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# Cognitive load of critical thinking strategies

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# COGNITIVE LOAD OF CRITICAL THINKING STRATEGIES

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ABSTRACT

**Cognitive Load of Critical Thinking Strategies**

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Critical thinking is important for today's life, where individuals daily face unlimited amounts of information, complex problems, and rapid technological and social changes. Therefore, critical thinking should be the focus of general education and educators' efforts (Angeli & Valanides, 2009; Oliver & Utermohlen, 1995). Despite passively agreeing or disagreeing with a line of reasoning, critical thinkers use analytical skills to comprehend and evaluate its merits, considering strengths and weaknesses. Critical thinkers also analyze arguments, recognizing the essentiality of asking for reasons and considering alternative views and developing their own point of view (Paul, 1990). Kuhn and Udell (2007) emphasize that the ability to participate in sound argument is central to critical thinking and is essential to skilled decision making.

Nussbaum and Schraw (2007) emphasized that effective argumentation includes not only considering counterarguments but also evaluating, weighing, and combining the arguments and counterarguments into support for a final conclusion. Nussbaum and Schraw called this process argument-counterargument integration. The authors identified three strategies that could be used to construct an integrative argument in the context of writing reflective essays: a refutation, weighing, and design claim strategy. They also

developed a graphic organizer called the *argumentation vee diagram (AVD)* for helping students write reflective essay.

This study focuses on the weighing and design claim strategies. In the weighing strategy, an arguer can argue that the weight of reasons and evidence on one side of the issue is stronger than that on the other side. In a design claim strategy, a reasoner tends to form her opinion or conclusion based on supporting an argument side (by taking its advantages) and eliminating or reducing the disadvantages of the counterargument side. Based on learning other definitions for argumentation, I define argumentation in this study as a "reasoning tool of evaluation through giving reasons and evidence for one's own positions, and evaluating counterarguments of different ideas for different views."

In cognitive psychology, cognitive load theory seems to provide a promising framework for studying and increasing our knowledge about cognitive functioning and learning activities. Cognitive load theory contributes to education and learning by using human cognitive architecture to understand the design of instruction. CLT assumes limited working memory resources when information is being processed (Sweller & Chandler, 1994; Sweller, Van Merriënboer & Paas, 1998; Van Merriënboer & Sweller, 2005).

## The Present Research Study

### *Research Questions*

1- What is the cognitive load imposed by two different argument-counterargument integration strategies (weighing, and constructing a design claim)?

2- What is the impact of using the AVDs on amount of cognitive load, compared to using a less diagrammatic structure (linear list)?

It is hypothesized that the weighing strategy would impose greater cognitive load, as measured by mental effort rating scale and time, than constructing a design claim strategy. As proposed by Nussbaum (2008), in using weighing strategy a larger number of disparate (non-integrative) elements must be coordinated and maintained in working memory. It is also hypothesized that the AVDs would reduce cognitive load, compared to a linear list, By helping individuals better connect, organize, and remember information (various arguments) (Rulea, Baldwin & Schell, 2008), and therefore freeing up processing capacity for essential cognitive processing (Stull & Mayer, 2007).

The experimental design of the study consisted of four experimental groups that used strategies and two control groups. I tested the hypotheses of the study by using a randomized 2x3 factorial design ANOVA (two strategies prompt x AVD and non- AVD) with a control group included in each factor. *Need for cognition (NFC),* a construct reflecting the tendency to enjoy and engage in effortful cognitive processing (Petty & Cacioppo, 1986), was measured and used as an indication of participants' tendency to put forth cognitive effort.

Thinking and argument-counterargument integration processes took place through electronic discussion board (WebCampus), considering analysis questions about grading issue "Should students be graded on class participation?" I chose that analysis question as it represents an issue that is meaningful and important for college students, in that they can relate and engage easily in thinking about it.

The results of the first research question pointed to a significant relationship between the complexity of an essay, as measured by complexity of weighing refutation, and cognitive load as measured by time and cognitive load scale. Weighing refutations also involved more mental effort than design claims even when controlling for the complexity of the arguments. The results also revealed that there was a significant interaction effect for NFC.

The results of the second research question were non-significant. The results showed that the linear list that was used by the control group was as productive as the AVDs. There was no difference between the control and experimental groups in the amount of cognitive load that they reported in terms of mental effort and time spent on the thinking and integration process.

Measuring the cognitive load of different argument-counterargument integration strategies will help inform instructional efforts on how best to teach these strategies, design effective instructional techniques for teaching critical thinking, and will also help provide theoretical insight in the cognitive processes involved in using these strategies.

# DEDICATION

This accomplishment is dedicated to my husband, Dr. Eng. Khaled Moustafa, who was a continuous source of strength to me. I will forever be grateful for his support. I also dedicate it to my loving mother, Mubaraka Alsaeed, and to my deceased father, who hoped to witness that moment, both taught me to have hope and to work hard to achieve my goals. I also dedicate this dissertation to the light of my life, my kids, Zeyad and Omar, who lived every moment of this dissertation with me and were patient while they waited for their mommy to finish her big homework.

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# CHAPTER 1

# INTRODUCTION

Critical thinking is indispensable for today's life, where individuals daily face unlimited amounts of information, complex problems, and rapid technological and social changes. Therefore, critical thinking should be the focus of general education and educators' efforts (Angeli & Valanides, 2009; Oliver & Utermohlen, 1995). Rather than passively agreeing or disagreeing with a line of reasoning, critical thinkers use analytical skills to comprehend and evaluate different viewpoints, considering strengths and weaknesses. Critical thinkers also analyze arguments, recognizing the essentiality of asking for reasons and considering alternative views and developing their own point of view (Paul, 1990).

In the early 1980s, the report of the National Commission on Excellence in Education, *A Nation at Risk* (1983), emphasized the lack of effective attempts to promote higher order thinking skills in schools such as critical thinking. It revealed that around 40 percent could not come to a conclusion from a written material and around one fifth of participants could not write a persuasive essay. By 1990, following the findings of a *Nation at Risk*, most states designed programs to teach students to think critically (Willingham, 2007).

Kuhn and Udell (2007) emphasize that the ability to partake in sound argument is vital to critical thinking and is essential for decision making skills. In a different sense, Halpern (1998) highlights prevalence of pseudoscientific thinking in American society (widespread belief in astrology, untested health remedies, etc.). She proposed a taxonomy for teaching critical thinking skills in classrooms. In this taxonomy, Halpern indicates that argumentation is one major component that students need to learn for promoting critical thinking. Furthermore, Paul (1990) and Beyer (1995) put argumentation as a core aspect and strategy for critical thinking.

Recently, the growing understanding of cognitive structures and processes has offered a strong basis of research and instructional design (Sweller, Van Merrienboer, & Paas, 1998). In cognitive psychology, cognitive load theory seems to provide a promising framework for studying and increasing our knowledge about cognitive functioning and learning activities. Cognitive load theory contributes to education and learning by using human cognitive architecture to deal with the design of instruction, assuming limited working memory resources are available when information is being processed (Sweller & Chandler, 1994; Sweller, Van Merriënboer & Paas, 1998; Van Merriënboer & Sweller, 2005). Some research studies have indicated high cognitive demands of dialogic or written elaborated argumentation (e.g., Bernardi & Antolini, 1996; Coirier, Andriessen & Chanquoy, 1999; Kuhn, 2005; Nussbaum, 2008), explaining students' difficulties in engaging in argumentation processes in terms of cognitive overload. Yet, no studies have measured the cognitive load associated with any argumentation processes (e.g., strategies or moves).

Using cognitive load theory as a framework, we can attain more knowledge about human cognitive structure, which may lead to facilitating learners' cognitive performance in different tasks. Particularly, research suggests that learners' performance on any given task is a function of three constraints: the mental strategy for approaching the task, the demand the strategy places on learners' mental capacity, and the learners' available mental capacity (Case, 1974).

The present study explored argumentation as a core feature of critical thinking ability; in particular, the study examined the cognitive load of two argument-counterargument integration strategies. These strategies aim to integrate arguments and counterarguments into an overall final opinion or conclusion. Participants were undergraduate and graduate students who are enrolled in educational psychology courses at the University of Nevada, Las Vegas.

## Critical Thinking and Argumentation

Critical thinking consists of a combination of skills; it is a comprehensive way of thinking that entails evaluation, synthesis, recognizing alternative assumptions, and drawing conclusions (Sendag & Odabas, 2009). Definitions of critical thinking are wide-ranging (Kuhn & Dean, 2004) but most definitions incorporate individual ability to build and assess conclusion based on evidence (Eggen & Kauchak, 2010). Chance (1986) defines critical thinking as “the ability to analyse facts, generate and organize ideas, defend opinions, make comparisons, draw inferences, evaluate arguments and solve problems” (p.6). Furthermore, in Ennis' Weir Critical Thinking Essay Test, test takers are required to create a complex argument in response to a previous argument. The test aims to assess the student's critical thinking ability throughout analysing and evaluating an argument and offering a reasoned response (Ennis & Weir, 1985).

Critical thinking skills include considering (integrating) multiple viewpoints or taking both sides of an issue into account (Angeli & Valanides, 2009;  Willingham, 2007), examining related elements, resolving disagreements with reason and proof, and re-evaluating one’s own perspective through deliberation of new information (Angeli & Valanides, 2009). Accordingly, critical thinking is considered a constructivist analytical tool that enables us to: evaluate problems, take actions towards a goal, make decisions, and conduct thoughtful reflections on our reasoning (Sendag & Odabas, 2009). More specifically, Halpern defines critical thinking as “the use of those cognitive skills or strategies that increases the probability of a desirable outcome....It is purposeful, reasoned, and goal directed” (Halpern, 1998, p. 449). She also emphasizes that, in critical thinking processes, one can appraise the outcomes of one’s thoughts and evaluate the perspectives of others. Chinn and Anderson (1998) use the term interactive argumentation to refer to “discussions in which participants present reasons and evidence for different positions” (p. 317). Additionally, students in interactive argumentation reflect critically in other perspectives by being able to consider arguments on different sides of an issue (Chinn & Anderson, 1998). Halpern’s (1998, 2001) definition of critical thinking is very similar to the definition of “interactive argumentation” as both definitions include presenting reasons and considering other perspectives

In the same sense, Voss and Means (1991) illustrate that an inferential structure of reasoning constitutes the processes of argumentation. According to Voss and Means, reasoning is defined as “an inferential process by which a person, beginning with some given information or premise, makes an inference which enables that individual to reach a conclusion or provide some new (inferred) information that was not given” (p. 338). Furthermore, Beyer (1995) defines critical thinking briefly as “making reasoned judgments" (p. 8).

Therefore, in this study, augmentation was considered as the process by which critical thinking was articulated; and participants’ integrated arguments or essays were the finished product of their thinking (Andrews, 2007). In the critical thinking movement, many researchers regard critical writing as being not only a relevant topic for investigation but also a defining attribute of critical thinking (Nussbaum, 2002, 2008; Paul, 1990; Quitadamo & Kurtz, 2007; Wade, 1995).

## What is Argumentation?

The terminology used to portray argumentation is somewhat problematic (Naylor, Keogh & Downing, 2007). The terms "argument" and "argumentation" can both be used as an indication of raging discussion or debate (Andriessen, Baker & Suthers, 2003). This is not what it indicates in critical thinking. In critical thinking, an argument is "a proposition with its supporting evidence and reasoning" (Beyer, 1995). In other words, argumentation is more general as it represents a process of thinking and social interaction, in which individuals construct and evaluate arguments (Beyer, 1995; Nussbaum, 2007; Taylor, 1971). Andriessen, Baker and Suthers (2003) emphasize that restricted meanings of the term argument refers to "reason advanced" and the term argumentation refers to a "methodological (line of) reasoning." Likewise, Andrews (2005) suggests that argument is "a mode of thinking and composition" while argumentation is "the process of operating within that mode." Accordingly, argument refers to the phenomenon and argumentation refers to the arguing process.

Similarly, Taylor (1971) views argumentation as "the theory of argument": a process by which people take decisions and solve problems (Taylor, 1971). In a similar vein, Voss and Means (1991) view argumentation as "the generation and evaluation of arguments." Beyond considering the term "argument" in relation to "argumentation," many definitions are offered for an argument from different perspectives. Some definitions view argumentation from a justification and persuasion perspective (Toulmin, 1958; The National Development Conference on Forensics, cited in Freeley & Steinberg, 2000), from a reasoning perspective (Chinn, 2006), and as a social phenomenon (Eemeren, Grootendorst & Henkmans, 1996).

The present study focused on argumentation as an aspect of thinking, in which individuals can evaluate and critique arguments (Nussbaum, 2007). The aim of argument in this study involved judgments, opinions, and subjective preferences (Coirier, Andriessen & Chanquoy, 1999). For example, participants in the present study critically evaluated arguments and counterarguments through critical questions in order to reach an overall final integrated conclusion. Consequently, the current study defined argumentation as a "reasoning tool of evaluation through giving reasons and evidence for one's own positions, and evaluating counterarguments of different ideas for different views."

Argumentation may take place within an individual (Voss et al., 1999). This study employed argumentation as an interior, individual form, which occurs "when one argues with oneself or formulates a line of reasoning to support a claim" (Kuhn, 2005, p. 113). In this study students argued about an analysis question individually, judging, giving reasons, and considering the merits of both sides of an argument. Furthermore, argumentation can occur in various types of media including physical means of expression and representations (Anderiessen et al., 2003). The mean of expression of this study was through writing and also diagrammatic as the study utilized a graphic organizer.

## Argument-Counterargument Integration

Nussbaum and Schraw (2007) emphasized that effective argumentation includes not only considering counterarguments but also evaluating, weighing, and combining the arguments and counterarguments into support for a final conclusion. Nussbaum and Schraw called this process argument-counterargument integration. Argument integration was studied earlier by some researchers and called "conceptual/integrative complexity" (Marry, 2002; Suedfeld, Tetlock & Streufert, 1992; Tetlock, 1984, 1986), integrative thinking (Martin, 2007; Sill, 1996). It is also close to "cognitive complexity" (Biwri, 1971 as cited in Suedfeld et al., 1992), and "cognitive structure" (Scott, Osgood & Peterson, 1979 as cited in Suedfeld et al., 1992).

Nussbaum and Schraw (2007) emphasize three main reasons for the importance of argument-counterargument integration. First, integration requires students to reflect on argumentation process deliberately to make sure that arguments and counterarguments relate and reply to one another. This reflection facilitates learning as it requires students to elaborate and organize their ideas and thinking. Second, argument-counterargument integration helps in producing logically stronger written arguments. Finally, argument-counterargument integration is important because it is a central aspect of critical thinking.

