait… ok, there’s no study thing"), even though it was explained in the PowerPoint presentation at the beginning of the session. Nevertheless, she soon figured out what she was required to do and seemed to have no problem following this transition from instructional explanations to self-explanation prompts on the following days when studying worked examples. Another observation worth mentioning is that while studying worked examples with self-explanation prompts, Chris went back and forth between the worked examples and the prompts as Roy did.

As far as practice problem solving was concerned, it seemed that Chris referred back to the paired worked examples most frequently as compared with the other three students involved in the think-aloud sessions. She referred back to the paired worked examples for help seven times when she was not sure how to solve the practice items. For example, in one instance where she was presented with an example-practice pair on identifying clauses, she first read the instructional explanations and attended to the solution steps for the worked examples in the left box. She repeated the instructional explanations again before turning to the paired practice problem, apparently trying to comprehend the information contained in the explanations. She then turned to the right box for the practice item. After she read the practice sentence there, she seemed to have some difficulty identifying the clauses in the sentence; she then went back to the paired example sentence again and read the instructional explanations there one more time. After a short pause, she successfully identified the clauses in the practice item.

With regard to her performance on the practice exercises, Chris correctly solved most of the practice items (20 out of 22). Her responses to the self-explanation prompts were all correct except for one instance where she mistakenly attributed the reason (no
FANBOYS word) why no comma was applied for one example sentence. In one of the instances where Chris solved the practice item incorrectly, she mistakenly identified an object-functioning noun as the subject and thus incorrectly identified the clauses in the sentence. In the other instance, she failed to apply the FANBOYS rule for a practice item even though it seemed that she correctly comprehended the FANBOYS rule when she was studying the paired worked example. Thus, attending to the instructional explanations did not always guarantee the correct responses for the practice items.

The above are a few accounts of the findings related to each of the four student’s experience with the particular worked example types they received. These findings, along with those obtained from the quantitative data analysis, are discussed in the following chapter.
CHAPTER 5

DISCUSSION

The two research questions examined in this study were: 1) Do worked examples improve learning and transfer as compared to conventional problems?; and 2) Do explanations, either instructional explanations, self-explanation prompts, or the combination of the two, improve the effect of standard worked examples? Analysis of the data found several statistically significant results:

- **Learning and Transfer.** There was a significant interaction between instructional explanations and self-explanation prompts on both learning and transfer when the four worked example treatments were examined. The follow-up simple effect analysis showed that when self-explanation prompts were not provided, students who received instructional explanations performed better on both learning and transfer test than students who did not receive instructional explanations.

- **Perceived cognitive load during practice.** There was a significant main effect for both instructional explanations and self-explanation prompts, revealing that a) students presented with self-explanation prompts during practice reported higher cognitive load than students who did not receive such prompts; and b) students presented with instructional explanations reported lower cognitive load than those who did not receive such explanations.

- **Time spent during practice.** A significant main effect for self-explanation prompts, which showed that students who received self-explanation prompts spent significantly more time during practice than students who did not receive such prompts.

- **Performance on practice exercises.** Students in the worked example approach scored significantly higher on the practice exercises than did the students in the conventional problems group.

- Correlation between the number of self-explanation prompts students responded to correctly and test performance. There was a significant positive correlation between
the number of self-explanation prompts students responded to correctly and their performance on the learning and transfer tests.

No other significant results were found on the dependent variables. The above findings are discussed in the following section. Where appropriate, results from the qualitative data analysis are used to support the discussion points based on the above quantitative findings. Limitations and implications for research and practice are then addressed, followed by a concluding section of the chapter.

**Discussion of Research Findings**

**Comparison Among Four Types of Worked Examples**

It was interesting to note that in two of the cases where there were significant differences, the results pointed to the benefits of using instructional explanations with worked examples. First, it was found that when self-explanation prompts were not provided, students who received instructional explanations performed better on both the achievement and transfer tests than students who did not receive instructional explanations. The positive effect of this instructional strategy on student test performance has been found in previous research (e.g., Renkl, 2002; Lee & Hutchison, 1998; Schworm & Renkl, 2002) and is likely due to the fact that the instructional explanations provide necessary external support for students to comprehend the unexplicated solution steps in the worked examples. As noted in a previous chapter, standard worked examples provide only solution steps without further information that explains the problem solving steps in the worked examples. For example, while students who received standard worked examples could see that a comma was inserted in a sentence, they might not understand why the comma was there. However, students who received the instructional explanations not only had access to the ‘worked-out’ steps in the examples, but also the information as to why the comma was needed. Without the added instructional explanations, standard worked examples may be less effective than if such information is provided. In other words, accompanying worked examples with instructional explanations, in the form of correct or expert knowledge on why particular solutions steps
are arrived at, may provide students with the additional instructional support they need in order to gain greater benefit from the worked examples.

Second, in this study the use of instructional explanations with worked examples resulted in reduced cognitive load during practice. Students who received instructional explanations reported lower cognitive load than the students who received no instructional explanations. One possible reason for the lower cognitive load associated with this strategy is the interactivity of different sources of cognitive load. First, by providing additional expert information, instructional explanations may well have helped to reduce the extraneous cognitive load resulting from the insufficient clarity of standard worked examples. At the same time, instructional explanations added to the worked examples should have resulted in an increase in germane cognitive load (see van Gog et al., 2006) since studying this added information was directly contributing to learning. From either perspective, the reasoning is consistent with the higher test performance observed for students who received instructional explanations during practice, and it is reasonable to argue that the overall lower cognitive load associated with instructional explanations strategy can be explained by the interactivity of the two different sources of cognitive load.

In sum, the findings discussed above suggest the benefits of adding instructional explanations to worked examples. However, the beneficial effect of instructional explanations was not observed when this strategy was combined with self-explanation prompts. This finding is consistent with some previous findings focusing on the integration of the instructional explanations with self-explanation prompts (e.g., Schworm & Renkl, 2002). One likely explanation for the result might be related to the way instructional explanations and self-explanation prompts were combined in the present study.

As pointed out in Chapter 2, how the two types of information are presented may influence the effect of this combination strategy. Previous research mainly examined two types of combinations: (a) a synchronous combination, by having both types of information accessible to the students at the same time, or (b) a transitional combination, by having instructional explanations presented first, followed by self-explanation prompts. The present study employed a transitional combination strategy rather than a
synchronous one due to the fact that empirical research findings suggested that the former strategy was more effective than the latter. More specifically, the transition in the present study was realized by providing instructional explanations for the first half of worked examples and then prompting students for self-explanations for the second half of the worked examples. This transitional method did not enhance student learning with worked examples. The main reason could be attributed to the non-gradual nature of the transition. That is, instead of a gradual withdrawal of the instructional explanations, the transition was quite abrupt, moving directly from one approach to the other. Students might have had difficulty getting used to this kind of transition, especially the first time when they encountered this format, as observed during the think-aloud session with Chris. Moreover, instructional explanations may have been withdrawn earlier than they should have been, before students were able to fully benefit from this approach. A more gradual transition between the two instructional approaches might have been more effective.

The above reasoning was consistent with the fact that the results obtained in the present study did not point to any advantages to using self-explanation prompts. Students who received self-explanation prompts spent significantly more time, as well as reported a significantly higher cognitive load during practice, than those students who did not receive such prompts. However, the additional time and the higher cognitive load during practice did not result in better test performance.