Moreover, Nussbaum and Schraw (2007) identified three strategies that could be used to construct an integrative argument in the context of writing reflective essays: refutation, weighing, and synthesizing strategy. As an illustration of how each strategy can be used in the integration process, Nussbaum and Schraw provided an example for an argument about whether candy should be forbidden at school as it makes kids very active and reduces concentration. The counterargument is that children should sometimes have candy in school because it pleases them and provides them with some energy.

Considering both the argument and the counterargument, an arguer might try to refute the counterargument using a "refutation strategy." By using this strategy, the arguer could argue that there are other things, such as additional recess or physical activities, which can make children happy more than candy. On the other hand, the arguer might try to take "in-between" positions and build up a final conclusion reflecting benefits of an alternative while attempting to lessen or eliminate negative consequences cited in a counterargument, thus taking the counterarguments into account. This can happen by arguing that children should only be allowed to eat candy during the last hour of the school day, and then any resulting hyperactivity will not hinder students' learning. Nussbaum and Schraw (2007) initially termed this strategy "synthesis," but Nussbaum and Edwards (in press) termed this strategy constructing a design claim, that is, a claim regarding how a solution should be designed. A third strategy identified by the authors was the weighing strategy. By using this strategy, an arguer can argue that the weight of reasoning and evidence on one side of the issue is stronger than that on the other side.

*Argumentation Diagrams*

Researchers have used representational tools to facilitate argumentation learning, helping students to learn how to argue about knowledge. Argumentation diagrams are one of those representational tools which visualize the domain that is being discussed (Van Amelsvoort, Andriessen & Kanselaar, 2007). Suthers (2003) defines representational tools as "software interfaces in which users construct, examine, and manipulate external representations of their knowledge" (p. 28). Representation tools are mainly used to support students' collaborative argumentation learning, assuming that an argumentative diagram can support both cognitive and interactional processes (Van Amelsvoort et al., 2007; Van Drie, Van Boxtel, Erkens & Kanselaar, 2005).

*Argumentation vee diagram (AVD).* Nussbaum and colleagues employed graphic organizers in several research studies in the context of writing opinion essays. Nussbaum and Schraw (2007) developed a graphic organizer for helping undergraduate students write reflective essays. Nussbaum (2008) introduced a redesigned graphic organizer known as an argumentation vee diagram (AVD) (Figure 1), and employed it to support argument-counterargument integration. The AVD was adapted from a tool originally used to structure science investigations. It involves listing arguments on both sides of an issue. Various questions can be included at the base of the "V" to scaffold students' thinking. Moreover, Nussbaum (2008) suggested that to engage in argument–counterargument integration, students need to evaluate the strength of arguments. Therefore, there are some critical questions under the vee diagram encouraging students to think more about both sides of the argument such as, "Which side is stronger, and why?" and "Is there a creative solution?"

These strategies require the integration of multiple ideas, and such integration occurs in working memory (Christoff et al., 2001; Krumm, Ziegler & Buehner, 2008). Waltz et al. (1999) distinguished between the capacity required to comprehend single relations and the capacity to integrate multiple relations, emphasizing that integrating multiple relations requires much more capacity from a learner. This is because integrating two relations involves more than perceptual or linguistic processing (Waltz et al., 1999), which may require more devoted mental resources, inducing cognitive overload on learners' working memory. Argument-counterargument integration requires consideration of relationships of the elements making up an argument as well as the relationship among arguments, and so—it is hypothesized—high cognitive effort on the part of reasoners.

## Cognitive Load Theory

Cognitive load theory (CLT) (Sweller, 1988; Sweller & Chandler, 1994; Sweller, Van Merrienboer & Paas, 1998; Van Merrienboer & Sweller, 2005) is concerned with the manner in which cognitive resources are used during learning and problem solving. The theory was shown to assist in presenting information and helping in designing efficient instructional environments (Clark, Nguyen & Sweller, 2006; Kirschner, 2002). CLT focuses on knowledge about human cognitive architecture. The theory has several assumptions: the assumption of unlimited long-term memory, schema theory of mental representations of knowledge, and limited-processing capacity assumption for working memory (Sweller & Chandler, 1994). According to CLT, meaningful learning depends on active cognitive processing for information in learners' working memory (Paas, Tuovinen, Tabbers & Van Gerven, 2003b; Sweller et al., 1998).

### *Types of Cognitive Load*

CLT distinguishes three types of cognitive load: extraneous, intrinsic and germane cognitive load (Gerjets, Scheiter & Cierniak, 2009; Sweller et al., 1998). *Extraneous cognitive load* is cognitive load imposed by the format and the manner in which information is presented to learners (Brunken, Plass & Leutner, 2003). *Intrinsic cognitive load* is intrinsic to the nature of the material or a task being taught (Clark et al., 2006). It is related to the "complexity of a domain" (Paas, Van Gerven & Wouters, 2007), or the “intellectual complexity of information” (Pollock, Chandler & Sweller, 2002). *Germane cognitive load* directly contributes to learning; that it facilitates learners’ construction of cognitive structures and processes that improve performance (Van Merrienboer, Kester & Paas, 2006).

CLT is concerned with the learning of complex cognitive tasks, in which learners face a number of interactive elements that need to be processed in working memory (Kirschner, Paas & Kirschner, 2009). According to this theory new information must be processed through working memory, which is limited in capacity and duration, in order for learning to take place (Sweller et al., 1998; Van Merrienboer & Sweller, 2005). Therefore, the amount of cognitive processing required for learning simultaneously should not go beyond the learner’s processing capacity (DeLeeuw & Mayer, 2008).

## The Present Research Study

Most of the work available to date in the argumentation literature has only dealt theoretically with cognitive overload without measuring it. This study highlights the importance of considering the cognitive load that the learners experience during critical thinking (engaging in argument-counterargument integration process). The study also provides new avenues for understanding argumentation processes through understanding its underlying cognitive mechanisms. This study is assumed to take cognitive load theory a step further, applying its principles on the context of critical thinking.

In the present study, thinking and argumentation process related to an analysis question regarding the grading issue “Should students be graded for class participation?” As a response for that question, I provided students with some arguments and counterarguments that represent two different sides or viewpoints about that issue. Then I asked them to think critically about the two sides and try to integrate it into a final conclusion, using one of the integration strategies; weighing refutation strategy or constructing a design claim. I chose that analysis question as it represents an issue that meaningful and important for college students, in that they can relate and engage easily in thinking process about it.

This study aimed to answer the following research questions:

1- What is the cognitive load imposed by two different argument-counterargument integration strategies (weighing, and constructing a design claim)?

2- What is the impact of using the AVDs on amount of cognitive load, compared to using a less diagrammatic structure (a linear list)?

I hypothesized that the weighing strategy would impose greater cognitive load, as measured by mental effort ratings and time, than constructing a design claim strategy. As proposed by Nussbaum (2008), in using weighing strategy, a larger number of disparate (non-integrative) elements must be coordinated and maintained in working memory.

I also hypothesized that there would be a significant interaction between need for cognition, weighing refutations and cognitive load. In that the strength of a relationship between weighing refutation complexity and mental effort depended on the level of NFC. Sweller (2010) emphasized that learners' characteristics are related to cognitive load and can affect it.

For the second research question, I hypothesized that the AVDs would reduce cognitive load, compared to a linear list, By helping individuals better connect, organize, and remember  information (various arguments) (Rulea, Baldwin & Schell, 2008), and therefore freeing up processing capacity for essential cognitive processing (Stull &

Mayer, 2007). I tested the hypotheses using a randomized 3x2 factorial design (two strategies prompt and control x AVD and non AVD) with a control group included in each factor. *Need for cognition,* a construct reflecting the tendency to enjoy and engage in effortful cognitive processing (Petty & Cacioppo, 1986), was also measured and used as an indication of participants' tendency to put forth cognitive effort.

The argument-counterargument integration processes occurred through an electronic discussion board (WebCampus), considering a discussion question of "Should students be graded on class participation?" The study utilized argument vee diagrams (AVDs) for integrating both arguments and counterarguments. The c*ognitive load rating scale* (Paas, 1992) also was used to measure mental efforts as an indication of intrinsic cognitive load associated in conducting a specific task. Moreover, the time for finishing the task was calculated as another indication for the amount of cognitive load that invested on a task.

## Results

The findings of this study support the notion that working memory affects performance on reasoning tasks (Kyllonen & Christal, 1990; Means &Voss, 1996). The results of the first research question "what is the cognitive load imposed by two different argument-counterargument integration strategies (weighing, and constructing a design claim)?" pointed to a significant relationship between the complexity of an essay, as measured by complexity of weighing refutation, and cognitive load as measured by time and cognitive load scale. Weighing refutations also involved more mental effort than design claims even when controlling for the complexity of the arguments. The results also revealed that there was a significant interaction effect with NFC. However, the results of the second research question "what is the impact of using the AVDs on amount of cognitive load, compared to using a less diagrammatic structure (a linear list)?" were not significant. The results showed that the linear list that was used by the control group was as productive as the AVDs. There was no difference between the control and experimental groups in the amount of cognitive load that they reported in terms of mental effort and time spent on the thinking and integration process.

The results of the study were consistent with my first two hypotheses in that the weighing refutation strategy imposed more cognitive load and there is a significant interaction effect for need for cognition. However, the results of the study were not consistent with my second hypothesis in that the AVD would reduce the cognitive load of participants of experimental groups comparing to participants of the control group who used a linear list.

## Discussion

The findings of the study are meaningful when explained in the context of cognitive processing and cognitive load theory. CLT assumes that working memory is limited in duration and capacity. The weighing refutation strategy requires a reasoner to maintain at least two sides of an issue simultaneously in working memory, evaluating, giving opinion, and considering the merits of both sides of an argument to produce a final conclusion. It is possible that this process of integrative and critical thinking required more cognitive resources from the participants and caused more cognitive load, particularly intrinsic cognitive load. Research suggests that intrinsic cognitive load is determined by the extent to which various elements interact at any one time in order to successfully perform a task (Paas & Van Gog, 2006; Pollock et al., 2002). Furthermore, Waltz et al. (1999) illustrate that integrating multiple relations is resource demanding on learners working memory as it requires much more cognitive capacity from a learner.

For the other research question of the study “what is the impact of using the AVDs on amount of cognitive load, compared to using a less diagrammatic structure (a linear list)? The findings showed the linear list was as efficient as the AVD in reducing students’ cognitive load. Considering the way the linear list was organized, I suggested that it was possible that the linear list was short and organized enough to help students process the two sides of the issue as easily as with an AVD. In sum, this study provides some answers to important research questions and links cognitive load theory and argument-counterargument integration. The study also has practical importance for educational practice in addition to theoretical importance. Measuring the cognitive load of different argument-counterargument integration strategies can help inform instructional efforts on how best to teach these strategies, design effective instructional techniques for teaching critical thinking, and will also help provide theoretical insight in the cognitive processes involved into using these

# CHAPTER 2

# REVIEW OF RELATED LITERATURE

This chapter reviews the literature regarding argumentation (as a core concept of critical thinking) and cognitive load theory. Cognitive psychology did not traditionally pay a lot of attention to argumentation (Bouvier, 2007; Voss et al., 1999). Also, argumentation theories have not looked at cognitive load; no studies are reported measuring the cognitive load associated with any of argumentation processes (e.g., strategies or moves).

This chapter is organized as follows. The first major section offers an overview of critical thinking and argumentation, the theoretical frameworks, the importance and difficulties of considering counterarguments, and argument-counterargument integration concept. The second section presents cognitive load theory, its history, basic assumptions and the different types and measurements of cognitive load, as well as the relation between argumentation integration and cognitive load. The chapter also addresses the literature on graphic organizers and argumentation diagrams. Finally, an outline of present research is reviewed.

## Argumentation

### *Critical Thinking and Argumentation*

Argumentation is an essential tool of reasoning (Andriessen et al., 2003; Coirier et al., 1999; Nussbaum, 2002, 2008; Voss & Means, 1991; Voss, Wiley & Sandak, 1999), and argumentation skills are considered as basic to reasoning ability (Kuhn, 1991; Voss & Means, 1991). Billig (1987) puts argumentation in a central place in the theory of thinking, concluding that “there is nothing especially distinct about thinking, as opposed to argument" (p. 110). Kuhn (2005) also views thinking as "a social activity embodied in people's discourse to advance their individual and shared goals" (Kuhn, 2005, p.15). In addition, Kuhn and Udell (2007) emphasize that the ability to engage in sound argument is central to critical thinking and is essential to decision making ability.

Chance (1986) defines critical thinking as "the ability to analyse facts, generate and organize ideas, defend opinions, make comparisons, draw inferences, evaluate arguments and solve problems" (p.6). Similarly, research stresses that critical thinking entails evaluating and constructing arguments (Beyer, 1985; 1995) in addition to the ability to form (or integrate) a conclusion from multiple premises (Alagozlu, 2007; Willingham, 2007). Beyer (1995) also emphasizes that argument is one of the six distinguishing elements of critical thinking, functioning as the principle form by which people support the results of their thinking. These results of thinking can be conclusions, solutions, factual claims, judgments, decisions, or anything people declare to be accurate, or correct.

Because argumentation is central to critical thinking, several research studies have promoted critical thinking through different forms of argumentation (e.g. Bas, de Leng, Dolmans, Jöbsis, Muijtjens & Vleuten, 2009; Malamitsa, Kasoutas & Kokkotas, 2009; Weinstock, Assor & Broide, 2009). For example, Malamitsa et al. (2009) conducted a study to examine the development of sixth grade students' critical thinking skills in science teaching. The project focused on dilemmas, debates, active participation by teamwork, developing argumentation, problem-solving, and on engaging students in practical work. One of the main results of the project was that it helped in promoting students' critical thinking skills, which manifested in identifying and evaluating arguments, assessing claim, forming conclusions, and justifying procedures.

Weinstock, Assor and Broide (2009) studied teachers' encouragement of critical thinking as a mean of promoting moral judgment. In this study teachers used forums where participants were encouraged to speak their minds and evaluate merits of arguments and present their viewpoints. Moreover, Kent Colbert, in Freeley and Steinberg (2000), carried out a one-year study, allowing students to engage in either the Cross Examination Debate Association or the National Debate Tournament. The findings suggested that debaters were more advanced than the non-debaters on critical thinking tests.

Based on the central role that argumentation play in critical thinking, there has been growing interest among educational and developmental psychologists in argumentation (Nussbaum, 2007). In the past, argumentation used to be a topic that concerned lawyers and philosophers. Today, argumentation is conceived as mostly cognitive and interactive activity with a strong formal foundation, which is linked to both knowledge and logical thinking (Mirza & Tartas, 2007; Fox et al., 2009). From a theoretical perspective, argumentation can be viewed as a path for understanding human cognition (Fox et al., 2009). It is also an effective mechanism to explore different points of view, and to increase one's knowledge as it involves different socio-cognitive operations such as justification and negotiation (Mirza & Tartas, 2007).

## Theoretical Frameworks

### *Sociocognitive Conflict*

In cognitive sciences and social psychology, many cognitive theories embrace Piaget's notion of *homeostasis* (Pasquier et al., 2003), *equilibration* (Ames & Murray, 1982; Lee et al., 2003) or *social conflict* (Mugny & Doise, 1978). According to Piaget, this notion implies that "human beings incline to maintain or restore some physiological or psychological constants regardless of the outside environment variations" (Pasquier et al., 2003, p. 2). In other words, equilibration is related to the process of self-regulation that conserves a balance between assimilation and accommodation (Lee et al., 2003). Learners in a state of cognitive conflict may express signs of curiosity, and inner drive to solve the conflict, and ultimately contentment as they arrive at a meaningful resolution (Parker, 2006). During the last years of Piaget's work and since the middle of the 1970s, the notion of equilibration or conflict became an essential key for explaining cognitive development through trying to reconcile conflicting views (Leitão, 2000; Murray, 1982).

Leitão (2000) draws some similarities between argumentation and Piaget's ideas of achieving equilibrium in intellectual exchange. Leitão demonstrates that both processes originate when individuals become aware of opposition between their points of views and information given to them. Additionally, both processes progress through reflecting on one's existing knowledge; which may lead individuals either to confirm or counteract parts of that knowledge. Moreover, dealing with opposition in both cases (argumentation and equilibrium) is considered an essential step for rational thinking, and the moving forward from old views to new ones.

Moreover, Leitão (2000) emphasizes that argument and counterargument were already part of Piaget's early work and received considerable treatment within his theory. She illustrated that Piaget viewed children's disagreements about intellectual or moral issues as important experiences for advancing children's cognitive development. Moreover, in Piaget's theory, children's discussions were depicted as scenarios that allowed for conflict between participants' perspectives to start; this conflict in turn stimulates children to search for new forms of knowledge that match reality better than their original perspectives (Leitão, 2000).

In addition, students' interest may be stimulated when they argue about issues and discover that their peers have different ideas; it might be also engaging to try to resolve conflicting perspectives (Chinn, 2006). Furthermore, Veerman and Treasure-Jones (1999) emphasize that when individuals are confronted with conflicts and try to manage and resolve them through negotiation (argumentation) this provides an impetus for learning, and defines the organization and nature of learning situation (Veerman & Treasure-Jones, 1999). On the other hand, avoiding conflict may be risky for learning as it may deprive students from recognizing and exploring other perspectives (Webb, 1997).

*Cognitive Elaboration Theory*

Cognitive elaboration theory emphasizes the importance of argumentation in promoting deeper learning (Nussbaum, 2008; O'Donnell & King, 1998). Knowledge elaboration could involve creating logical relationships between old and new learned materials through refining, expanding, integrating, and linking prior knowledge and the new information (Kalyuga, 2009; Weinstein, 1977). In argumentation process, individuals who develop defences or attacks for their own or for their partner's claims have to reappraise and monitor their own beliefs and understand the beliefs of their partner. Such monitoring requires explanation, which links argumentation to the self-explanation effect (Lund, Molinar, Sejourne & Baker, 2007) and thereby elaboration, deeper processing and understanding of the learned material (Ainsworth & Th Loizou, 2003; Chi, Bassok, Lewis, Reimann & Glaser, 1989; Munneke, Andriessen & Kanselaar, 2007; Tajika, Nakatsu, Nozaki, Neumann & Maruno, 2007).

*Self-Explaining*

Self-explaining has been studied extensively by Chi and her colleagues (Chi, 2000; Chi et al., 1989) and refers to a type of verbal practice in which learners explain the content of a text during learning. The goal of the explanations is for learners to make sense of what they are learning. Furthermore, Chi (2000) proposes that self–explanation is a method of “constructivism” and knowledge acquisition based on information gathering and working the information into an individual’s mental models, in addition to helping one to internalize learning and make it sensible.

According to Chi, the self-explanation effect is assumed to work via two main contrasting approaches. The first is generating inferences beyond information contained in text sentences. These inferences are determined on the basis of information that missing from the text sentence. Thus, self-explanation implies a direct communication between the model conveyed by the text and the learner’s mental model. The second way by which self-explanation works in the human mind, is through repairing individuals’ mental models. This process assumes that inferences fill gaps in one’s representations when a mental model conflicts with a text model and some violation is detected and repair is undertaken through resolving discrepancies in understanding.

By considering argumentation as a learning facilitator through self-explanation and elaboration, Webb and colleagues (Webb et al., 2008; Webb, Troper & Fall, 1995) investigated learning in collaborative small groups through discussions. They emphasized the power of self-explanation that can occur through that type of interaction and can lead learners to more elaborated conceptual understandings than learning material by themselves. More specifically, Webb et al. illustrate that the process of giving explanations may encourage explainers to clarify or reorganize material in new ways through resolving conflicts and inconsistencies. Additionally, through self-explanation, students can recognize and fill the gaps in their understanding and develop new perspectives.

Webb (1997) also suggests that disagreement and resolving conflicts can be beneficial mechanisms for learning. These mechanisms can help students learn and produce high quality products. Webb also emphasizes that students working together can build on each other's ideas and viewpoints to construct new knowledge. For example, when students recognize that their beliefs are different from others, they may learn by explaining and providing reasons to their own views, identifying different perspectives, resolving the differences, and reaching agreement on a decision (Webb, 1997).

In addition, according to this view, argumentation may encourage students to generate relationships among concepts and with prior knowledge (Wittrock, 1992). Discussion situations also can expose individuals to different points of views, stimulate children to produce their own ideas (which requires examining individuals' own ideas and other ideas through reflection, self-explanation, and elaboration), and create situations in which these ideas are challenged by peers' different ideas (Reznitskaya et al., 2001). Furthermore, generating counterarguments and expressions of views under criticism could lead to more elaborated and integrated discourse on the topic being discussed.

Consequently, counterargument can be considered as a possible mechanism in facilitating students' learning from argumentation situations (Andriessen et al., 2003). In argumentation situations students also have to express their thoughts explicitly and integrate information from different sides, searching for causes and relations in the topic under discussion (Van Amelsvoort, Andriessen & Kanselaar, 2007). Accordingly, students may recognize that their point of disagreement cannot be resolved without obtaining further information either from their teacher or peers (Lund et al., 2007), which may stimulate more explanations, points of views, and ideas.

*Sociocultural Constructivist*

A constructivist view of learning implies an active process of personal construction, by which existing knowledge, understanding, and experiences are integrated with new experiences and ideas (Parker, 2006). Negotiated construction of knowledge among individuals is one of the main principles of constructivist learning theory. Such negotiation facilitates testing understanding and ideas against each other as a mechanism for enriching and expanding understanding of a discussed phenomenon. Accordingly, understanding is achieved through interaction with others within an environment (Veerman & Treasure-Jones, 1999).

In fact, this idea of building knowledge through interaction and dialogue with others traces back to early philosophers such as Plato, Socrates, and Aristotle (Anderson et al., 2001; Billing, 1987; Kuhn, 1991). For example, in Billing (1987), Socrates claims "the same arguments which we use in persuading others when we speak in public, we employ also when we deliberate in our thoughts" (p. 110). In addition, Plato claims that "thought and speech are the same; only the former, which is a silent inner conversation of the soul with itself, has been given the special name of thought" (p. 111).

Recently, the same ideas of the relation between argumentation and thinking are articulated in the work of the Russian psychologist, Vygotsky (1896-1939), who claims that forms of discourse such as argumentative talk become forms of thinking (Anderson et al., 2001; Kuhn, 1992; Reznitskaya et al., 2001; Schwarz, Neuman & Biezuner, 2000). Vygotsky's perspective focuses on the social context of cognition. He emphasizes that higher mental functions and development of cognition build up through a process by which the learner has social interactions with others (Bruning, Schraw, Norby, & Ronning, 2004; Salkind, 2004).

Furthermore, a major theme in Vygotsky's theory is that cognitive processes are mediated by cultural tools (De Lisi, 2006). In this view, language is a very important developmental and cognitive tool in that it helps minds to grow and expand already existing ideas into new realms (Salkind, 2004). Moreover, Vygotsky (1978) proposed the term "internalization" to describe the process by which learning concepts entails the transformation of an interpersonal process and an intrapersonal process. Therefore, concepts are not to be only conceived as mental entities in our heads, which reflect internal representations of the world, but rather as part of the social practices in which people participate. Concepts are intended as conceptual and reasoning tools that are used when people think "intramentally" and communicate with others "intermentally" (Mason, 2007). Vygotsky (1981) expressed the internalization notion as follows: "the higher functions of child thought first appear in the collective life of children in the form of argumentation and only then develop into reflection for the individual child" (Anderson et al., 2001, p. 1).

Drawing from Vygotsky's notion of internalization, Anderson et al. (2001) studied social influences on development of reasoning and rhetorical strategies of fourth graders during small-group discussions. Anderson et al. employed a broader social definition of argument, assuming that reasoning is profoundly dialogical. Anderson et al. assumed that extended arguments can be broken down into recurrent patterns called "argument stratagems." Focusing on the way these argument stratagems are internalized through children's reasoning, the study analysed children's argument based on 13 stratagems that children use during their dissections (e.g., "think [POSITION] because [REASON]," and "if [ACTION], then [BAD CONSEQUENCE])."

Anderson et al. used the term "snowball" to refer to how once a useful stratagem has been used by a child during a discussion, it tends to spread to other children and occur with increasing frequency. In this study, children took part in a series of discussions with traditional classes. Anderson et al. concluded that social interaction is an essential process in children's development of language and thought. His work is significant because it synthesizes cognitive theory (specifically schema theory, Rumelhart, 1980) with sociocultural and dialogic perspectives.

Recently, researchers do not only focus on studying argumentation within various contexts, rather, there is a growing understanding for the importance of evaluating individuals' ability to consider and defend views and to generate counterargument to those views (Leitão, 2003). In addition, " it appears to be a matter of consensus that part of what predicts good reasoning is the extent to which arguers are able to not only justify their own position, but also to take a real or virtual opposition (counterargument) into account" (Santos & Santos, 1999, p. 86).

## Counterarguments

### *What are Counterarguments? Why are They Important?*

A counterargument refers to "An argument, or a reason or a line of reasoning, given in opposition to another augment" (Counterargument in Webster's New World College Dictionary), to any challenges to an argument (Leitão, 2000), or to an opposite conclusion (Nussbaum, 2008). Various authors use the term of counterargument differently such as refutations, rebuttal (Aufschnaiter, Erduran, Osborne & Simon, 2008) or undercutting defeaters (Pollock, 1987).

Counterarguments lie at the heart of argumentation process as argumentation presupposes opposition. Understanding of the role that opposition plays in argumentation becomes important for understanding argumentative thinking. Such seems to be the perspective taken by Leitão's (2000) work, in which she proposes that the experience of being opposed stimulates processes of belief revision that enable people to move on from old (already existing) to new perspectives on a topic. Thus, counterargument to an opponent's position is considered as necessary quality to a definition of good argument (Santos & Santos, 1999), essential "building blocks" for complex arguments (Kuhn, 2005), and a basic "developmental mechanism" (Leitão, 2000).

Furthermore, for making a decision, one should evaluate the costs and benefits or pro and contra reasons of each side (Voss et al., 1999). Kuhn (2005) developed an argument curriculum based on various activities; one of these activities was generating counterarguments to other's reasons (Kuhn, 2005). The final assessment showed that participants were more able to develop and use counterarguments, addressing their opponents' claims. Felton (2004) also suggested that the argumentation construction processes entails three component skills: producing justifications, producing counterarguments, and rebutting counterarguments. Additionally, consideration of counterarguments is an essential aspect of good writing (Nussbaum & Kardash, 2005; Wolf & Britt, 2008). Nussbaum and Kardash (2005) specified two reasons for the importance of counterarguments in writing. The first reason is that generating and rebutting counterarguments on balance strengthen persuasiveness of a text. Nussbaum and Kardash emphasize O'Keefe's (1999) findings that texts which considered and rebutted counterarguments were more persuasive than texts that did not. The second reason specified by Nussbaum and Kardash was that many models of good thinking involve the ability to consider and evaluate alternative viewpoints (e.g. Baron, 1988)

Moreover, the existence of counterargument affects the strength of a given argument (Voss & Means, 1991). More specifically, the strength of an argument is not independent of counterarguments. An argument might be considered strong by itself, while it might be evaluated as less strong when a counterargument is included (Voss, 2001). Therefore, counterargument is considered an evaluative criterion of the soundness of an argument and including counterarguments indicates argument integration (Voss, 2001; Voss & Means, 1991).

In addition, Kuhn (2005) described three forms of counterarguments. In Kuhn's view, the most powerful way to deal with an opponent's claim is to propose a counterargument that reduces or deletes the force of the claim. She calls this a Counter-C.

The weaker form of counterargument (Counter-A) is an expression of an alternative to the opponent's conclusion. In this case, the counterargument does not directly deal with the weaknesses of opponent's argument; instead, the alternative is implied to be more worthy. For the third form (the weakest) of counterargument, an arguer offers a simple disagreement to an opponent's argument without including any reasons or alternatives. Such disagreement merely reflects attention to the opponent's view.

In the same vein, Aufschnaiter et al. (2008) proposed a framework for the analysis of argumentation offering a hierarchy of increasing argumentation quality and developed differentiating three levels of arguments with rebuttals. These levels were arguments with weak or incomplete rebuttals; arguments with clear rebuttals; and arguments with multiple rebuttals.

*Difficulties of Considering Counterarguments*

Difficulties in considering counterarguments are weaknesses that many individuals exhibit when performing argumentative task (Chinn & Anderson, 1998; Kuhn, 1991, 2005; Nussbaum & Kardash, 2005; Reznitskaya & Anderson, 2002). A national assessment of students' argumentative writing showed that most of students' written arguments are poorly reasoned and unpersuasive; highlighting that those students rarely acknowledged opposing positions. Students also rarely considered the relative merits of different views, or attempted to integrate conflicting perspectives (Ferretti, MacArthur & Dowdy, 2000), which has been referred to as the "myside bias" (Baron, 1988). The myside bias was first identified by Perkins and colleagues (1985, 1989) and has been studied by a number of researchers for more than two decades (Wolfe & Britt, 2008).