Self-explanation prompts were designed to improve the effect of worked examples. Why, then, were the intended effects not achieved? One likely explanation is that, in the case of many students, the prompts did not serve their intended purpose. As shown in Chapter 3, each prompt for self-explanations in the study was a scaffolded prompt in that students were asked to select from a list of potential responses, rather than having to construct self-explanations completely on their own. In addition, prompts for each worked example were intended to induce a logical reasoning process as to why the final solution was arrived at. It was hoped that, by so doing, students who received prompts would generate correct and complete self-explanations which, consequently, would enhance their understanding of the unexplained solution steps in the worked examples. In spite of the good intention, an examination of student self-explanation answers found that, in many cases students either failed to respond to these prompts or
provided incorrect responses. Indeed, students correctly responded to the self-explanation prompts only 62% of the time. This percentage is particularly low when one considers the fact that the self-explanation process was highly scaffolded. The reason that the intended effect of self-explanation prompts was not achieved could be that these students did not learn the two comma rules well enough to be able to self-explain how the solutions were reached. Further and more direct support might have been more beneficial for these students. This reasoning is consistent with the finding that instructional explanations benefited both student learning and transfer.

In several respects, the nature of the feedback the students in the self-explanation conditions received may have contributed to the ineffectiveness of the self-explanation prompts strategy. First, no immediate feedback to student self-explanations was provided. Instead, feedback to each practice exercise, including feedback to the self-explanation responses, was provided on the following day. More immediate feedback might have helped to improve the effect of the self-explanation prompts. As observed during the think-aloud sessions, students tended to have misconceptions related to applying the two comma rules, such as putting a comma before a FANBOYS word without considering whether it joined two independent clauses or not. Providing feedback to the students right after they completed a set of paired worked examples and practice problems may have helped them immediately overcome such misconceptions. As some researchers have indicated, since the majority of students do not self-monitor their understanding when studying worked examples, “[i]mmediate feedback on self-explanation correctness protects these students from learning wrong knowledge from incorrect self-explanations, and simply makes the other students [who do self-monitoring their understanding] detect the conflict sooner than they would on their own” (Aleven & Koedinger, 2002, p393).

Indeed, studies where self-explanation prompts were found to be effective involved immediate, rather than delayed, feedback to self-explanation responses (Aleven & Koedinger, 2002; Atkinson et al., 2003). The importance of the immediacy of feedback was also documented in a review of previous research on feedback in general (Kulik & Kulik, 1988).

Second, the kind of feedback provided may have been problematic. In the present study, the day after responding to the paired worked examples and practice problems,
students were simply informed as to whether each of their self-explanation responses was
correct or incorrect and were also provided with a separate answer sheet listing the
correct responses. In hindsight, such feedback was unlikely to help students overcome
their misconceptions. As observed in the think-aloud sessions, sometimes student
misconceptions seemed not easy to correct. For example, even after studying the related
lessons, two of the four students seemed to still hold misconceptions related to what a
clause is. They made the same mistake more than once in practice exercises as well as on
the posttest, despite the fact that feedback for each practice exercise was provided on the
following day. Perhaps instructional feedback, informing the learner as to what the
correct response was and why it was correct, would have helped students overcome their
misconceptions.

Third, during classroom sessions, it was observed that oftentimes some students
did not carefully review the feedback provided to them. The two-point scoring scale (1 or
0) was designed in the hope that it would direct student attention to their errors, as well as
to the corresponding correct answers provided on the answer sheets that were given to
them. However, this strategy apparently did not work. As discussed in Chapter 4,
classroom observations revealed that many students seemed to be only interested in the
total scores they received, rather than what they did wrong and how to correct those
errors. All of these factors may have contributed to the fact that, on the whole, students
who received self-explanation prompts did not benefit from this strategy as intended.

As noted above, the quantitative data analysis revealed that students who received
self-explanation prompts reported a significantly higher cognitive load during practice
than students who did not receive such prompts. This finding is supported by the results
of the think-aloud sessions, which indicate that the design of the self-explanation prompts
may have led to a split-attention effect (Sweller & Chandler, 1994, Tarmikzi & Sweller,
1988). In particular, the two students who received self-explanation prompts frequently
switched between studying the example sentences and the associated prompts when
studying worked examples, likely resulting in split attention and an increase in
extraneous cognitive load. Indeed these two students reported a higher cognitive load
during practice than the two students who did not receive such prompts. Of course, the
source of this higher cognitive load could be germane cognitive load, resulting from
having to respond to the self-explanation prompts. However, given the fact that students who were prompted for self-explanations did not outperform their counterparts on the measures of learning and transfer, it seems reasonable to assume that this additional load was extraneous.

It is also possible that the effort involved in trying to respond to the self-explanation prompts may have served as an extraneous cognitive load for those students who had difficulty responding to those prompts. As has been suggested (Chi et al., 1989; van Gog et al., 2004), in order to benefit from self-explanations, learners must engage in a conscious effort, which may constitute a germane cognitive load for good students; but may involve an extraneous load for poorer students. Indeed, for each student, the higher cognitive load may be due to a higher germane cognitive load, higher extraneous cognitive load, or both. Regardless of the cause for the increased cognitive load, it seems reasonable to conclude that the format used in this study for worked examples with self-explanations prompts could be improved so as to reduce the possible extraneous cognitive load such a format is likely to produce.

Although for the most part, the effects of self-explanation prompts were not positive, there was some evidence showing the value of self-explanation prompts. First, there was a significant positive correlation between the number of self-explanation prompts students responded to correctly and their performance on the final practice activity. Those students who answered more of the self-explanation prompts correctly tended to score higher on the achievement test and on the transfer test. Second, data obtained from the four students involved in the think-aloud sessions also seem to provide partial support for the value of self-explanation prompts. The two students who received self-explanation prompts improved more from the pretest to the posttest as compared with the other two students who did not receive such prompts. We may say that the larger learning gain of the former two students may be a result of the effect of self-explanations. However, on the other hand, since both students scored much lower than the other two students during the pretest, i.e., they started from a lower level of domain-specific prior knowledge, their larger learning gain could also be because they had more room to improve. It would have been more informative if think-aloud students were chosen based
on their domain-specific prior knowledge level, rather than their general language ability as determined by teacher judgment.

Conventional Problems versus Worked Examples

As for the comparisons of worked example approaches versus the conventional problem approach, the benefits of the former found in previous literature were not confirmed in this study. No differences were found on learning, transfer, cognitive load, or time on task between the two types of approaches. The only difference observed between the conventional problem condition and the worked example conditions was on practice performance. Students in the worked example conditions performed significantly better during practice than those students in the conventional problem condition.

Several reasons might have contributed to the failure for detecting differences between the conventional problems approach and the worked examples approaches on learning and transfer. Among them, student prior knowledge might have been a major factor in determining why students in the worked example conditions did not outperform their peers in the conventional problems condition. The pretest showed that students participating in the study started the Hip Hop Comma program with relatively high prior knowledge (53% on the achievement test and 54% on the transfer test). On the one hand, higher prior knowledge of the students made less room for the effect of worked examples to be observed. Across the various treatment groups, there was not much improvement between student pretest and posttest performance. In particular, average student performance (across all treatment conditions) on the achievement test increased by only 8% from pretest to posttest (from 53% on the pretest to 61% on the posttest). Moreover, average student performance on the transfer test increased by only 11% (from 54% on the pretest to 65% on the posttest). On the other hand, as presented in the previous chapter, there was some prior knowledge existing in the form of misconceptions regarding the learning content, which could also have weakened the effect of the treatments. For example, as presented previously, many students had the misconception that a comma was needed before a FANBOYS word without considering whether it joins two independent clauses or not. Considering the length of the program, the instruction may
not be effective enough to overcome the misconceptions that had existed in student minds for a relatively long time. This notion is supported by the fact that students in the worked example conditions performed better during practice than students in the conventional problems condition, but did not perform better on the measures of learning and transfer test.