Kuhn (1991) carried out a comprehensive study on a sample of life-span subjects; she found that only few subjects consistently generated genuine evidence for their theories, alternative theories, counterarguments, and rebuttals (Kuhn, 1991). In particular, individuals generate arguments that support their own position much easier than generating arguments that support an opposite position (Chinn & Anderson, 1998). Furthermore, Santos and Santos (1999) suggested that the inability to generate counterarguments to support the opposite side is considered a problem related to people's inclination to reason the way that matches their prior beliefs, which has been referred as "faulty situation modelling." Similarly, Baron (1988) emphasized that considering the other side of an argument and showing complex thinking is affected by the way people think and their personal values. In particular, people are more open to counterevidence when the counterevidence supports a personal goals of a thinker.

Moreover, another possible explanation for students' poor performance in reasoning, (including difficulties in generating counterarguments) may be that students lack practice with argumentation (Reznitskaya & Anderson, 2002). Therefore, instructional interventions have been offered as a solution for helping students consider opposing perspectives on controversial issues, enabling them to improve their reasoning through generating more balanced reasoning (through considering both sides of an argument) (Chinn & Anderson, 1998; Reznitskaya & Anderson, 2002 ; Wolfe & Britt, 2008). Chinn and Anderson (2000) used collaborative discussion to promote students' engagement in argumentative discourse, emphasizing that discussion that involves group argumentation can be used as an effective method to develop individuals' reasoning (Chinn & Anderson, 1998).

Additionally, students' poor performance on generating counterarguments is sometimes attributed to the difficulty in establishing appropriate goals or sub-goals to support their overall aim of persuading an audience (Ferretti et al., 2000). Accordingly, there is a line of research that has focused attention on goal instructions as one way for helping students overcome their "myside bias" during argumentative writing (e.g. Ferretti et al., 2000; Golanics & Nussbaum, 2007; Nussbaum, 2005; Nussbaum & Kardash, 2005). Goal instructions are identified as "short statements at the end of a discussion prompt specifying how students should complete the task" (Golanics & Nussbaum, 2007, p. 168).

Ferretti et al. (2000) carried out a study including two different conditions. In the first condition, students had general goal condition where they were asked to write a letter to persuade an audience to agree with their position. In the second condition, students had an elaborated goal, where they were given the same general goal in addition to explicit sub-goals based on the elements of argumentative discourse. The results suggested that students in the elaborated goal condition produced more persuasive essays and included a greater number of argumentative elements in their essays than did the other group. Furthermore, Nussbaum and colleagues examined the impact of goal instruction on both written argumentation and discussion. Nussbaum and Kardash (2005) found that students given specific goals generated more counterarguments and rebuttals in writing argumentative texts than students who were not. Nussbaum (2005) reported that the goal instruction resulted in more sophisticated arguments in the context of Web-based discussions.

*Argument-Counterargument Integration*

Good argument implies a set of given premises that justify the conclusion. Therefore, the mere existence of pros and cons in argumentation is not sufficient to describe an argument as a good argument (Santos & Santos, 1999). Means and Voss (1996) emphasized that "as the argument incorporates more aspects of good argumentation, it is regarded as a higher quality of informal reasoning" (p. 142). Nussbaum and Schraw (2007) emphasized that effective argumentation includes not only considering counterarguments but also evaluating, weighing, and combining the arguments and counterarguments into support for a final conclusion. Nussbaum and Schraw called this process *argument-counterargument integration*.

Argument-counterargument integration is considered an important aspect of argumentation skills. In the psychology of reasoning, an important consideration is to create balanced reasoning (Baron, 1988; Nussbaum, 2008). De Fuccio, Kuhn, Udell and Callender (2009) designed an intervention for promoting argumentation skills; one of these skills was conducting and evaluating two-sided arguments (or integration). The findings revealed that the experimental group offered more and higher quality reasons, showing gain in their ability to generate counterarguments against the opponent's claims, as well as rebuttals of the opponent's counterarguments of their own claims. Pasquier et al. (2003) also proposed a model for argumentation process containing three steps: (1) argument generation, (2) argument evaluation, and (3) argument integration.

Furthermore, Nussbaum and Schraw (2007) emphasize three main reasons for the importance of argument-counterargument integration. First, integration requires students to reflect on their argumentation deliberately to see how arguments and counterarguments relate to one another. This reflection facilitates learning as it requires students to elaborate and organize their ideas and thinking. Second, argument-counterargument integration helps in producing logically stronger written arguments. Finally, argument-counterargument integration is important because it is a central aspect of critical thinking. Baron (1988) called this processes of integration "active open-mindedness," emphasizing that as thinking gets differentiated (involves consideration of counterevidence to an initial possibility), people would show complex thinking.

Argument integration was studied earlier by some researchers as *conceptual/integrative complexity* (Suedfeld, Tetlock & Streufert, 1992; Tetlock, 1984, 1986), it is also related to *integrative thinking* (Martin, 2007, 2009; Sill, 1996), *cognitive complexity* (Biwri, 1971 cited in Suedfeld et al., 1992), and *cognitive structure* (Scott, Osgood & Peterson, 1979 cited in Suedfeld et al., 1992). Suedfeld et al. (1992) explain that the conceptual/integrative complexity construct was stemmed from Kelly's (1955) personal construct theory and it relates to the cognitive styles approach.

According to Suedfeld et al. integrative complexity refers to "the degree to which thinking and reasoning involve the recognition and integration of multiple perspectives and possibilities and their interrelated contingencies" (Suedfeld et al., 1992). Cognitive complexity focuses on the structure of thought rather than on its content, reflecting the complexity of information processing and decision making ability. Suedfeld et al. also emphasized the importance of integrative complexity as entails an educational goal of higher education such as the development of critical thinking skills.

Tetlock (1983, cited in Baron, 1988) measured the integrative complexity of U.S. senators' speeches using a scale that scored from 1 to 7. This scale was arranged in that each score represented the extent to which a senator was able to consider the other side of the speech or the counterevidence. The study revealed that individuals think more complexly (higher integrative complexity) when they have conflicting goals and values (Baron, 1988).

Recently, Roger Martin issued an article "*How successful leaders think*" (2007), and a book called "*The opposable mind, winning through integrative thinking*" (2009), highlighting the ability of integrative thinking versus conventional thinking. He focused on effective leadership for successful business. Martin met 50 leaders for six years and he concluded that, in addition to other traits, they mainly have the ability to hold in their mind two opposing ideas at once. He illustrated that integrative thinkers look at the problem or a situation as a whole, have the ability to "synthesis" and solve ideas creatively, think of relevant consideration while weighing options, and consider different relationships between the dimensions of an issue.

Although argument-counterargument integration is a very important aspect of reasoning (Baron, 1988; Chinn & Anderson, 1998; Kuhn, 2005; Means & Voss, 1996; Nussbaum, 2008), only a couple of psychological research studies have focused on how well individuals are able to integrate arguments and counterarguments (Nussbaum, 2008). Therefore only few research studies have suggested some argumentation integration strategies. The argumentation strategies aim to integrate arguments direct counterarguments towards an overall final opinion or conclusion (Nussbaum et al., 2007).

Felton and Kuhn (2001) coded individual statements in a sample of adults and adolescents dialogues and they suggested three "strategic sequences" or dialogic argumentative strategies that are loosely related to the refutation strategy. These strategies are a “corner sequence,” “rebuttal,” and “block.” Corner sequence, according to Felton and Kuhn, were categorized “either a Clarify-? Or interpret by the speaker, a response by the partner, and then a Counter-C (counterargument) by the speaker” (p. 145). In such sequences, the speaker seeks to corner the partner into an untenable or weak position. The second strategy is rebuttal strategy, which represents a defensive move used to get rid of or reduce the force of a partner’s counterargument by critiquing it. The third strategy, identified by Felton and Kuhn, is the block strategy, which represents a defensive move on the part of the speaker and it occurs when the speaker counterargues the premise of a leading question posed by the partner. Accordingly, the speaker avoids being forced to undermine his or her position.

Moreover, Nussbaum and Schraw (2007) identified three strategies that could be used to construct an integrative argument in the context of writing reflective essays: refutation, weighing, and synthesizing. Nussbaum and Schraw (2007) initially termed the latter strategy “synthesis,” which is considered one of creative and integrative thinking skills (Sill, 1996). Nussbaum and Edward (in press) termed this strategy later as constructing a design claim, that is, a claim regarding how a solution should be designed. In this strategy a reasoner tends to form her opinion or conclusion based on supporting an argument side (by taking its advantages) and eliminating or reducing the disadvantages of the counterargument side with a solution.

A third strategy suggested by the authors was the weighing strategy. By using this strategy, an arguer can argue that the weight of reasons and evidence on one side of the issue is stronger than that on the other side. Furthermore, Nussbaum and colleagues suggested that encouraging students to ask critical questions to evaluate argument strength resulted in more integrated arguments when composing essays (Nussbaum, 2008), and during online discussions (Nussbaum et al., 2007).

There are cognitive mechanisms and processes that mediate and underpin the process by which information and skills are acquired (Kyllonen & Stephens, 1990; Rouet, 2009). Understanding these mechanisms through the lens of argumentation can increase our knowledge about the way learning and reasoning occurs in the human mind (Bouvier, 2007; Rips, 1998). It is known that reasoning processes rely heavily on working memory (Kyllonen & Christal, 1990). However, psychological investigation of argumentation has not been extensively studied (Voss et al., 1999), and argumentation theories have not looked much at cognitive load. The next section will, therefore, discuss cognitive load as it is one of the important cognitive mechanisms that underlie students' critical thinking and argumentation.

## Cognitive Load Theory

Cognitive load theory (CLT) (Sweller, 1988; Sweller & Chandler, 1994; Sweller, Van Merrienboer & Paas, 1998; Van Merrienboer & Sweller, 2005) is concerned with the way limited cognitive resources are used during learning tasks and problem solving.

### *History of Cognitive Load Theory*

Cognitive load theory (CLT) has been developed by Sweller and his colleagues (Sweller, 1988; Sweller & Chandler, 1994; Sweller, Van Merrienboer & Pass, 1998; Van Merrienboer & Sweller, 2005). The early idea of the theory started in the late 1980s with a line of research focusing on students' learning to solve problems. Next, the theory underwent several refinements and growth in the 1990s (Pass, Renkl & Sweller, 2003a). In the book *Efficiency in learning, evidence- based guidelines to manage cognitive load*

(Clark et al., 2006), Sweller presents the origin and history of cognitive load theory. He mentions that in one of his research studies, (Sweller, Mawer & Howe, 1982), the findings revealed that the problem solution was easy to learn for problem solvers from worked examples whereas discovering the rule for solving a problem was hard.

Therefore, the researchers started to question why it was hard to discover the rule. They speculated that solving problems by searching for a solution imposes serious demands on working memory capacity. Those demands can lead to a successful problem solution, but without leaving enough working memory capacity to connect the moves with particular problem situations. Accordingly, problem solvers dedicate all of their working memory resources to figuring out which move were best at each point. Thus, they had no working memory capacity remaining to concentrate on the relations between moves and learning the rule (Clark et al., 2006).

Researchers suggested two techniques that may reduce the load on working memory such as goal free problems and worked example. Furthermore, research within the context of cognitive load theory not only examines problem solving and worked examples, but also knowledge acquisition from different instructional materials such as multimedia learning (Schnotz & Kürschner, 2007).

*Fundamental Assumptions of Cognitive Load Theory*

The primary focus of CLT is on a cognitive perspective on learning, particularly, knowledge about human cognitive architecture and limited processing capacity. The theory has several assumptions regarding this architecture: the assumption of unlimited long-term memory, schema theory of mental representations of knowledge, and limited-processing capacity for working memory (Sweller & Chandler, 1994; Schnotz &

Kürschner, 2007). Based on that attempt to understanding human cognitive architecture, cognitive load theory suggests that many traditional instructional techniques do not consider the limitations of human cognitive capacity and overload a learner's working memory (Schnotz & Kurschner, 2007). Therefore, central to CLT is the assumption that working memory architecture and its processing limitations should be considered when designing instruction (Paas et al., 2003a). In other words, overloading learners' working memory makes learning difficult, so to facilitate learning instruction should minimize overloading learners' cognitive system (Ayres, 2006b).

*Cognitive Load Theory and Working Memory*

*Working memory*. Human activities and learning rely mainly on two memory systems: working memory and long-term memory. These two memory systems work together. Long-term memory is the main knowledge storage for new knowledge and skills, whereas working memory underlies the processing of new information from the environment (Clark et al., 2006). Learning takes place in working memory in addition to all conscious processing of information (Sweller & Chandler, 1994). In fact, understanding the working memory system is important from a theoretical perspective and for applied purposes in both fields of development and education (Janczyk, Wienrich & Kunde, 2008).

Working memory is very limited in both duration and capacity (Miller, 1956). In George Miller's 1956 seminal article: *the magical number seven, plus or minus two: some limits on our capacity for processing information*, Miller postulates that working memory capacity is limited and ranges from seven plus or minus two storage units or "chunks." Baddeley (1986) proposed a model of working memory (Bruning et al., 2004).

According to Baddeley, the term working memory refers to “a brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks such as language comprehension, learning and reasoning” (Adcock, 2009, p. 2). Baddeley proposed a multicomponent model that consists of three main components: the executive control system and two “slave systems.” These components perform the mental operations assigned to working memory.

The executive control system is assumed to have limited capacity. It coordinates what goes into short term memory and selects strategies necessary to process information. The central executive also controls the two “slave systems”: the visual–spatial sketch pad and the articulatory loop. While the visual–spatial sketch pad enables humans to hold visual-spatial information in working memory and to carry out a variety of computations on that information, the articulatory loop is the verbal analog of the sketch pad. It enables individuals to hold audio information temporarily (for 2 to 4 seconds) via rehearsal (Bruning et al., 2004).

Since working memory has limited processing capacity, “tradeoffs” are important in managing processing demands. As a result, the ability to limit the amount of irrelevant information in active memory (inhibition) is necessary for working memory performance (Nyberg, Brocki, Tillman & Bohlin, 2009). Hoch (1984) investigated the cognitive processes underlying predictive judgments about uncertain future events. In his study, students were encouraged to generate arguments and counterarguments for why future event might or might not occur. Hoch found that students generated more reasons for the side that they were asked to produce first. He explained these results in that generation is a special case of more general retrieval processes and whatever people think about it first inhibits later retrieval and generation.

Inhibition works through exerting control over the content of working memory and helping prevent irrelevant stimuli from saturating working memory capacity. Therefore, efficient inhibitory mechanisms allow focus on relevant task goals without distraction by irrelevant information (Borella, Carretti & De Beni, 2008).

*Application of cognitive load theory*. CLT takes into account the limitation of working memory, considering that few elements of information can be processed in working memory at the same time, and too many elements may overburden working memory and reduce the effectiveness of processing (Kalyuga, Chandler, Touvinen & Sweller, 2001; Van Merrienboer & Sweller, 2005). In addition, the amount of working memory resources devoted to achieving a particular task affects the amount and the complexity of what is learned (Paas et al., 2003b). From a cognitive load perspective, this working memory capacity and limitations only apply to novel information attained where "no schema-based central executive is available." On the contrary, working memory has no identified limitations when dealing with integrated information retrieved from long-term memory. For example, a chess expert develops complex schemata for different positioning of chess pieces. These schemata not only organize and store a chess experts' knowledge, but also reduce working memory load because even a highly complex schema can be dealt with as one element in working memory (Van Merrienboer & Sweller, 2005).

Unlike Baddeley's model of working memory, cognitive load theory does not assume a "domain unspecific central executive." Instead, it assumes that schemata organize and store knowledge. Attaining expertise in a domain increases individuals' stored knowledge in long-term memory. This organized stored knowledge allows working memory to function more efficiently. Working memory can also deal with more information, and can limit the risks of cognitive load during learning (Clark et al., 2006). In other words, working memory alone would only allow minor human cognitive activities, while long-term memory with chunks and schemata provides humans with the ability to expand their cognitive processing ability. Accordingly, long-term memory contains enormous numbers of schemata (Paas et al., 2003a).

*Cognitive Load Theory and Schema*

According to Rumelhart (1980), the term schema refers to "data structure for representing generic concepts in memory. There are schemata representing our knowledge about all concepts: those underlying objects, situations, events, sequence of events, actions, and sequence of actions" (Reznitskaya & Anderson, 2002, p. 320). CLT assumes that schemata organize and store knowledge, and function in a manner similar to how the central executive functions in Baddeley's model (Van Merrienboer & Sweller, 2005). More specifically, Sweller et al. (Sweller, 1994; Sweller & Chandler, 1994) emphasize that schema acquisition and transfer from controlled to automatic processing are the major learning mechanisms that help to reducing the burden on working memory (Sweller, 1994; Sweller & Chandler, 1994).

For example, schema allows us to ignore most of the information that face our senses. Since our mind cannot store enormous details, our schemas allow us to recognize each subject without retrieving the endless details about that subject. For instance, despite the fact that all trees differ, when we see a tree, we recognize it as a tree. In this case, the infinite variety of tress can be ignored because of our schemas (Sweller, 1994; Sweller & Chandler, 1994). Therefore, multiple elements of information can be chunked into one information unit in cognitive schemas, and in turn can be automated to a large extent (et al., 2003a). Accordingly, schemata can act as a "central executive," organizing information or knowledge that needs to be processed in working memory (Schnotz & Kurschner, 2007; Van Merrienboer & Sweller, 2005).

CLT suggests that instructional designs that require students to perform activities that are not directed to schema acquisition and automation assume processing capacity greater than students' cognitive limits. Therefore, according to CLT, the main goals of instruction are the construction and automation of schemas (Sweller, 1994). However, before information can be stored in schematic form in long term memory, it must be extracted and manipulated in working memory. Therefore, work within the cognitive load framework has concentrated on the design of instructional methods that efficiently use working memory capacity (Paas, Touvinen, Tabbers & VanGerven, 2003; Sweller et al., 1998). In other words, CLT is concerned with techniques for managing working memory load in order to facilitate the changes in long term memory associated with schema construction and automation (Paas et al., 2003a). Experts are able to integrate many single elements into one information unit

Reznitskaya and Anderson (2002) attempted to connect schema theory and argumentation. They proposed the concept of argument schema, postulating that "argumentation is a knowledge domain in-and-of itself, and that it contains concepts and principles that go across topical domains" (p. 320). The authors suggest that this argumentation schema serves many functions in facilitating students' reasoning and resolving a variety of issues. In their view, the argumentation schema has many functions including: (a) focusing students' attention to argument-relevant information; (b) assisting argument comprehension, construction, and repair; (c) organizing argument- relevant information; (d) providing the basis for enabling students to anticipate objections and to discover flaws in one's own and others' arguments; and (e) facilitating retrieval of argument-relevant information from memory. In addition, Chinn and Anderson (1998) define argument schema as a network that unites single arguments, representing extended stretches of argumentative discourse.

## Types of Cognitive Load

CLT distinguishes between three types of cognitive load: extraneous, intrinsic, and germane cognitive load. Some forms of cognitive load are useful, while others waste cognitive and mental resources. Since the total mental capacity is limited, learners need to balance the three forms of cognitive load to maximize learning efficiency. In particular, an effective instruction should consider minimizing the unproductive intrinsic and extraneous cognitive load while stimulating the desirable germane cognitive load (Clark et al., 2006; Gerjets, Scheiter & Cierniak, 2009; Sweller et al., 1998).

### *Extraneous Cognitive Load*

Cognitive load imposed by the format and the manner in which an instructional material is presented to learners is referred as disadvantageous, unnecessary, or extraneous cognitive load (Brunken, Plass & Leutner, 2003; Chandler & Sweller, 1991; Paas et al., 2003a; Sweller et al., 1998). In particular, extraneous cognitive load results from inadequately designed instruction. Therefore, reducing this load should be an important consideration when designing instruction as it is under instructors' control.

Extraneous load can also be varied based on the manner in which information is presented and the activities required of learners (Clark et al., 2006; Paas et al., 2003a; et al., 2003b; Van Merrienboer & Sweller, 2005).

Moreover, extraneous load imposes mental work that is unrelated to instructional goals. Accordingly, it interferes with understanding of the material and wastes limited mental resources (Sweller, 1994), in addition to interfering with learners' schema acquisition and automation process (Paas et al., 2003b). Learning activities with many extraneous sources of cognitive load results in consuming longer times to learn, producing poorer learning outcomes, or both (Clark et al., 2006). Van Merrienboer and Sweller (2005) emphasize that although extraneous load does not hinder learning when tasks are low in intrinsic load, it hinders learning when tasks are high in intrinsic load; thus, reducing extraneous load is necessary for such tasks (Van Merrienboer & Sweller, 2005).

*Intrinsic Cognitive Load*

Intrinsic cognitive load is intrinsic or inherent to the nature of the material or task being taught (Clark et al., 2006). It is related to the "complexity of a domain" (Paas, Van Gerven & Wouters, 2007), or the "intellectual complexity of information" (Pollock, Chandler & Sweller, 2002). In particular, intrinsic cognitive load is determined by the extent to which various elements interact in order to successfully perform a task. An element is the information that can be processed by a particular learner as a single unit in working memory (Paas & Van Gog, 2006; Pollock et al., 2002). Therefore, element interactivity or connectedness is the main generator of intrinsic cognitive load (Sweller, 1994).

According to CLT, a task is difficult because many elements have to be incorporate simultaneously, not because of the number of elements that a task contains (Pollock et al., 2002). Therefore, when a task is low in element interactivity, it is easy to learn as it contains elements that can be learnt in isolation rather than simultaneously. This results in a low working memory load because the task can be learnt without holding more than a few elements in learners' working memory at once. In contrast, when a task is high in element interactivity, it is difficult to learn as many elements interact at once, resulting in high working memory load (Ayres, 2006; Pollock et al., 2002; Sweller, 1994). Also, Van Merrienboer, Kester and Paas (2006) suggest that element interactivity in a task depends on a learner's expertise because numerous elements for a low-expertise learner may be chunked into one or a few elements for a high-expertise learner. Therefore, the expertise of the learner plays an essential role in determining the intrinsic cognitive load or complexity of the material.

In fact, people sometimes think that the term complexity is a synonym with difficulty. Halford and McCredden (1998) present an important distinction between both terms, emphasizing that tasks can be difficult for many reasons other than complexity. For example, a learner can fail a task due to lack of knowledge or strategies, unavailability of correct hypotheses, or poor motivation. With respect to complexity, complex tasks are those in which more sub-goals have to be met before the top-goal. Therefore, the complexity of a task depends on the number of entities that are related (Halford & McCredden, 1998).

At the early stage of the CLT, the theory assumed that instructors cannot directly alter the inherent intrinsic load of an instructional content. Accordingly, intrinsic cognitive load was considered to be out of instructors' control, and only extraneous cognitive load could be varied due to instructional design (Paas & Van Gog, 2006; Van Merrienboer & Sweller, 2005).

Therefore, Sweller and his colleagues subsequently modified the theory to postulate that learners and instructors can reduce intrinsic cognitive load by reducing the number of interacting elements in a task at the beginning of learning and reintroducing more later after the essential elements have been understood. Moreover, for complex, or multi-step academic operations, instructors should decompose it into a series of prerequisite tasks and simple steps (Clark et al., 2006).

*Germane Cognitive Load*

It was initially thought that total cognitive load is a combination of merely two types of cognitive load: extraneous load, which is imposed by instructional methods and intrinsic load, which is inherent to a learnt martial or a task (Sweller, 1994). Therefore, CLT research has focused on studying instructional designs, trying to mange extraneous cognitive load (Kirschner, 2002). However, Paas and Van Merrienboer (1994) suggested a different type of positive or germane cognitive load.

In their study, Paas and Van Merrienboer (1994) employed worked examples that differed considerably in variability. They found that worked examples with high variability resulted in better learning than low variability examples. Accordingly, they suggested that the variable worked examples imposed a different type of cognitive load other than commonly studied extraneous and intrinsic load. This form of cognitive load is called *germane* load because it is a load that is germane or useful to schema acquisition and automation (Paas & Van Merrienboer, 1994).

In other words, germane cognitive load is mental processing that is imposed by instructional design that positively contributes to attaining better learning outcome. It is also can be viewed as “generative” (DeLeeuw & Mayer, 2008) and relevant load that facilitate schema construction and automation (Clark et al., 2006; Leahy & Sweller, 2005). The basic assumption of generating germane cognitive load is that, when an instructional design or learnt information does not occupy the whole working memory capacity (because of a low intrinsic and extraneous cognitive load), increasing germane load may enhance learning process. That happens through engaging learners in conscious cognitive processing that is directly relevant to schema construction (Kirschner, 2002).

Kirschner also emphasizes that employing germane load should be employed within working memory limits. More particularly, the three types of cognitive load are assumed to be additive. Therefore, the total cognitive load for an instructional design, intrinsic CL plus extraneous CL plus germane CL, should not exceed the working memory resources available if learning is to take place (Gerjets et al., 2009; Kirschner, 2002; Paas et al., 2003a). Furthermore, there are some strategies that can be used to induce germane cognitive load. Paas and Van Gog (2006) suggest that using worked examples for novice learners and increasing worked example variability can promote students’ self-explanations for the rationale behind worked-out solution steps, which may induce a germane cognitive load (Paas et al., 2003a; Paas & Van Gog, 2006). Germane load contributes to construction of cognitive structures and productive cognitive processes that enhance performance (Renkl, Hilbert & Schworm, 2009; Van Merrienboer, Kester, & Paas, 2006). It can also be a factor that promotes depth of processing (Craik & Lockhart, 1972), enhancing a learner's ability to "organize" and "integrate" learned material (Stull & Mayer, 2007), which helps in achieving instructional goals.

As mentioned previously, research (e.g. Webb et al., 2008; Webb, Troper & Fall, 1995) has shown that in argumentation the process of giving explanations may encourage explainers to clarify or reorganize material in new ways through resolving conflicts and inconsistencies in addition to constructing more elaborated conceptual notions. In argumentation situations students also have to express their perspectives openly and integrate information from different sides, searching for causes and relations in the topic under discussion (Van Amelsvoort, Andriessen & Kanselaar, 2007).

## Measuring Cognitive Load

Paas and Van Merrienboer (1994) presented a "general model for schematic representation" of the cognitive load construct. According to this model, cognitive load is a construct that consists of many dimensions that represent the load that completing a particular task imposes on learners' cognitive system. The construct can be considered to consist of causal factors (factors that affect cognitive load) and assessment factors (factors affected by cognitive load).

Causal factors reflect task or environment characteristics, subject characteristics, and the interaction between them. Task characteristics include task complexity, time pressure, and pacing of instruction, in addition, the environment factors (e.g. noise and temperature). Subjects' characteristics include cognitive abilities, age, cognitive style, and prior knowledge. The subject-task environment interaction can affect cognitive load through factors such as internal criteria of optimal performance, motivation, or state arousal.

With regard to the assessment factors or dimensions that reflect the measurable concepts, cognitive load can be conceptualized into three dimensions: *mental load* (is considered to reflect the amount of capacity or resources imposed by the task/environment demands), *mental effort* (considered to reflect the amount of capacity or resources that is actually allocated to task performance), and *performance* (learners' achievements, such as the number of correct test items, number of errors, and the time on task that can be determined while people are working on the task or thereafter) (Paas, 1992; Paas et al., 2003b; Paas & Van Merrienboer, 1994).

There are various methods for assessing cognitive load. The methods that are currently available are as follows: rating scale, psychological techniques, task and performance-based techniques, and mental efficiency of instructional condition.

First, rating scales (self-reports) have been found reliable for assessing intrinsic cognitive load or inherent complexity of a task. The idea for the rating scale is based on the assumption that people are able to introspect on their cognitive processes and to report the amount of mental effort expended. By using self-report, subjects report their invested effort on a 9-grade symmetrical category scale, by translating the perceived amount of mental effort into a numerical value. This method was first used by (Paas, 1992), and it was also endorsed and utilized by many other researchers and studies (e.g., Ayres, 2006; Brunken, Plass & Leutner, 2003; Clark et al., 2006; Paas et al., 2003a; Paas & Van Merrienboer, 1994; Paas & Van Gog, 2006). Mental effort reflects the amount of capacity or resources that is actually allocated to task performance (Paas et al., 2003b).

Based on a comprehensive review of about 30 studies, Paas et al. (2003b) concluded that "the use of rating scales to measure mental effort and cognitive load remains popular, because they are easy to use; do not interfere with primary task performance; are inexpensive; can detect small variations in workload (i.e., sensitivity); are reliable; and provide decent convergent, construct, and discriminate validity" (p. 68). Salomon (1984) also employed a self-report to measure to determine the amount of mental effort that students invested during learning from watching TV comparing to print. According to Salomon (1984), mental effort is defined as "our perception of the mental energy required to use "non automatic" knowledge to solve problems, learn or transfer knowledge to new tasks."

Additionally, Clark (1999) emphasizes that the most efficient measures for mental effort are those including estimates of how "difficult" or how much "thinking" the task required. He also suggests that the reliability of self-report measures is often quite high (Clark, 1999). Furthermore, DeLeeuw and Mayer (2008) suggested the same method (rating scale). They used mental effort rating for assessing participants' intrinsic load during learning in multimedia lesson. In their study they manipulated intrinsic processing through the complexity of the sentences.