Another fact that may explain the small learning gain from the pretest to the posttest could be related to the degree of student engagement in the program or how serious these students were when studying the program. Although most students completed the program as instructed, how much they truly engaged in the program is a question. Many students seemed to study the program in a superficial manner. That is, it seems that they considered this program as just another task that they needed to complete in classroom, but how much they could get out of the program seemed not their concern. For example, the amount of time several of the students in the worked example conditions spent on the practice problems was quite limited, indicating that they did not attempt to carefully examine the worked examples provided to them. In addition, as mentioned previously regarding student behaviors on receiving feedback on practice exercises, many students seemed to be more interested in the total score they received for each practice exercise rather than on how to learn from their errors in the practice exercises. Such behavior is related to student goal orientation (Dweck, 1990). More specifically, these students seemed to be performance-goal-oriented learners who were primarily interested in the outcomes of their learning activities, rather than mastery-goal-oriented learners whose primary focus is on learning. In general, it has been postulated that students with performance goals are less likely to succeed because they do not focus on the learning process itself (Hagen & Weinstein, 1995). This may explain the small overall learning gain from the pretest to the posttest. More importantly, the small learning gain might explain why the worked examples effect was not observed in this study.

Another reason that the worked example groups did not perform better than the conventional problems group might have to do with how the worked example-problem pairs were used by many of the learners. It was observed that some students apparently did not pay sufficient attention to the information in the worked examples. For instance, as noted earlier in the chapter, some students who received self-explanation prompts
failed to respond to the prompts for some exercises. Also, it is very likely that some
students in the other worked example conditions ignored the information that they were
supposed to study. One reason that students failed to attend to the information in the
worked examples could be that, as discussed previously, they did not take the learning of
task seriously. It could also be because students were not aware of effective strategies to
make the most use of the worked examples. As Alex, the think-aloud student who
received WE with instructional explanations, mentioned, he intentionally ignored some of
the instructional explanations because he (incorrectly) thought that the same information
could be obtained from the worked example itself. In addition, it was also observed that
Sarah oftentimes just quickly read through the worked examples without attending to all
the essential information in the examples. That is, although she literally read the words in
the example sentences, she did not seem to carefully “study” them. One possible reason
for Sarah’s study behaviors may be that she oftentimes failed to self-monitor\(^1\) her
understanding during the learning process. It also seemed likely that Sarah did not
possess effective cognitive strategies for studying worked examples and solving the
paired practice problems. As mentioned previously, in this study, each worked example
was paired with a conventional problem similar in structure. That is, the first sentence in
each pair was a condition-specific worked example, while the second sentence in the pair
was a conventional problem that students were required to solve after studying the paired
worked example. Sentences were paired based on their structural similarity. Although
Sarah was shown, as were the other students, how to use the example-problem pairs via a
brief automated PowerPoint presentation, apparently, she did not employ this strategy.
Highlighting the key information in worked examples in one way or another might have
prevented students from disregarding the information.

In future studies, researchers might attempt to teach students in a more explicit
manner the value of worked examples, as well as the effective strategies for studying
worked examples and utilizing example-problem pairs. Sweller and his colleagues have
used the example-problem pairs consistently in their studies on worked examples,
arguing that the practice problems paired with the worked examples motivate students

\(^1\) Self-monitoring is “the deliberate observation of covert and overt aspects of one’s performance outcomes
on a given task” (Zimmerman, Bonner, & Kovach, 1996, p2), which is an important self-regulatory skill.
(Cooper & Sweller, 1987; Sweller & Cooper, 1985; Ward & Sweller, 1990). Other researchers (Trafton & Reiser, 1993) also claim that “the most efficient way to present material to acquire a skill is to present an example, then a similar problem to solve immediately following” (p1022). Even though the example-problem format was found useful in previous research, this study suggested that for less self-regulated younger learners, encouraging analogical reasoning by more explicitly making students realize a direct comparison between the sentences in each pair might have increased the effectiveness of worked examples.

In this study, students were provided with necessary information but were not helped in using the information productively. A more structured approach may improve student learning from worked examples. For example, it was observed that even though think-aloud students attended to the explanation information in the worked examples, it did not always guarantee them the correct responses for the practice items. One possible reason could be that the students failed to recognize the similarity between the example sentence and the practice sentence, or, they failed to apply the same strategies in the worked examples when solving the paired problems. For example, in cases where students had confusion or difficulty solving the paired worked examples, did they know that they needed to apply the same strategies observed in the worked examples? More specifically, for the students receiving standard worked examples, did they know that they should follow the same solution steps when solving the paired problem? For the students receiving worked examples with instructional explanations, did they know that they could follow the same expert reasoning process observed in the worked example? For the students receiving worked examples with self-explanation prompts, did they know that they might want to ask themselves the similar questions they were asked when studying the worked example? If more time was spent on showing students exactly how to make use of the worked examples, the results of the student may have been different.

Another reason that worked examples were not found more effective than conventional problems might be related to the nature of the worked examples in this study. More specifically, the worked examples employed in the study were not structured in an “explicit” step-by-step manner as has been the case in other subject matter areas such as mathematics, physics, and computer programming. As discussed previously,
typical worked examples in those areas contain step-by-step solution steps where each step is either clearly labeled (e.g. step 1, step 2 etc. or 1, 2, 3 etc.) or put on a separate line. However, the solution steps of the worked examples in this study were not presented in such an explicit algorithmic step-by-step fashion. Despite the fact that each step was taught in a separate lesson and an expert’s problem solving model was presented in each worked example, solution steps were not explicitly labeled as step 1 or 2 etc; rather, they were integrated in the example sentence itself. In other words, steps were structured in a more implicit manner, where students needed to infer by themselves the sequential order of the steps. This structure could have affected the effect of the worked examples used in this study. Catrambone and his colleagues in a series of studies (1994, 1995, 1996; Catrambone & Holyoak, 1990) have shown that the structure of worked examples could have an impact on worked example effects: labeling solution steps or isolating them visually improved student learning from worked examples. In view of this, the less explicit structure of the worked examples in the present study might be a likely reason for their limited effect when compared with conventional problems.

The nature of the learning content in this study may also have influenced the effectiveness of using a worked example approach. Unlike most previous research, the subject matter area of the study was language learning, more specifically, how to apply comma rules. Language learning in general falls into a less procedure-oriented domain when compared with subject matter areas such as mathematics or physics. Therefore, an explicit step-by-step presentation of the solutions might not work as effectively.

Finally, the setting of the study may have also contributed to the results of the study. Unlike most previous research on worked examples, this study was conducted in a natural school setting rather than a controlled lab setting. Accordingly, there were interfering factors that could not be controlled for, such as student inattention, which may have contributed to the results obtained from this study.

Due to factors discussed above, the potential effect of worked examples might have been weakened, which may also explain why no differences were found on cognitive load and time on task between the conventional problem condition and the worked example conditions.
Limitations and Suggestions for Future Research

Described below are several potential limitations and suggestions as to how future studies might be designed so as to overcome some of the problems that have been identified. In addition, implications for future research and practice are discussed.

Unlike most of the previous research on worked examples, which has been conducted in laboratory settings, this study was conducted in a real classroom setting. While conducting the study in this type of environment increased the external validity of the study, it had a negative impact on internal validity. For example, the three teachers who participated in the study did not administer the treatments in a consistent manner. One example of inconsistency involved use of the song that was part of the program and that was intended to serve as a mnemonic device to help students recall the comma rules. Whereas two of the teachers encouraged their students to sing along with the song while it was being played, the other teacher discouraged the students to do so. Another example of inconsistency involved the amount of time the teachers reviewed the practice activities with their classes the day after each practice activity was administered. Whereas two teachers spent approximately the same amount of time reviewing each practice exercise, the third teacher cut down the practice exercise review time during the last few days of the experiment so that she could cover other content unrelated to the comma rules the students were being taught. In future studies, additional efforts should be undertaken to insure uniformity in the manner in which treatments are administered. One possible means of doing so would be to deliver the instruction via computer, rather than via print and a live instructor. Such an approach would also help address another limitation of this study – namely the nature of the feedback students received.

In this study, the feedback students received on practice activities simply entailed (a) returning their answer sheets to them with each answer marked as correct or incorrect, (b) providing each student with a sheet listing the correct answers, and (c) giving the students five minutes to review these two documents on their own. Although this type of feedback may have been somewhat helpful, it was not tailored to specific mistakes that students made, and therefore it was unlikely to be sufficiently detailed to help correct student misconceptions. In addition, feedback for each practice exercise was provided
one day after students completed the exercise. Providing feedback immediately after each practice exercise might have been more effective than providing students with delayed feedback. Future studies may consider ways to incorporate these factors when designing feedback to practice activities.

Another limitation of the study is related to the design of the instructional program, more specifically, the format of the worked examples with self-explanation prompts, as well as the worked examples with both instructional explanations and self-explanation prompts. As discussed previously in the chapter, the design of the self-explanation prompts might have introduced a split-attention effect, which is likely to have served as a source of extraneous cognitive load. In order to better understand the effect of self-explanation prompts on learning and transfer, more attention should be paid to the design of worked examples with self-explanation prompts so as to reduce the likelihood of the materials causing a split attention effect. One way to address this issue is to better integrate the prompts into the worked examples by providing each prompt next to the solution step that it is related to, rather than providing all of the prompts above each worked example. At the same time, the format of the worked examples combining both instructional explanations and self-explanation prompts could also be improved by employing a more gradual transition between the two types of instructional means so as to not withdraw the instructional explanations so abruptly.

In addition, future worked examples might be designed so that the essential information in the worked examples is harder to ignore. For instance, key information may be highlighted in some way so that to appropriately and more effectively direct student attention, at least alerting students that the information is important. Although this may be more difficult to achieve in print-based instruction as compared with computer-based instruction, it is not impossible.
Another strategy that might get students to focus on the important aspects of the worked examples might involve helping students acquire strategies for effectively studying worked examples and solving paired practice problems. For example, a study strategy job aid, such as the strategy valuation matrix (see Figure 5.1) suggested by Schraw (1998), can not only be used to improve student metacognitive skills, but also be utilized to explicitly teach students effective strategies for studying different types of worked examples and how to make the most use of example-problem pairs. Future studies might investigate if this approach will help to make students more aware of the analogical reasoning between the worked examples and paired problems, and consequently, improve student learning from the worked examples.

### Implications for Future Practices

The findings of the study have several implications for instructional practices as well as for the design of instructional materials. First, based on the results of this study, instructional designers should consider elaborating on standard worked examples by

<table>
<thead>
<tr>
<th>Strategy</th>
<th>How to Use</th>
<th>When to Use</th>
<th>Why to Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan</td>
<td>Search for headings, highlighted words, previews, summaries</td>
<td>Prior to reading an extended text</td>
<td>Provides conceptual overview, helps to focus one’s attention</td>
</tr>
<tr>
<td>Slow down</td>
<td>Stop, read, and think about information</td>
<td>When information seems especially important</td>
<td>Enhances focus of one’s attention</td>
</tr>
<tr>
<td>Activate prior knowledge</td>
<td>Pause and think about what you already know. Ask what you don’t know</td>
<td>Prior to reading or an unfamiliar task</td>
<td>Makes new information easier to learn and remember</td>
</tr>
<tr>
<td>Mental integration</td>
<td>Relate main ideas. Use these to construct a theme or conclusion</td>
<td>When learning complex information or a deeper understanding is needed</td>
<td>Reduces memory load. Promotes deeper level of understanding</td>
</tr>
<tr>
<td>Diagrams</td>
<td>Identify main ideas, connect them, list supporting details under main ideas, connect supporting details</td>
<td>When there is a lot of interrelated factual info</td>
<td>Helps identify main ideas, organize them into categories. Reduces memory load</td>
</tr>
</tbody>
</table>

Figure 5.1 Strategy evaluation matrix in Schraw (1998)
adding instructional explanations to the solutions steps. Also, as this study found that some students tended to ignore self-explanation prompts, it is important for instructional designers to consider how to best present this type of information so that it looks less daunting and, at the same time, harder to ignore. Moreover, if example-practice pairs are to be employed, researchers may want to construct self-explanation prompts that connect the example with the practice problem, which might increase the potential effectiveness of the self-explanation prompts. In addition, since it was found that introducing self-explanation prompts had the potential to introduce a split-attention effect, in the future, instructional designers who design such prompts should carefully consider how to design prompts that are unlikely to lead to such effects.

With regard to instructional practices, the results of this study indicate that it may be beneficial to teach students in a more explicit manner strategies for studying worked examples and making the most use of example-problem pairs before students study worked examples. This study found that students oftentimes failed to pay attention to the essential information in the worked examples, or tended to resort to ‘superficial comparison’ when studying the example-practice pairs, which is detrimental to effective learning. Training students to use effective strategies when presented with worked examples is likely to result in the students learning more from such examples.

**Conclusion**

Unlike previous studies, in the present study worked examples were not found to be more effective than conventional problems. This may be due to the fact that students in the present study had relatively high prior knowledge. As a result, these students failed to benefit from the potential advantages of the various worked examples. Nevertheless, the results from this study echoed previous research with regard to the beneficial effect of adding instructional explanations to standard worked examples. On the other hand, the data obtained failed to support the notion that prompting students for self-explanations enhances their learning from worked examples. However, a number of factors may have contributed to the lack of positive results related to the use of self-explanation prompts.
These factors included findings on how the self-explanation prompts were integrated with the worked examples, the type of feedback that was provided, and how students used that feedback. In light of these results, future studies examining these variables should be designed to examine how to improve the design of self-explanation prompts, as well as how to best integrate instructional explanations and self-explanation prompts to provide the desirable amount of support for learning with worked examples. In addition, it also seems important to conduct research that examines strategies designed to make students more attentive to the essential information contained in worked examples. Research examining these variables is likely to further extend our understanding of how to make the best use of worked examples in instructional programs.
APPENDIX A
EXAMPLE PRACTICE EXERCISE FOR THE CONTROL CONDITION

EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Directions: Insert comma where necessary in the sentences below. If no comma is needed, check the box below the sentence.

1. He will not permit the change nor will he even consider it.
   [ ] Check if NO comma is needed

2. He cannot find anyone now and he will never find anyone.
   [ ] Check if NO comma is needed

3. Over the years I have met many kind people.
   [ ] Check if NO comma is needed

4. Throughout this paper he made the same mistake.
   [ ] Check if NO comma is needed

5. If students show up for my next class I will allow them to skip the mid-term exam or they may opt for extra 20 bonus points toward the final exam score.
   [ ] Check if NO comma is needed

6. Before I moved in for the fall term he had required me to pay a $500 deposit and I had signed up for a one-year lease for this tiny apartment.
   [ ] Check if NO comma is needed

Exercise continues on the next page →
EXERCISE 6 (Cont’)
Applying the FANBOYS & Introductory Elements Rule

Directions: Insert comma where necessary in the sentences below. If no comma is needed, check the box below the sentence.

7. All new band students should attend the beginning band orientation and choose an instrument after that.
   □ Check if NO comma is needed

8. One of the team members must summarize the project findings and make a presentation by Friday.
   □ Check if NO comma is needed

9. Ms. Lim invited me to join the potluck picnic at Tom Brown park before she left the office today.
   □ Check if NO comma is needed

10. The landlord asked May to move out of the house by this week although she had paid the rent on time.
    □ Check if NO comma is needed

11. Because my parents were away for a year I had to learn to live independently and I gained valuable experiences during that year.
    □ Check if NO comma is needed

12. Although the term paper is due tomorrow I haven’t started to write anything but I will submit an outline before the deadline.
    □ Check if NO comma is needed
**EXERCISE 6**
Applying the FANBOYS & Introductory Elements Rule

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very, very low mental effort</td>
<td>Low mental effort</td>
<td>Moderate mental effort</td>
<td>High mental effort</td>
<td>Very, very high mental effort</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Indicate the amount of mental effort you spent on answering the previous items. Circle the corresponding number below.*

**Exercise End time:** ________________
APPENDIX B
EXAMPLE PRACTICE EXERCISE FOR STANDARD WE CONDITION

EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #1

Study this

Then do this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.

He will not permit the change, nor will he even consider it.