Second, physiological techniques are based on the assumption that changes in cognitive functioning are reflected in physiological variables. These techniques include measures of heart activity (e.g., heart rate variability), brain activity (e. g., task-evoked brain potentials), and eye activity (e.g., pupil dilation, and blink rate) (Paas et al., 2003b). In addition, learners' time-on task can be seen as an indicator of different load levels. For example, the different amount of time that participants spent learning with variant of multimedia instruction could be a result of different amounts of load induced by these variants (Brunken et al., 2003).

Third, task and performance-based techniques include two subclasses: (a) primary task measurement and (b) secondary task methodology or dual- task measurement. The primary task measurement is based on task performance, while the secondary task methodology is based on the performance of a secondary task that is performed concurrently with the primary task. In this procedure, performance on a secondary task is supposed to reflect the level of cognitive load imposed by a primary task. Generally, the secondary task entails simple activities requiring sustained attention, such detecting a visual or auditory signal. Secondary task methodology has been utilized rarely in cognitive load research (Brunken, Plass & Leutner, 2003; Chandler & Sweller, 1996; Paas et al., 2003a). DeLeeuw and Mayer (2008) suggested that response time (RT) to a secondary task during learning (created by redundant text) appears appropriate when the goal is to assess the level of extraneous cognitive load.

Finally, mental efficiency of instructional conditions combines measures of mental effort with measures of the associated primary performance. In this method, the efficiency (E) metric is calculated by subtracting mental load (ML, which is measured by self-report for task difficulty) from performance (P) outcomes; expressed mathematically as E= P-ML. When performance is greater than mental load, the efficiency value is positive. But if performance is lower than mental load, the efficiency value is negative (Clark et al., 2006; Paas et al., 2003b).

## Argument-Counterargument Integration and Cognitive Load

Argument-counterargument integration and cognitive load can be related based on the relation between reasoning and working memory, considering that argumentation is central to reasoning (Kuhn, 1991, 2005; Voss & Means, 1991) and working memory capacity is a central concept of cognitive load theory (Paas et al., 2003a; Paas et al., 2004; Sweller et al., 1998). Kyllonen and Christal (1990) carried out four studies to examine the relationship between general working memory capacity and general reasoning abilities. The authors reported a high correlation between them. In addition, Kyllonen and colleagues proposed a four source model, postulating that individual differences on cognitive tasks originate from four primary sources: the speed of processing, the capacity of working memory and the breadth of both declarative and procedural knowledge (Kyllonen & Christal, 1990; Kyllonen & Stephens, 1990).

Moreover, integrating multiple relations occurs in working memory imposes cognitive load (Christoff et al., 2001; Krumm et al., 2008). Such integration depends on the interactions of multiple relations.  Reasoning is crucial for human high-level knowledge representations and cognition. Reasoning relies on the ability to structure and manipulate mental representations of relations between objects and events (Waltz et al., 1999). More specifically, the ability to consider relationships between multiple mental representations is directly linked to the capacity to logical thinking and problem solving in novel situations. This capacity emerges in the first two or three years of life after development of general perceptual and attentional capabilities (Crone et al., 2008).

Furthermore, Waltz et al. (1999) distinguished between the capacity required to comprehend single relations and the capacity to integrate multiple relations, emphasizing that integrating multiple relations requires much more capacity from a learner. This is because integrating two relations requires more than perceptual or linguistic processing (Waltz et al., 1999), which may require more devoted mental resources, inducing cognitive overload on learners' working memory. For example, in argument integration, students should critically evaluate arguments and counterarguments or different ideas in order to reach an overall final opinion. This integration requires attending to both sides of an issue. (There also might be several arguments on one side of an issue and several arguments on the other side.) Finally, integration requires considering their relationship to each other (Nussbaum et al., 2007; Nussbaum & Schraw, 2007).

In addition, Nussbaum and Schraw's (2007) concept of argument-counterargument integration is indirectly based on the neo-Piagetian developmental theory of reasoning. According to this theory, development is viewed as a process of coordinating and integrating disparate elements in working memory into a more coherent conceptual structure. In other words, reasoning organizes and synthesizes dissimilar ideas in working memory towards the creation of an integrated conceptual framework (Nussbaum, 2008; Nussbaum & Schraw, 2007). Generally, according to the neo-Piagetian's perspective, the development of working memory is a major component of cognitive development (e.g. Case, 1974; 1985). Working memory capacity imposes constraints that limit the general cognitive performance on the cognitive level that can be attained in any task. Accordingly, working memory capacity is a prerequisite for performance in a cognitive task; the increase in working memory capacity accounts for the likelihood to reach higher cognitive levels (De Ribaupierre & Lecerf, 2006).

Although considering multiple arguments and counterarguments may create a relatively high cognitive load, there are ways of reducing this load, and building argument schemas, through the use of graphic organizers.

## Graphic Organizers and Educational Research

Graphic organizers are types of adjunct displays that are designed to assist students in comprehending texts (Robinson & Molina, 2002). Stull and Mayer (2007) identify graphic organizers as "spatial arrangements of words (or word groups) intended to represent the conceptual organization of text" (p. 810). This definition consists of three parts: (a) the main elements in a graphic organizer are words or word groups, (b) relations among elements are represented by the spatial arrangement of the elements on the page, and (c) the graphic organizer symbolizes the conceptual organization of a written text (Stull & Mayer, 2007). Graphic organizers were first designed to function as advance organizers, helping students' learning by activating prior knowledge and linking it with new concepts (Nesbit & Adesope, 2006).

According to research in educational psychology, graphic organizers facilitate learning and recall of information (e.g., DiCecco & Gleason, 2002; Kim, Vaughn, Wanzek & Wei, 2001; Robinson & Schraw, 1994; Robinson & Skinner, 1996). In addition, Robinson et al. (2006) examined the role of graphic organizers in comprehending course material for an undergraduate educational psychology course. They suggested that the graphic organizers' task may not only help students understanding of course content but may also promote important metacognitive strategies, such as identifying text structure. Kim et al. (2004) also suggested that graphic organizers lead to better learning as they provide learners with a tool for relating their existing knowledge to new information.

Many studies have been carried out to investigate whether adjunct displays (including graphic organizers) improve memory for a related text (Robinson & Schraw, 1994).

However, graphic organizers were not only used in reading comprehension (Kim et al., 2001) but they have been also used in many different lines of research such as scientific research (Rulea, Baldwin & Schell, 2008), web-based research (Crooks, White & Barnard, 2007), note taking with both print-based (Robinson et al., 2006), and computer-based instruction (Katayama & Grooks, 2003; Katayama, Shambaugh, & Tasneem, 2005). Furthermore, diagrams facilitate and organize thinking. Brna, Cox and Good (2001) presented several specific modeling approaches, investigating the particular role which diagrammatic and external representations play within an educational environment. The authors presented a notion of "thinking with diagrams" which means learning to think and communicate using diagrams.

*Argumentation Diagrams*

Researchers have used representational facilitators or tools to present argumentative learning, helping students to learn how to argue about knowledge. Argumentative diagrams are one of these representational tools that are used to visualize the domain that is being discussed (Van Amelsvoort, Andriessen & Kanselaar, 2007). Suthers (2003) defines representational tools as "software interfaces in which users construct, examine, and manipulate external representations of their knowledge" (p. 28). Representation tools are mainly used to support students' collaborative argumentation learning, assuming that an argumentative diagram can support both cognitive and interaction processes (Van Amelsvoort et al., 2007; Van Drie, Van Boxtel, Erkens & Kanselaar, 2005).

Several research studies have investigated argumentation diagrams for different purposes. Van Amelsvoort et al. (2007) examined the conditions under which diagrammatic representation support collaborative argumentation-based learning in a computer environment. Results suggested that students who constructed a diagram themselves explored the topic more than students who used a diagram that was constructed for them and more than the students who used individual texts they wrote. In addition, Suthers et al. (Suthers, 2003; Suthers & Hundhausen, 2003) examined the roles of different external representations (diagram, matrices and text) in collaborative problem solving. Suthers (2003) reported that matrix representation led to more discussion about evidential relations because the empty cells triggered discussing missing information during students' discussion. In a study by Mayer (1995), two third-grade classes participated in a13-week study. One class used a graphic organizer and the other one did not. The two classrooms were given several creative writing assignments. Results indicated that the students using the graphic organizers showed an improvement in their creative writing. Mayer emphasizes that during writing process, graphic organizers can help writers focus on the topic by having their ideas presented in front of them.

Graphic organizers are assumed to support argumentation integration by reducing cognitive load and helping participants maintain arguments and counterarguments simultaneously in their working memory (Nussbaum & Edwards, in press). Research (Munneke, Andriessen & Kanselaar, 2007) showed the advantage of using a graphical representation over a non-graphical representation for argumentation. Graphic organizers can also facilitate managing cognitive load by lightening the working memory demands and freeing up space to focus on the requirements of a task rather than investing efforts for understanding the content of the text (e.g. Crooks, White & Barnard, 2007; Larkin & Simon, 1987; Stull & Mayer, 2007). Graphic organizers may help relational learning and integrated writing (Robinson &  Kiewra,1995), allowing students to learn relations easily

(Robinson & Schraw, 1994) and helping effective processing of relational information (Bera & Robinson, 2004).

*Argumentation vee diagrams (AVD).* Nussbaum and colleagues employed graphic organizers in several research studies in the context of writing opinion essays. Nussbaum and Schraw (2007) developed a graphic organizer for helping undergraduate students to write reflective essays. Nussbaum (2008) introduced a redesigned graphic organizer known as an argumentation vee diagram (AVD) , which looks like letter ”V”, and employed to facilitate argument-counterargument integration (see Figure 1). The AVD was adapted from a tool originally used to assist in science investigations. It involves listing arguments on both sides of an issue. At the base of the diagram, students develop an overall integrated conclusion.

Nussbaum and colleagues (Nussbaum, 2008; Nussbaum & Edward, in press) suggested that to engage in argument–counterargument integration, students need to evaluate and judge the strength of arguments. Therefore, they have used some critical questions under the vee diagram encouraging students to think more about both sides of the argument such as, “Which side stronger, and why?” and “Is any of the arguments not as important as others?” Nussbaum and Edwards (in press) suggested that encouraging students in the experimental condition to ask these questions resulted in more integrated arguments than students in control condition.

In Nussbaum (2008), the AVDs were utilized in planning argumentative and reflective essays in a classroom sitting. In a different manner, Nussbaum et al. (2007) utilized the AVDs in online asynchronous discussions. The study examined the effect of the AVD in facilitating argument-counterargument integration. Finally, Nussbaum and

Edwards (in press) utilized the AVD for enhancing and analyzing students' reasoning practices. The results suggested that there was a general improvement in argument skills from participating in discussions and completing the AVDs.

## The Present Research

### *Rationale for the Study*

In cognitive psychology, cognitive load theory seems to provide a promising framework for studying and increasing our knowledge about cognitive functioning and learning activities. Cognitive load theory contributes to education and learning, attempting to understand human cognitive architecture to address the design of instruction (Sweller & Chandler, 1994; Sweller, Van Merriënboer & Paas, 1998; Van Merriënboer & Sweller, 2005). Some research studies highlight cognitive demands of dialogic or written elaborated argumentation (Bernardi & Antolini, 1996; Coirier, et al., 1999; Kuhn, 2005; Nussbaum, 2008), explaining students' difficulties to engage in argumentation processes in terms of cognitive overload. Yet, no studies are reported that measure the cognitive load associated with any argumentation processes (e.g., strategies or moves).

Kuhn (Kuhn, 2005; Kuhn & Udell, 2007) investigated how students fare when asked to engage in a dialogic argument with a peer who embraces an opposing view. She asked students of middle school and community college populations to engage in a discussion about capital punishment with a peer having a different opinion. Kuhn aimed to understand the cognitive demands that discourse requires, questioning why students showed difficulties in engaging in "authentic argumentative discourse" on a familiar topic for them. Kuhn speculated that students' cognitive resources might be the reason behind this failure and she suggested that “students’ attention to their peer’s ideas might have created cognitive overload. Or considering these ideas might simply not have been recognized as part of the task” (Kuhn, 2005, p. 146).

Moreover, Coirier et al. (1999) described the specificity of argumentative writing in relation to other types of texts, presenting major difficulties associated with writing elaborated argumentative text. They demonstrated that writing an elaborated text increases the problem of managing different constraints at the same time, which can cause a cognitive overload. Coirier et al. also emphasized that the imposed cognitive load is not the same for experts and non-experts writers. For non-experts, collaborative argumentative results in higher cognitive load and this load is seriously reduced for expert writers (Coirier et al., 1999).

Likewise, Bernardi and Antolini (1996) stressed some reasons that argumentation writing task are more difficult than dialogue in terms of cognitive load framework. They demonstrated that writing argumentation requires a schematic presentation of one’s own ideas and simultaneous adjustment of the text to fit with the “addressees” mental representations. In other words, argumentation writing requires adequate support for the writer’s own position in addition to the ability to anticipate the readers' counter-arguments and refute them, which can lead to significant cognitive overload (Bernardi & Antolini, 1996).

Furthermore, research has suggested that working memory is strongly related to reasoning abilities and directly affects reasoning tasks (Kyllonen & Christal's, 1990) as well as argument generation and evaluation (Means & Voss, 1996). Means and Voss (1996) carried out two experiments to examine the relation of informal reasoning skills to students' grade, ability, and knowledge levels, considering that argument generation and evaluation is the core of informal reasoning skills. In this study, students were classified as gifted, average, or below average according to their ability. The results of the study showed that gifted students performed better than the average or below-average students on almost every measure of reasoning quality. Another study by Voss and Means (1991) also found that gifted and older children tended to generate a greater number of claims, supportive reasons, and qualifiers than younger and lower ability level children.

Means and Voss (1996) explained these ability level results in terms of participants' differences in working memory capacity, clarifying that higher levels of performance in informal reasoning (argumentation) have at least two necessary conditions. One is that an individual needs to store in working memory some information related to the issues under consideration; the other is that the individual needs to search, find, and use that information under the appropriate input conditions. Thus, Means and Voss assumed that gifted students and high-ability individuals, who showed better informal reasoning, might have larger working memory capacity than lower ability individuals, thereby being able to connect more elements in working memory.

Nussbaum (2008) also found that weighing strategy was the least used by participants who engage in argument-counterargument integration process. The most commonly used strategy was the synthesis strategy (constructing a design claim). Nussbaum explained this result in the context of cognitive load theory, hypothesizing that the weighing strategy imposed higher load on learners' working memory in contrast to a synthesis strategy which involves creating an integrated representation, therefore imposing lower cognitive load.

Overall, there is not enough psychological investigation on argumentation (Voss et al., 1999). There are also only a handful of studies relating cognitive load to argumentation, and none of these studies directly measured cognitive load. As indicated previously, although argument-counterargument integration is a very important aspect of reasoning (Baron, 1988; Means & Voss, 1996) and critical thinking (Kuhn 1991; 2005; Nussbaum & Schraw, 2007), only a few psychological research studies have focused on how well individuals are able to integrate arguments and counterarguments, as most prior argumentation models have emphasized refutation over integration (Nussbaum, 2008).