☐ Check if NO comma is needed

He cannot find anyone now and he will never find anyone.

☐ Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #2

Study this

Then do this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.

Introductory Phrase ↓ Independent Clause
Over the years, [I have met many kind people].

☐ Check if NO comma is needed

Throughout this paper he made the same mistake.

☐ Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #3

Study this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.

Before I moved in for the fall term, he had required me to pay a $500 deposit and I had signed up for a one-year lease for this tiny apartment.

Then do this

☐ Check if NO commas is needed.
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #4

Study this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.

[All new band students should attend the beginning band orientation and choose an instrument after that.]

One of the team members must summarize the project findings and make a presentation by Friday.

Check if NO comma is needed

Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #5

Study this

Independent Clause

Ms. Lim invited me to join the potluck picnic at Tom Brown park [before she left the office today].

☑ Check if NO comma is needed

Then do this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.

The landlord asked May to move out of the house by this week although she had paid the rent on time.

☐ Check if NO comma is needed.
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #6

Study this

1. [Because my parents were away for a year], [I had to learn to live independently], and [I gained valuable experiences during that year].

Then do this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.

Although the term paper is due tomorrow I haven’t started to write anything but I will submit an outline before the deadline.

☐ Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Indicate the amount of mental effort you spent on answering the previous items. Circle the corresponding number below.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very, very low mental effort</td>
<td>Low mental effort</td>
<td>Moderate mental effort</td>
<td>High mental effort</td>
<td>Very, very high mental effort</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Exercise End time: ________________
APPENDIX C
EXAMPLE PRACTICE EXERCISE FOR THE WE WITH INSTRUCTIONAL EXPLANATION CONDITION

EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #1

Study this

In the example sentence below, a comma is inserted before nor because the FANBOYS rule applies: nor is one of the FANBOYS word & it joins two independent clauses he will not permit the change and will he even consider it.

Independent Clause
[He will not permit the change], nor [will he even consider it].

☐ Check if NO comma is needed

Then do this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.

He cannot find anyone now and he will never find anyone.

☐ Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #2

Do this

In the sentence below, why is the comma there?

a. Two independent clauses are joined by a FANBOYS word
b. An introductory phrase precedes an independent clause
c. A dependent clause precedes an independent clause

Therefore, which comma rule applies?

a. Introductory Elements rule    b. FANBOYS rule
   c. Neither

Then do this

Insert comma(s) where necessary in the sentence below. If
no comma(s) is needed, check the box below the sentence.

Use the example sentence in the box on the left to help you.

Throughout this paper he made the same mistake.

☐ Check if NO comma is needed
**EXERCISE 6**

**Applying the FANBOYS & Introductory Elements Rule**

<table>
<thead>
<tr>
<th>Do this</th>
<th>Pair #3</th>
<th>Then do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the sentence below, why is the first comma there?</td>
<td>Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.</td>
<td></td>
</tr>
<tr>
<td>a. Two independent clauses are joined by a FANBOYS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. A dependent clause precedes an independent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. A independent clause precedes a dependent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Therefore, which comma rule applies?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. FANBOYS rule</td>
<td>b. Introductory Elements rule</td>
<td></td>
</tr>
</tbody>
</table>

| Why is the second comma there? | | |
| a. Two independent clauses are joined by a FANBOYS | | |
| b. A dependent clause precedes an independent clause | | |
| c. A independent clause precedes a dependent clause | | |

| Therefore, which comma rule applies? | | |
| a. FANBOYS rule | b. Introductory Elements rule | |

**Example Sentence:**

**Before I moved in for the fall term, he had required me to pay a $500 deposit and I had signed up for a one-year lease for this tiny apartment.**

- [ ] Check if NO comma is needed

Before I moved in for the fall term, **he** **had** **required** **me** **to** **pay** **a** **$500** **deposit** **and** **I** **had** **signed** **up** **for** **a** **one-year lease** **for** **this** **tiny** **apartment.**

- [ ] Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #4

In the sentence below, why is there no comma?

a. There is no FANBOYS word in the sentence
b. There is no dependent clause in the sentence
c. The FANBOYS word does not join two independent clause

Therefore, which comma rule applies?

a. Introductory Element rule  b. FANBOYS rule
c. Neither

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you!

One of the team members must summarize the project findings and make a presentation by Friday.

☐ Check if NO comma is needed
**EXERCISE 6**
Applying the FANBOYS & Introductory Elements Rule

---

### Pair #5

<table>
<thead>
<tr>
<th>Do this</th>
<th>Then do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the sentence below, why is there no comma?</td>
<td>Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. <em>Use the example sentence in the box on the left to help you.</em></td>
</tr>
<tr>
<td>a. There is only one dependent clause in the sentence</td>
<td></td>
</tr>
<tr>
<td>b. There is only one independent clause in the sentence</td>
<td></td>
</tr>
<tr>
<td>c. The dependent clause comes after the independent clause</td>
<td></td>
</tr>
</tbody>
</table>

Therefore, which comma rule applies?

<table>
<thead>
<tr>
<th>a. Introductory Elements rule</th>
<th>b. FANBOYS rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>c. Neither</td>
<td></td>
</tr>
</tbody>
</table>

Invalid choice

- **Ms. Lim invited me to join the potluck picnic at Tom Brown park.** *(before she left the office today).*

- Check if NO comma is needed

- The landlord asked May to move out of the house by this week although she had paid the rent on time.

- Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Do this

Pair #6

Then do this

In the sentence below, why is the first comma there?

a. Two independent clauses are joined by a FANBOYS
b. A dependent clause precedes an independent clause
c. A independent clause precedes a dependent clause

Therefore, which comma rule applies?

a. FANBOYS rule b. Introductory Elements rule

Why is the second comma there?

a. Two independent clauses are joined by a FANBOYS
b. One dependent clause precedes an independent clause
c. One independent clause precedes a dependent clause

Therefore, which comma rule applies?

a. FANBOYS rule b. Introductory Element rule

Although the term paper is due tomorrow I haven’t started to write anything but I will submit an outline before the deadline.

[Check if NO comma is needed]

[Check if NO comma is needed]
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very, very low</td>
<td>Low mental effort</td>
<td>Moderate mental effort</td>
<td>High mental effort</td>
<td>Very, very high mental effort</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Indicate the amount of mental effort you spent on answering the previous items. Circle the corresponding number below.

Exercise End time: ________
APPENDIX D
EXAMPLE PRACTICE EXERCISE FOR THE WE WITH SELF-EXPLANATION PROMPTS CONDITION

EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #1

Do this

In the sentence below, why is the comma there?
   a. There is a FANBOYS word
   b. An introductory clause precedes an independent clause
   c. Two independent clause are joined by a FANBOYS word

Then do this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.

Therefore, which comma rule applies?
   a. Introductory Elements rule
   b. FANBOYS rule
   c. Neither

Independent Clause
[(He will not permit the change), nor [he will be even consider it].]

Independent Clause

Check if NO comma is needed

Check if NO comma is needed

He cannot find anyone now and he will never find anyone.
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #2

Do this

In the sentence below, why is the comma there?

a. Two independent clauses are joined by a FANBOYS word
b. An introductory phrase precedes an independent clause
c. A dependent clause precedes an independent clause

Then do this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence.

Use the example sentence in the box on the left to help you

Therefore, which comma rule applies?

a. Introductory Elements rule  b. FANBOYS rule
c. Neither

Examples:

Introductory Phrase ↓ Independent Clause

Over the years, (I have met many kind people).

☐ Check if NO comma is needed

Throughout this paper he made the same mistake.

☐ Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

<table>
<thead>
<tr>
<th>Do this</th>
<th>Pair #3</th>
<th>Then do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the sentence below, why is the first comma there?</td>
<td>Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.</td>
<td></td>
</tr>
<tr>
<td>a. Two independent clauses are joined by a FANBOYS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. A dependent clause precedes an independent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. A independent clause precedes a dependent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Therefore, which comma rule applies?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. FANBOYS rule</td>
<td>b. Introductory Elements rule</td>
<td></td>
</tr>
<tr>
<td>Why is the second comma there?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Two independent clauses are joined by a FANBOYS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. A dependent clause precedes an independent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. A independent clause precedes a dependent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Therefore, which comma rule applies?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. FANBOYS rule</td>
<td>b. Introductory Elements rule</td>
<td></td>
</tr>
</tbody>
</table>

Before I moved in for the fall term he had required me to pay a $500 deposit and I had signed up for a one-year lease for this tiny apartment.

- [ ] Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #4

Do this

In the sentence below, why is there no comma?

a. There is no FANBOYS word in the sentence
b. There is no dependent clause in the sentence
c. The FANBOYS word does not join two independent clauses

Therefore, which comma rule applies?

a. Introductory Element rule    b. FANBOYS rule
c. Neither

Independent Clause

[All new band students should attend the beginning band orientation and choose an instrument after that.]

☐ Check if NO comma is needed

Then do this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you!

One of the team members must summarize the project findings and make a presentation by Friday.

☐ Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #5

In the sentence below, why is there no comma?

a. There is only one dependent clause in the sentence
b. There is only one independent clause in the sentence
c. The dependent clause comes after the independent clause

Therefore, which comma rule applies?

a. Introductory Elements rule   b. FANBOYS rule
c. Neither

[Ms. Lim invited me to join the potluck picnic at Tom Brown park] [before she left the office today].

Check if NO comma is needed

The landlord asked May to move out of the house by this week although she had paid the rent on time.

Check if NO comma is needed
**EXERCISE 6**

**Applying the FANBOYS & Introductory Elements Rule**

<table>
<thead>
<tr>
<th>Do this</th>
<th>Pair #6</th>
<th>Then do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the sentence below, why is the first comma there?</td>
<td>Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. <em>Use the example sentence in the box on the left to help you.</em></td>
<td></td>
</tr>
<tr>
<td>a. Two independent clauses are joined by a FANBOYS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. A dependent clause precedes an independent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. A independent clause precedes a dependent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Therefore, which comma rule applies?</td>
<td></td>
<td>Use the example sentence in the box on the left to help you</td>
</tr>
<tr>
<td>a. FANBOYS rule</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Introductory Elements rule</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Why is the second comma there?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Two independent clauses are joined by a FANBOYS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. One dependent clause precedes an independent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. One independent clause precedes a dependent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Therefore, which comma rule applies?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. FANBOYS rule</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Introductory Element rule</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Dependent Clause**

```
(Because my parents were away for a year), (I had to learn
to live independently), (I gained valuable experiences
during that year).
```

[ ] Check if NO comma is needed.

**Although the term paper is due tomorrow I haven’t**

**started to write anything but I will submit an outline**

**before the deadline.**

[ ] Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Indicate the amount of mental effort you spent on answering the previous items. Circle the corresponding number below.

1 2 3 4 5 6 7 8 9

Very, very low mental effort
Low mental effort
Moderate mental effort
High mental effort
Very, very high mental effort

Exercise End time: __________
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

In the example sentence below, a comma is inserted before nor because the FANBOYS rule applies: nor is one of the FANBOYS word & it joins two independent clauses he will not permit the change and will he even consider it.

Independent Clause: [He will not permit the change], nor [will he even consider it].

☐ Check if NO comma is needed

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.

He cannot find anyone now and he will never find anyone.

☐ Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #2

Study this

In the example sentence below, a comma is inserted after over the years because the Introductory Elements rule applies; over the years is an introductory phrase that comes before the main independent clause I have met many kind people.

Then do this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.

Throughout this paper he made the same mistake.

Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Study this

In the example sentence below,
• Comma 1 is inserted because the Introductory Elements rule applies: if students show up for my next class is an introductory dependent clause that comes before the independent clause I will allow them to skip the mid-term exam.
• Comma 2 is inserted because the FANBOYS rule applies: there is one FANBOYS word or & it joins two independent clauses.

Before I moved in for the fall term, he had required me to pay a $500 deposit and I had signed up for a one-year lease for this tiny apartment.

Then do this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you.

Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

Pair #4

Do this

In the sentence below, why is there no comma?

a. There is no FANBOYS word in the sentence
b. There is no dependent clause in the sentence
c. The FANBOYS word does not join two independent clause

Therefore, which comma rule applies?

a. Introductory Element rule b. FANBOYS rule
c. Neither

Then do this

Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you!

[All new band students should attend the beginning band orientation and choose an instrument after that]

☐ Check if NO comma is needed

One of the team members must summarize the project findings and make a presentation by Friday.

☐ Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

In the sentence below, why is there no comma?

a. There is only one dependent clause in the sentence
b. There is only one independent clause in the sentence
c. The dependent clause comes after the independent clause

Therefore, which comma rule applies?

a. Introductory Elements rule  b. FANBOYS rule  c. Neither

Independent Clause

Ms. Lim invited me to join the potluck picnic at Tom Brown park before she left the office today.

Check if NO comma is needed

The landlord asked May to move out of the house by this week although she had paid the rent on time.

Check if NO comma is needed
EXERCISE 6
Applying the FANBOYS & Introductory Elements Rule

<table>
<thead>
<tr>
<th>Do this</th>
<th>Pair #6</th>
<th>Then do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the sentence below, why is the first comma there?</td>
<td></td>
<td>Insert comma(s) where necessary in the sentence below. If no comma(s) is needed, check the box below the sentence. Use the example sentence in the box on the left to help you</td>
</tr>
<tr>
<td>a. Two independent clauses are joined by a FANBOYS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. A dependent clause precedes an independent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. A independent clause precedes a dependent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Therefore, which comma rule applies?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. FANBOYS rule</td>
<td>b. Introductory Elements rule</td>
<td></td>
</tr>
<tr>
<td>Why is the second comma there?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Two independent clauses are joined by a FANBOYS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. One dependent clause precedes an independent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. One independent clause precedes a dependent clause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Therefore, which comma rule applies?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. FANBOYS rule</td>
<td>b. Introductory Element rule</td>
<td></td>
</tr>
</tbody>
</table>

```
[Because my parents were away for a year], I had to learn to live independently, and I gained valuable experiences during that year.
```

- Check if NO comma is needed.

```
Although the term paper is due tomorrow I haven't started to write anything but I will submit an outline before the deadline.
```

- Check if NO comma is needed
**EXERCISE 6**
Applying the FANBOYS & Introductory Elements Rule

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very, very low mental effort</td>
<td>Low mental effort</td>
<td>Moderate mental effort</td>
<td>High mental effort</td>
<td>Very, very high mental effort</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Indicate the amount of mental effort you spent on answering the previous items. Circle the corresponding number below.*

**Exercise End time:** __________
APPENDIX F

COMMA HIP HOP SONG LYRIC

Trying the comma hip hop song
Again
Here we go
SP
C
I or D
FANBOYS
and
Introductory
SP
C
I or D
FANBOYS
and
Introductory
Subjects and predicates make a clause
That’s how you start the comma comma comma rules
Clauses are either I or D
Independent or Dependent is what you’ll see
When two I clauses meet FANBOYS
A comma between them cuts off the noise
If an introduction starts the whole thing
A comma after the intro makes it all sing
SP
C
I or D
FANBOYS
and
Introductory
SP
C
I or D
FANBOYS
and
Introductory
...

123
APPENDIX G

_Hip Comma Program_  
STUDENT ATTITUDE SURVEY

Name: ______________________________________________________________

Please respond to this survey about the _Hip Comma_ program you just completed. Your honest responses will help us improve the program for future students.