Furthermore, most research conducted based on the framework of CLT focus on problem solving (statistics, geometry, and math) (e.g., Sweller, 1988; Paas, 1992; Ayres, 2006), and instructional design (e.g., Kalyuga et al., 2001; Rourke & Sweller, 2009; Sweller, 1994; Paas & Van Merrienboer, 1994). No studies exist that address the topic of cognitive load in the context of critical thinking. Therefore, this study is assumed to take the cognitive load theory a step further, applying its principles on the context of critical thinking.

To summarize, the rationale of this study focuses on three main reasons: (a) research suggested that engaging in argumentation can impose cognitive load on learners' working memory, (b) few research studies have focused on studying argument-counterargument integration, and (c) cognitive load theory has not been applied to critical thinking studies.

For these reasons, this study focuses on the cognitive load imposed on learners' working memory during argumentation processes, taking argument-counterargument integration as an example. In fact, this study is needed as most of the work available to date in argumentation literature has only dealt theoretically with cognitive overload without measuring it. The present study represents an attempt to inter-relate these two concepts, providing insights to the nature of reasoning and the nature of working memory capacity. Such a study can highlight the importance of considering the cognitive load that the learners experience during engaging in argument-counterargument integration process. The study can also provide fruitful avenues for understanding argumentation processes through understanding its underlying cognitive processes.

*Goals of the Present Study*

This study seeks to answer the following research questions:

1- What is the cognitive load imposed by different argument-counterargument integration strategies (weighing, and constructing a design claim)?

2- What is the impact of using the AVDs on amount of cognitive load, compared to using a less diagrammatic structure (linear list)?

*Hypotheses of the Study*

1- The weighing strategy would impose greater cognitive load, as measured by mental effort ratings scale and time, more than constructing a design claim strategy.

   A. Because the complexity of an argument (based on the complexity of weighing refutations) may be related to cognitive effort, this hypothesis applies more to students generating more complex weighing refutation.

   B. Because need for cognition predicts the tendency to put forth cognitive effort, this hypothesis applies more to individuals with high need for cognition (i.e., there would be a significant positive interaction with need for cognition).

As mentioned above, Nussbaum (2008) found that the weighing strategy was the least used by participants who did engage in argument-counterargument integration. The most common strategy was synthesis (constructing a design claim). Nussbaum explained these results in terms of cognitive load. He hypothesized that in using a weighing strategy; larger number of disparate (non-integrated) elements must be coordinated and maintained in working memory which might impose high cognitive load on participants working memory. In the case of constructing a design claim strategy, that strategy might help a learner to create a more united mental representation that impose lower cognitive load on working memory. Constructing a design claim might also be more meaningful or familiar to students, or they may enjoy the creativity this strategy facilitates (Nussbaum & Edward, in press). Nussbaum (2008) argued that the disparate elements in argumentation mean individual arguments and counterarguments that can be integrated in different ways.

2- AVDs would reduce cognitive load compared to a linear list, as measured by the mental effort rating scale and time.

Cognitive load theory is concerned with the manner in which cognitive resources are used during an instructional task. Stull and Mayer (2007) theorized that graphic organizers' scaffolding helps learners to save their valuable cognitive capacity without wasting it on extraneous processing. Crooks, White and Barnard (2007) mention that such extraneous processing can occur when learners use working memory resources in ways unrelated to schema development. Accordingly, utilizing graphic organizers is assumed to reduce cognitive load and to free up processing capacity for essential cognitive processing (Stull & Mayer, 2007). Furthermore, Stull and Mayer's study revealed that students scored higher on a transfer test after reading a passage that contained graphic organizers more than students who were asked to generate their own graphic organizer. In addition, Rulea, Baldwin and Schell (2008) used graphic organizers and cards to help students organize, connect, and remember information.

Moreover, Larkin and Simon (1987) compared searching information in a text with searching information in a diagram. In the first case, if the information is presented as text, a linear search starts. When a first relevant fact about the concept is found, it has to be stored in memory while the search continues for the next relevant fact. Once found, it also has to be remembered while the text is searched for the next important part of the problem. This search process takes place in working memory until the task is completed. Then, learners waste a great deal of their cognitive resources which makes it likely that an error will occur. On the contrary, when searching a diagram for information, once the first relevant fact is found, it is likely that the next fact will be found. Therefore, this spatial advantage is assumed to reduce the amount of time spent in searching and eliminate the need to manage facts in memory to compute the relationship. Accordingly, several facts about the concept can be viewed simultaneously and fewer cognitive resources are required.

Munneke, Andriessen and Kanselaar (2007) compared an argumentative diagram with a linear list to investigate the way that each representational tool sustained the “broadening” and “deepening” of argumentation among students. Findings suggested that participants who engaged in a discussion supported by an argumentative diagram argued more in “depth” and “breadth” about the topic under discussion. They also built diagrams that included more complex arguments; more claims, supportive theories, evidence, alternative theories and rebuttals than the outlines of participants supported by a text-outline.

## Summary

Argumentation is a core concept of critical thinking. This chapter presented a literature review for addressing argumentation and cognitive load theory. Cognitive load and argumentation arise from different traditions, as cognitive load theory is more related to information processing (Sweller, 1988; Sweller & Chandler, 1994; Sweller, Van Merrienboer & Paas, 1998), and argumentation is more related to reasoning (Andriessen et al., 2003; Coirier et al., 1999; Nussbaum, 2002, 2008; Voss & Means, 1991; Voss, Wiley & Sandak, 1999). Research, however, has showed that both are related and working memory capacity directly affects performance on reasoning tasks. Particularly, all conscious processing take place in our working memory. Furthermore, reasoning requires the ability to integrate multiple relations; such process also occurs in working memory.

Working memory is a central concept of cognitive load theory and working memory processing limitations are largely accepted among researchers; only a limited amount of information can be activated at the same time. In the meantime, the working memory limitations are the defining aspects of cognitive load theory as the theory focuses on the way limited cognitive resources are used during an instructional task. Accordingly, cognitive load theory postulates that working memory can be negatively loaded either externally, from the way instruction is designed, or internally, from the number of elements that should be simultaneity processed to achieve understanding. The theory also suggests another positive type of load that is directly relevant to schema construction, which is called “germane load.”

In fact, argumentation is a daily activity for everybody as individuals needs to make different decisions. For example, one may make pro and contra reasons for a claim in every day decision making. There are arguments involving small decisions, and there are arguments involving great decisions (Freeley & Steinberg, 2000; Taylor, 1971). Decision making requires conducting balanced reasoning. This balanced reasoning was one of the main concerns of this chapter. It can be achieved through considering both sides of an argument and integrating them into a final conclusion. However, some people have difficulties in generating and considering arguments that support opposite views. Fortunately, this ability can be improved through instruction and engaging in collaborative reasoning groups and sometimes through intervention with some tools such as graphic organizers. However, any instructional intervention must take into account the cognitive load involved.

# CHAPTER 3

# METHOD

This study focuses on the cognitive load imposed on learners' working memory during argumentation as a reasoning tool, specifically focusing on argument-counterargument integration. This study aims to measure the cognitive load associated with two strategies of argument integration (constructing a design claim strategy and weighing refutation strategy) as well as the way that graphic organizers affect the amount of cognitive load imposed by such a task.

## Participants

Participants were graduate and undergraduate students enrolled in educational psychology courses at the University of Nevada, Las Vegas. The students participated in this experiment to satisfy a course requirement. The sample size ($n$ = 285) was determined based on using Gpower software (Faul, Erdfelder, Lang & Buchner, 2007), selecting a medium effect size of 0.25, alpha level of .05, and power of .95. I assumed that some of the F-tests would require 2 numerator degrees of freedom.

The sample consisted of 205 females and 80 males with a percentage of 71.9% for females and 28.1 % for males. In addition, 1.8 % of the participants were freshmen, 15.8% sophomores, 38.9 % juniors, 13.3 % seniors, and 30.2% graduate students. With respect to the college program of the participants, 84.2% were education majors and the rest were from majors such as business, accounting, social sciences, health promotion, and criminal justice. The ethnicity of participants was 64.2 % Caucasians, 16.5% Hispanic, 6.7% African American, 0.4% American Indian, 8.8% Asian, and 3.5 % other.

## Materials and Measures

### *Argument Vee Diagrams (AVDs)*

As explained previously, an AVD is a type of graphic organizer that contain arguments that represent two different viewpoints about an issue in addition to critical questions in the base to guide students to judge how one side of argument was stronger or weaker than another (Nussbaum, 2008; Nussbaum & Schraw, 2007). This study utilized three different AVDs, one for each argument-counterargument integration strategy and one for a control group (see Figures 2, 3).

### *WebCampus*

Participants used an electronic discussion board (WebCampus) for conducting the integration process after reading the arguments and counterarguments. Students were directed to complete a quiz (Appendix A), with the AVD and critical questions in a criteria box as the first two items, and the integration paragraph as another item (see Appendix A).

### *Demographics Survey*

Students were asked to complete a demographics survey (Appendix B) that consisted of seven questions. The questions ask participants for information about age, gender, ethnicity, year in college, college program, current G.P.A., and intention to pursue teaching certification.

### *Need for Cognition (NFC) Scale*

The Need for Cognition Scale (Cacioppo, Petty, & Kao, 1984) (Appendix C) is an individual difference variable measuring the tendency to enjoy engaging in effortful cognitive tasks (Petty & Cacioppo, 1988). In this study, need for cognition was used as an indication of participants' tendency to put forth cognitive effort. The scale consisted of 18 items and it was on a 5-point Likert scale with answers ranging from 1 (strongly disagree) to 5 (strongly agree). According to Petty and Cacioppo, "Items on this scale ask participants to rate the degree to which they consider the scale's statements to be characteristic or uncharacteristic of themselves" (Petty & Cacioppo, 1988, p. 209). The scale contained such items as ''I prefer my life to be filled with puzzles that I must solve'' or ''I only think as hard as I have to.'' The scale was administered to the participants as a pre-task questionnaire. The scale has high reliability; the Cronbach's alpha coefficient as reported in Cacioppo et al. (1984) was + .90 for the 18 items. A factor analysis for the scale was also conducted for validation and it was characterized by one dominant factor (Cacioppo et al., 1984). I also calculated the reliability of the need for cognition scale in this study and it was .85.

*Cognitive Load Rating Scale (Self-Report)*

This scale measures self-reported mental effort as an indication of intrinsic cognitive load associated in conducting a specific task (Appendix D). By using this scale, participants reported their invested effort on a 9-grade symmetrical category scale, by giving a numerical value of their mental effort. The numerical values and labels assigned to the categories ranged from (1) very, very low mental effort to (9) very, very high mental effort. Paas (1992) was the first to develop and use this self-report technique in the context of CLT. Many studies have used and endorsed this measure such as: Ayres (2006), Brunken et al. (2003), Clark et al. (2006), Paas and Van Merrienboer, (1994), Paas et al. (2003b), and Paas and Van Gog (2006).

*Time Measure.* The time for finishing the task was calculated as another indication of the amount of cognitive load (mental effort) invested in a task. Despite the lack of studies in which time is utilized to assess and measure cognitive load, Barrouillet, Bernardin, Portrat, Vergauwe and Camos (2007) suggest that time is an important determinant of cognitive load and mental effort. Schmutz, Heinz, M´etrailler, and Opwis (2009) measured cognitive load for the participants involved in searching for products in online book stores. Their findings suggested that high cognitive load which participants reported on a mental workload scale were related to task completion time; the higher cognitive load, the longer task completion time.

WebCampus provides times for individual tasks (quizzes). It also gives a record of how long it took students to answer each item. Therefore, students did the first task, which is the Need for Cognition and demographics survey. Then, they completed the AVD or the linear list. The first item on the second quiz presented the AVD, and contained the criteria box that has the critical questions (Appendix A). And the last item was the integrating paragraph; it was a “paragraph” item.

Then the time that students took to finish their thinking and integration process was monitored through a time column in WebCampus. The allotted time for the assessment was 30 minutes. To make sure that students focused on finishing the integrating task (doing it in one sitting) without wasting task time in any other activity, participants were informed that there was a certain amount of time allocated to completing their AVDs (Appendix E).

*Analysis Question*

The students in the experimental and control groups thought about and integrated arguments and counterarguments about the same analysis question. The question was "Should students be graded on class participation?" previously used by Nussbaum et al. (2007). I provided the students with some arguments and counterarguments that represent two different viewpoints as a response to this question. Then, I asked the students to integrate both sides, using different integration strategies (see Figures 2, 3). The pro side had three arguments as follows: (1) to participate and to be involved in lecture would help concentration and understanding (2) if a professor is the only one talking during a lecture it would be boring for him/her and students, and (3) many students will not participate unless it is part of their grade.

The side of the counterarguments had three counterarguments as follows: (1) no, because some students prefer to concentrate in lectures and keep taking notes without participation, (2) some students are socially shy to talk in lectures in front of their classmates, and (3) grading may cause too many people to talk who do not have anything new to say.

*Linear List*

The students in the control groups used the same arguments and counterargument and strategies as a text-based content or a linear list (see Appendix F). The list has the analysis question on the top of the page and both sides of argument and counterarguments were written in items.

## Design and Procedures

The study manipulated two independent variables in a 3 x 2 factorial design: (a) two argument-counterargument integration strategies versus a control, and (b) AVDs versus a linear list. The dependent variables were the amount of mental effort that students invest in using each argument-counterargument integration strategy in addition to the time for completing the task. The participants were randomly assigned to each of the six conditions.

The study consisted of two parts. The first part included consent forms, the need for cognition scale and the demographics survey. The second part included two phases, utilizing argument–counterargument integration strategies and asking the participants to report their invested mental effort.

### *Part 1*

Students were given informed consent forms. The need for cognition scale was administered to the participants to examine the individual's tendency to engage in effortful cognitive activities. Participants also completed a demographics survey.

### *Part 2*

Part 2 consisted of two phases. The first phase dealt with utilizing argument–counterargument integration strategies. The second phase included asking the participants to report their invested mental effort. Participants were assigned into one of six conditions.

*First Phase.* The six conditions had the same analysis question regarding grading participation. For the three AVD groups, the analysis question was accompanied with the AVDs in which arguments and counterarguments were listed on different sides of the diagram, and then participants thought about the two sides and wrote an integrated, concluding paragraph at the bottom of the diagram. For the linear list groups, the analysis question was on the top of the page, in which arguments and counterarguments were written in a linear manner below the analysis question. The participants in the strategy conditions were asked to integrate the arguments and counterarguments based on utilizing a different integration strategy. There were also some critical questions that relate to each strategy.