Circle your answer for each statement based on the following key:

- **sa** – strongly agree  
- **a** – agree  
- **d** – disagree  
- **sd** – strongly disagree

1. I liked studying about comma rules.  
2. The _Hip Comma_ program was interesting.  
3. I am confident that I can now apply the two comma rules to sentences.  
4. I had a hard time understanding how to apply comma rules to sentences.  
5. To really learn how to apply comma rules to sentences, I had to work hard.  
6. Studying the _Hip Comma_ program in class, by myself, was a difficult way to learn.  
7. I carefully studied the explanations and examples.  
8. I completed the practice exercises to the best of my ability.  
9. I did my best to learn about comma rules.  
10. The explanations in the program were clear to me.  
11. The practice exercises helped me learn the comma rules.  
12. The tasks that I had to complete each day in the program were clear to me.

13. What did you like the most about the _Hip Comma_ program?

14. What did you like the least about the _Hip Comma_ program?

_Thank you very much!_
APPENDIX H

CLASSROOM OBSERVATION CHECKLIST

Observation Date: __________ Observer: ____________________   Teacher: ____________________   Class (which period): ___________
Day of Instruction (According to the Instructor guide): ___________   Lesson Start Time: ____________   Lesson End Time: _______________

1. **Review the sections** of Instructor Guide and the Student Guide you will observe prior to going to class. Day 1 in the Instructor Guide will typically be taught on Monday, Day 2 on Tuesday, etc.

2. **During observation:**
   - In the Instructor Guide, note start and end times of key activities, such as when the overall lesson started and ended, when students begun working independently in their guides, when most students completed the assigned section, and any other time-related observations.
   - Write down any thoughts regarding improving the program in the Instructor and/or Student Guide. These observations could relate to delivery procedure, nature and sequencing of activities, content presentation, directions for activities, page layout, etc.

3. **After your observation**, summarize your thoughts by completing the Classroom Observation Checklist below. Complete a separate classroom observation form for each new observation.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Ratings</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The teacher followed the Instructor Guide closely</td>
<td>followed most procedures</td>
<td>did not follow the Guide</td>
</tr>
<tr>
<td></td>
<td>followed some procedures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>did not follow the Guide</td>
<td></td>
</tr>
<tr>
<td>2. The teacher had the necessary materials for implementing the program ready</td>
<td>most materials ready</td>
<td>didn’t have</td>
</tr>
<tr>
<td></td>
<td>a few materials ready</td>
<td>materials ready</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. The teacher attempted to motivate students to engage in the program | good attempt | fair attempt | poor attempt |
4. The teacher attempted to keep the students on task throughout the lesson | attempted most of the time | attempted some of the time | didn’t attempt |
5. The teacher facilitated a smooth transition from the Hip Comma program to other tasks | the transition was smooth | the transition was somewhat smooth | the transition was not smooth |
6. Students knew what to do as they proceeded through the lesson | knew most of the time | knew some of the time | frequently appeared confused about their tasks |
7. Students engaged in the assigned tasks throughout the lesson | most students engaged | some students engaged | few students engaged |
8. Overall the teacher did a good job at delivering the lesson | well delivered lesson | fairly well delivered lesson | poorly delivered lesson |

Other Comments:
This presentation will show you how to answer the problems in the Hip Comma program. Each of you has received a slightly different version of the program, so pay particular attention when we discuss the version you have received. *(play the hip comma song)*

Some of you have received Version A of the Hip Comma program. It includes practice problems that look like this. It is important that you read the directions at the top carefully. The directions will vary for each exercise. Please read them carefully before you start working with the sentences.

If you received Versions B or C, your practice problems will look similar to this one. When you see a practice problem like this, start by reading what is in the left box. The sentence in the left box will be very similar to the sentence in the right box, so by carefully studying the information in the left box, you should get the hints you need to correctly solve the problem in the right box.

If you received Versions D or E, your practice problems will look similar to this one. When you see a practice problem like this, start by answering the questions in the left box. Then carefully study the sentence in the right box. It will be very similar to the sentence in the right box. By carefully answering the questions and studying the information in the left box, you should get the hints you need to correctly solve the problem in the right box.
APPENDIX J

PRELIMINARY DATA ANALYSIS

*Outlier.* A visual inspection of Y versus X scatterplot suggested a few outliers on mean practice time on task, mean practice cognitive load, achievement test, transfer test, and posttest time on task. However, further analysis of delta beta ($\Delta \beta$) case index for each of these dependent variables showed that no observations had excessive influence on regression coefficients, thus the outliers were retained in the study.

*Independence of Observations.* This assumption was verified following a logical analysis of the study design and circumstances. Due to the nature of the study design, each student worked on the self-paced instructional material on his/her own with the facilitation of the teachers. Therefore, student peer interaction was minimized. This was verified by classroom observations conducted by the experimenters.

*Normal Distribution Assumption.* Histograms depicting the frequency distributions for each dependent variable were inspected to detect possible violations of this assumption. The data were deemed as reasonably normally distributed, except in a few cases. However, these cases were not judged problematic due to the fact that ANOVA is robust to moderate violations of this assumption when the sample size is sufficiently large (Tabachnick & Fidell, 2001), as was the case in this study.

*Homogeneity of variance.* The Levene test was used to verify homogeneity of variance. This assumption was satisfied for all tests except for practice percent score. Considering the fact that the size of the five groups is similar, ANOVA is reasonably robust to violations of this assumption (Stevens, 1996). However, to ensure that the resulting ANOVA was accurate, the Brown-Forsythe modification of Levene test statistics were examined for practice percent score rather than the omnibus-F ration test for the main ANOVA analysis, and the Games-Howell procedure was chosen for the post-hoc analysis.
### APPENDIX K

#### THINK-ALOUD STUDENT PERFORMANCE DATA

Table 4.25
Think-aloud student performance during Practice Exercise 2

<table>
<thead>
<tr>
<th>Students</th>
<th>Example-Practice Pair</th>
<th>Time</th>
<th>Correctness</th>
<th>Mental Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>SE prompts(L)</td>
<td>Practice problem</td>
</tr>
<tr>
<td>Sarah (Standard)</td>
<td>Pair 1</td>
<td>n.a.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>n.a.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>n.a.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>n.a.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Alex (IE)</td>
<td>Pair 1</td>
<td>n.a.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>n.a.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Roy (SE)</td>
<td>Pair 1</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chris (IE/SE)</td>
<td>Pair 1</td>
<td>n.a.</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>n.a.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Note. 1 means correct, 0 means incorrect
### Table 4.26
Think-aloud student performance during Practice Exercise 3

<table>
<thead>
<tr>
<th>Students</th>
<th>Pair</th>
<th>Time</th>
<th>Correctness</th>
<th>Mental effort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>SE prompts(L)</td>
<td>Practice problem</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarah (Standard)</td>
<td>Pair 1</td>
<td>n.a.</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>n.a.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>n.a.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Alex (IE)</td>
<td>Pair 1</td>
<td>n.a.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>n.a.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Roy (SE)</td>
<td>Pair 1</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chris (IE/SE)</td>
<td>Pair 1</td>
<td>n.a.</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Note. 1 means correct, 0 means incorrect

### Table 4.27
Think-aloud student performance during Practice Exercise 4

<table>
<thead>
<tr>
<th>Students</th>
<th>Pair</th>
<th>Time</th>
<th>Correctness</th>
<th>Mental effort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>SE prompts(L)</td>
<td>Practice problem</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarah (Standard)</td>
<td>Pair 1</td>
<td>n.a.</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>n.a.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Alex (IE)</td>
<td>Pair 1</td>
<td>n.a.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Roy (SE)</td>
<td>Pair 1</td>
<td>0</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chris (IE/SE)</td>
<td>Pair 1</td>
<td>n.a.</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>n.a.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Note. 1 means correct, 0 means incorrect
Table 4.28  
Think-aloud student performance during Practice Exercise 5

<table>
<thead>
<tr>
<th>Students</th>
<th>Pair</th>
<th>Time</th>
<th>Correctness</th>
<th>Mental effort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>SE prompts(L)</td>
<td>Practice problem</td>
</tr>
<tr>
<td>Sarah (Standard)</td>
<td></td>
<td></td>
<td>n.a.</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n.a.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n.a.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n.a.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n.a.</td>
<td>1</td>
</tr>
</tbody>
</table>

Alex (IE) |      |      | n.a. | 1 |       |
|          |      |      | n.a. | 1 |       |
|          |      |      | n.a. | 1 |       |
|          |      |      | n.a. | 1 |       |

Roy (SE) |      |      | 1 | 1 |       |
|          |      |      | 1 | 1 |       |
|          |      |      | 1 | 1 |       |
|          |      |      | 1 | 1 |       |
|          |      |      | 1 | 1 |       |

Chris (IE/SE) |      |      | n.a. | 1 |       |
|          |      |      | n.a. | 1 |       |
|          |      |      | 1 | 1 |       |
|          |      |      | 1 | 1 |       |

Note. 1 means correct, 0 means incorrect

Table 4.29  
Think-aloud student performance during Practice Exercise 6

<table>
<thead>
<tr>
<th>Students</th>
<th>Pair</th>
<th>Time</th>
<th>Correctness</th>
<th>Mental effort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>SE prompts(L)</td>
<td>Practice problem</td>
</tr>
<tr>
<td>Sarah (Standard)</td>
<td></td>
<td></td>
<td>n.a.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n.a.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n.a.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n.a.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n.a.</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n.a.</td>
<td>1</td>
</tr>
</tbody>
</table>

Alex (IE) |      |      | n.a. | 1 |       |
|          |      |      | n.a. | 1 |       |
|          |      |      | n.a. | 1 |       |
|          |      |      | n.a. | 1 |       |
|          |      |      | n.a. | 1 |       |

Roy (SE) |      |      | 1 | 1 |       |
|          |      |      | 1 | 1 |       |
|          |      |      | 1 | 1 |       |
|          |      |      | 1 | 1 |       |

131
Table 4.30
Think-aloud student performance during Pre- and Post-test

<table>
<thead>
<tr>
<th>Students</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Achievement test</td>
<td>Transfer test</td>
</tr>
<tr>
<td></td>
<td>Score</td>
<td>Mental Effort</td>
</tr>
<tr>
<td>Sarah (Standard WE)</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Alex (WE with IE)</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Roy (WE with SE)</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Chris (WE with IE/SE)</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>
APPENDIX L

YOUTH ASSENT FORM

Youth Assent Form

Dear Student,

I am a graduate student at Florida State University and I would like to ask you to participate in a study I am conducting. I am trying to identify how to do a better job of teaching middle school students how to properly use commas in the sentences they write. I hope you will agree to participate in this study.

During the study you will be asked to listen to a funny hip-hop song about using commas and you will be asked to study participate in several short lessons about using commas. I think you will enjoy these. If you would like to participate in this study, please sign this form.

If you choose not to participate or if you withdraw from the study at any time, there will be no penalty (it will not affect your grade). The results of the research study may be published, but your name will not be used. If you decide not to participate in the study, you will still be expected to complete the lessons on comma use as part of your regular English curriculum. However, I will not collect any of your personal information and will not use any data for research purposes.

If you have any questions concerning this research study, please contact me via e-mail at xh02@garnet.acns.fsu.edu. Thank you.

Sincerely,

Xiaoxia (Silvie) Huang

*******************************

I, __________________________ give my consent to participate in the above study.

(Inset your name here)

Student’s Signature: __________________________

Date: __________________________

[Signature]

Xiaoxia Huang
Dear Parent:

I am a graduate student under the direction of Professor Dr. Robert Reiser in the Department of Educational Psychology and Learning Systems at Florida State University. I am conducting a research study to investigate the different types of worked examples relating to comma usage on student performance in English classes.

Your child’s participation will involve studying a 5-lesson instructional program on applying two comma rules. Once students have studied each of the five lessons, they will be asked to complete a practice worksheet relating to the content taught in the corresponding lesson. At the end of the practice worksheets, your child will be asked to rate his/her perceived load of the practice activities. The length of each lesson is about 15-20 minutes. I will ask a few students to verbalize their thoughts and questions while they are studying the lessons and completing the corresponding practice worksheets. I will use a tape recorder to record their verbalized thoughts and questions to ensure all important information is analyzed.

Your child will complete a pretest and a posttest on comma usage and an attitude survey about the program. I’ll receive your child’s pretest, posttest, survey, and practice worksheet.

Your participation, as well as that of your child, in this study is voluntary. If you or your child chooses not to participate or to withdraw from the study at any time, there will be no penalty (it will not affect your child’s grade). The results of the research study may be published, but your child’s name will not be used. All students who participate in the study will complete the instructional program on comma use as part of their regular English curriculum. However, I will not collect any data about these students and will not use any data for research purposes.

Although there may be no direct benefit to your child, the possible benefit of your child’s participation is improved skills on punctuation.

If you have any questions concerning this research study or your child’s participation in the study, please call Silvie Huang at (850)766-0152 or Dr. Robert Reiser at (850)644-4592.

Sincerely,

Xiaoxia (Silvie) Huang

I give consent for my child __________________________ to participate in the above study.

(Insert your child’s name here)

I understand that my child may be tape recorded by the researcher if he/she agrees to verbalize his/her thoughts when studying the instructional program. These tapes will be kept by the researcher in a locked filing cabinet. I understand that only the researcher will have access to these tapes and that they will be destroyed by December 2007.

Parent’s Name: ____________________________________________

Parent’s Signature ____________________________ (Date) __________

If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Committee, Institutional Review Board, through the Vice President for the Office of Research at (850) 644-8633.
APPENDIX N

HUMAN SUBJECTS COMMITTEE APPROVAL FORM

Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8633 · FAX (850) 644-4392

APPROVAL MEMORANDUM

Date: 9/8/2006

To:
Xiaoxia Huang
MC 4453

Dept.: EDUCATIONAL PSYCHOLOGY AND LEARNING SYSTEMS

From: Thomas L. Jacobson, Chair

Re: Use of Human Subjects in Research
The Effect of Different Types of Worked Examples on Student Learning and Transfer of a Problem-Solving Task

The forms that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Human Subjects Committee at its meeting on 7/12/2006. Your project was approved by the Committee.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals which may be required.

If the project has not been completed by 7/11/2007 you must request renewed approval for continuation of the project.

You are advised that any change in protocol in this project must be approved by resubmission of the project to the Committee for approval. The principal investigator must promptly report, in writing, any unexpected problems causing risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols of such investigations as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Protection from Research Risks. The Assurance Number is IRB00000446.

cc: Dr. Robert Reiser
HSC No. 2006.0574
REFERENCES


Simon, D.


Tsai, C.-J. (1989). The effects of cognitive load of learning and prior achievement in the hypertext environment.


BIOGRAPHICAL SKETCH

Xiaoxia “Silvie” Huang joined the Instructional Systems program as a PhD student at Florida State University in 2002, with an interest in learning about different theories and practices that help create optimal teaching and learning environments. She received her Bachelor’s degree in English Language and Culture from Nanchang University in China in 1996 and her Master’s degree in English Studies from National University of Singapore in 2001.

During her PhD studies, Xiaoxia has worked as a research assistant on a couple of projects in military, K-12, or higher educational settings at Florida State University, with topics ranging from pedagogical agents, instructional design, team cognition, to student self-evaluation. In addition, Xiaoxia has several years’ teaching experience at the University level. She assisted two online (Blackboard-based) graduate level courses related to instructional design, including Introduction to Systematic Instructional Design and Instructional Material Development. In addition, she has been an instructor of a hybrid undergraduate level course Introduction to Educational Technology (Blackboard-enhanced) for two years at Florida State University. Besides her teaching experience at FSU, she has two years’ experience teaching English as a Second Language to college students and adult learners at Nanchang University in China.

Xiaoxia has received solid training in systematic instructional design based on design models and teaching/learning theories at Florida State University. At the same time, she considers herself a lifelong learner who is always willing to explore new teaching techniques/technologies and better practices for teaching and learning improvement.