The instructions and questions related to each strategy were as follows: (a) constructing a design claim strategy (“Please write a paragraph-length argument explaining why students should be graded for class participation, and how this can be done effectively”), “Do you have any ideas that would alleviate the problems mentioned in the counterarguments?,” “If you answered yes, please describe the ideas (Skip if you answered "no.”) Are your ideas practical? (Consider costs.), and “If you answered "no" to the previous question, please explain. (Skip if you answered "yes.")”

(b) Weighing strategy (“Please keep thinking about which arguments may be more or less important (or convincing) than those on the other side. Please write a paragraph-length argument explaining why arguments on one side of the issue are stronger (and the other side weaker). You must take a stand, giving your opinion with supporting reasons).” The critical questions prompts that were related to weighting strategy were “Are any of the arguments on one side more important than those on the other side?”, “If you answered yes, which argument is more important than those on the other side? Explain.” (Skip if you answered "no.") “Are any of the arguments not convincing enough? Explain" and "If you answered yes, which argument is not convincing enough? Explain."

For the control groups, students used the AVD (or linear list) but with no prompting for a particular strategy. The question for these groups was "Please write a paragraph-length argument here giving your opinion on this issue along with supporting reasons. You must take a stand." In respect to the AVD factor, the control group used the same analysis question and the same strategies but without using the AVD. Therefore, they had the argument and the counterargument as text-based content (see Appendix F).

*Second Phase.* For the experimental and the control conditions, after finishing integrating the arguments and counterarguments into an integrated opinion essay, either based on completing the AVDs or a linear list, each group was asked to answer a question about their perceived mental effort (cognitive load) that they experienced during integrating arguments and counterarguments using one strategy. They chose one of the nine degrees of difficulty representing the level of mental effort they experienced, using the Paas (1992) cognitive load measure.

## Summary

For the purpose of summarizing the design of the study, Table 1 presents a summary of the variables that were used in the study. The independent variables were (a) two argument-counterargument integration strategies versus a control, and (b) AVDs versus a linear list. The dependent variables were the amount of mental effort and time that students experienced in using each argument-counterargument integration strategy. Control variables were need for cognition and argument complexity.

# CHAPTER 4

# RESULTS AND ANALYSIS

## Introduction

In this chapter I present a description of the data analysis and results of this study. I begin by presenting pilot testing of instruments. Then I provide a description of essay coding, including weighing refutation and design claim complexity coding, forming scoring rubrics, the reliability of the rubrics and statistical analysis steps. The chapter also addresses the statistical analysis that I conducted to examine the two research questions of the study.

## Pilot Testing of Instruments

I carried out a pilot study to test and assess all instruments for potential revision before administration of the study. Participants for the pilot study were college students at the University of Nevada, Las Vegas ($N$ = 14). The pilot test occurred over a period of two weeks. Similar to the present research study, the pilot study was presented to participants in two parts, which occurred at the same sitting. To ensure that students clearly understood the items and the directions on the surveys, I asked students for feedback to identify any vague or difficult questions. I also asked students if they experienced any unclear directions or unusual formatting. Based on the students' feedback from the pilot study, I re-worded some of the questions that students reported difficulty in understanding.

## The Present Research Study

The administration of the study occurred over one and a half semesters. The application of the study was on WebCampus. Participants were 321 college students.

After checking the sample for any missing data and outliers, 36 cases were removed and the final number of participants became 285 students. Students were recruited to the study through the educational psychology research participation system. See Appendix G for the recruitment letter.

## Essays Coding and Statistical Analysis

Each group received only one of the different treatment conditions; comparisons among the different conditions were based on values of the dependent variable. I used the general linear model with need for cognition (an interval-level variable) as a covariate (so as to control for the disposition to put forth effort, per my first hypothesis) I also tested for the interactions with NFC. Table 2 shows means and standard deviations of variables used in the statistical analysis. The table shows that some variables had either positive or negative skewness. However, I had a sufficiently large sample size (N= 285) that, even with skewed data, the Central Limit Theorem shows that the sampling distribution will be approximately normal, so the use of parametric statistics is justified. For the time variable as one of the cognitive load measures, I used a logarithmic transformation (common log) to remove data skewness that was reflected in the time variable.

Data analysis for this study mainly consisted of: essay coding, weighing refutation and design claim complexity coding, and statistical analysis.

### *Essays Coding*

Students' essays were analyzed as a measure of thinking complexity. The essays were analyzed into five variables to make a scoring rubric (see Appendix H). The scoring rubric consisted of five categories: reasons, other side reasons, weighing refutation, design claim, and reasons for design claims. There are some research studies that suggested similar criteria for evaluating argument in relation to reasoning (e.g. Angel & 1964; Aufschnaiter et al., 2008; Means &Voss, 1996; Voss & Means, 1991). Such criteria indicate that a high quality argument should include supportive reasons for a claim, evaluate arguments, and consider the counterarguments of the other side of the issue and be able to refute it.

In this study the researcher and the advisor discussed and evaluated all students' essays together and carried out correlations and agreement for each one of the five variables before scoring the essays (see Table 3). These levels of reliability were deemed adequate except for the *Reasons* category, but that variable was not central to the hypotheses being tested.

*Weighing refutation and design claim complexity coding.* I analyzed the complexity of both weighing refutations and design claims. I wanted to examine if more complex arguments were associated with more cognitive load, and whether weighing refutation involved more load than design claim while controlling for argument complexity.

For weighing refutation, the analysis was based on a rubric consisting of four levels: 0, 1, 2, and 3. The level of 0 means that participants left the place of the essay blank or did not include any weighing refutation, then the other levels represent low, medium and high levels of weighing refutations (see Appendix I). The low level applied on essays that denied an argument but with no or weak support, was brief or unclear, generalized about the reasons on one side but without being very specific, made a pseudocontrast that reflected only the presence or absence of one attribute rather than weighing two different attributes. An example of a student's essay that contained a weighting refutation that I scored at the low level was "The argument for the professor being the only one talking during a lecture would be boring falls a little short for me."

The medium level of weighing refutation applied on essays that refuted an argument by introducing a new condition, constraint, relationship, consequence or consideration that made one side less (or more) likely or important, or denied the truth or applicability of a premise by providing a good reason. An example of a student's essay that contained a weighting refutation that I scored as medium level was "I would say the counterargument is the weaker one, because, even though students are shy, we as a teacher need try to help them get out of their box and express themselves."

The high level of weighing refutation applied on essays that identified two values and said one was more important than the other. An example of a student's essay that contained a weighing refutation that I scored as a high level was "I believe that the argument that some students are socially shy to talk in lecture in front of their classmates is more important or strong than, if a professor is the only one talking during a lecture it would be boring for him and the students. This is because the emotional consequences are more personal and deeper to have a feeling of shyness than boredom. Being forced to speak in public can cause anxiety and I have known someone to drop a course because she was afraid of giving an oral presentation. However, being bored may be uncomfortable for some but not necessarily detrimental to their health (stress) or a grade (dropping a class). "

For design claims, the analysis was based on a rubric consisting of 5 levels: 0, 1, 2, 3 and 4 (see Appendix J). The level of 0 meant that they left the place of the essay blank or without making any design claims, then the other levels represented simple, low, moderate and high levels. The simple level applied on design claim with no justifying reasons or contrast and which did not address any counterarguments. An example of a student's essay that contained a design claim that scored as a simple level was "Students should be graded for class participation...this can be done effectively by providing detailed feedback, praise when they get an answer correct." The low level was applied on design claims that was simple and brief but had a supporting reasons, or if the design claim had an implicit contrast to justify the design claim. An example of a student's essay that contained a design claim that I scored at the low level was "Students should be graded on class participation…. I do believe though that it should not be a very big part of the class, like if they not participate they will fail, but I do believe it should be about 5 to 7 percent of their grade."

The moderate level of design claim was applied on more complex design claims where a reason was given to justify the design claim (but which did not address one of the arguments/counterarguments on the AVD) or the design claim was simple and brief but did address a given counterargument An example of a student's essay that contained a design claim that I scored at a moderate level was "Students should be graded on class participation .Class participation does not have to involve speaking outloud or answering questions, but it should involve doing classroom activities as all the other students do, following along in reading and paying attention in class. That is still participation. Students should be graded on this to encourage them to do their work, but for actually doing it as well/

The high level of design claim was applied on design claims that were more than simple and brief and addressed one or more of the given counterarguments. An example of a student's essay that contained a design claim that I scored at the high level was "Classroom participation is important but not crucial. One way to grade students for participation in the classroom is to require that students speak during class, but not that they are constantly participating. Perhaps they can be required to add in one comment per class period (that way they are not talking too much as the counterargument states."

For coding the essays in this study, the focus was on structure of an essay rather than content of participants' thoughts or opinions; therefore there was no bias for or against any particular position, inclinations or researchers' personal preference (Aufschnaiter et al. 2008; Brown, Ballard, Vries, Suedfeld & Tetlock, 1992).

*Reliability for weighing refutation and design claim complexity.* In terms of the previously described scoring rubrics, the reliability for the complexity of weighing refutation variable and the design claim variable was evaluated and discussed by the researcher and the adviser (all the essays and not just a sample). The correlation coefficient was 75% for design claims and 63% for weighing refutations. While this degree of reliability was modest the fact of using double raters enhanced the reliability (since the scores after discussion, not the scores of a single rater, were used).

### *Statistical Analysis*

I conducted statistical analysis for the two research questions. The statistical analysis for the first question's hypothesis, weighing strategy would impose greater cognitive load, as measured by the mental effort ratings scale and time, more than constructing a design claim strategy, consisted of four steps. (As most of these steps involved a 3x2 ANOVA, they also addressed the second hypothesis, but I focus attention first on the first hypothesis.)

*Step 1: Did Condition/Strategy Instructions Affect Students' Argumentation*? Table 4 shows an analysis of variance (2x3 ANOVA) where the argumentation variables were treated as dependent variables for the conditions and the independent variables were strategy condition (weighing, design claim, and control) as one factor and AVD (vs. linear list) as the second factor. This analysis served to make sure that each strategy condition produced the strategies it was meant to produce. The table shows that there was a main effect of strategy on the argumentation frequency variables, but not a main effect or interaction effect for AVDs (versus linear lists). Because there was a main effect for strategy condition, the mean of each condition was computed (see Table 5) and pairwise comparisons made. For the weighing refutation (WR) condition, the number of WRs were significantly higher in the WR condition than the other conditions, $F(2, 278) =35.98$, $p < .001$, $\eta^2 = .21$. For the design claim (DC) condition, the number of DCs were significantly higher in the design claim condition than the other conditions $F(2, 278) = 81.90$, $p <.001$, $\eta^2 =.37$, as were reasons for design claims, $F (2, 278) = 24.17$, $p <.01$, $\eta^2 =.15$, and reasons $F(2, 278) = 3.39$, $p <.05$, $\eta^2 =.02$. However, for the other side reasons, the main effect was not significant.

Step 2: *Did strategy conditions have an effect on the cognitive load measures (relationship of conditions to cognitive load)?* I conducted multivariate tests (3x2 ANOVA) using strategies and AVDs as independent variables and time and mental effort score as dependent variables. The Multivariate Test ANOVA for the relationship of conditions with cognitive load was significant for strategies with cognitive load variables, Wilks' Lambda = .17, $F(4, 554) = 13.10$, $p < .001$, $\eta^2= .09$. (The AVD variable was not significant.) I then conducted a separate 3x2 ANOVA for each dependent variable examining the relationship of conditions to cognitive load variables (Table 6). The analysis showed that the multivariate effect was driven by time-log ($F(2, 277) = 27.34$, $p < .01$, and not mental effort $F(2, 277) = 1.4$, $p = .25$. The AVD variable was again not significant (AVDs with mental effort $F(1, 277) = .05$, $p = .82$, with time $F(1, 277) =.03$, $p = .87$). As can be seen from Table 6, individuals took longer (as measured by the log of time) in the strategies conditions. But there was not any effect on the mental effort variable. This could, however, be due to the fact that not all participants in the weighing and design claim conditions necessarily made weighing refutations or design claims, as was shown in Table 5 (proportions were 72% and 78% respectively). Therefore, I conducted a more fine grained analysis in Step 3 to compare the cognitive load on students who actually made weighing refutations and design claims, controlling for the complexity of the arguments.

*Step 3: Did the weighing refutation and the design claim complexity scores have an effect on the cognitive load measures?* Using the General Linear Model (regression), I examined whether there was a relationship between the complexity scores and the cognitive load variables. (ANOVA could not be used because, for this analysis, the independent variables were on a scale.) Students with zero scores on these scales did not make a weighing refutation or design claim. Would those who did experience more cognitive load as a function of how complex the weighing refutation and design claims were?

Table 7 shows that there was a significant relationship between the weighing refutation scores and the mental effort scores ($F$ (1, 280) = 9.09, $p < .01$, $\eta^2 = .03$) and the time scores ($F(1, 280) = 30.96$, $p < .01$, $\eta^2 = .10$). In contrast, design claims scores had a significant relationship with the time scores ($F$(1, 280) = 8.02, $p < .01$, $\eta^2 = .03$) but not the mental effort scores.  Making a complex design claim did not involve significantly more mental effort.

Because my first hypothesis was that weighing refutations involve more cognitive load than design claims, I tested whether the beta coefficients for weighing refutations were significantly greater than those for design claims. The beta coefficients reflect the magnitude (slope) of the relationship between these strategies and the cognitive load measures. The results were significant for both cognitive load variables (mental effort: $F$(1, 285) = 8.01, p < .05; time: $F$(1, 285) = 8.03, $p < .05$), showing that making weighing refutations of a given level of complexity involved more mental effort and time than making a design claim.

These results provide an answer to the first research question, which is "What is the cognitive load imposed by different argument-counterargument integration strategies (weighing, and constructing a design claim)?" They confirm the first part of the first hypothesis that weighing strategy would evoke more cognitive load (mental effort) than the design claim strategy when argument complexity is controlled.

*Step 4: Did need for cognition have an interaction effect?* In the previous analysis, NFC was included in the model as a covariate.  I revised the model to see if there was an interaction effect with need for cognition (NFC).  The results revealed that there was a significant interaction effect, $F$(1, 277) = 5.89, $p < .05$, $\eta^2 = .02$, which means that the strength of a relationship between weighing refutation and mental effort depends on the level of NFC. Figure 4 shows the relationship among mental effort, need for cognition and weighing refutation where the slopes of the weighing refutations complexity lines get steeper for higher levels of NFC. The figure shows that for students with average levels of NFC, the difference in mental effort in making a complex weighing refutation (3) and not making one at all (0) was about one point on the mental effort scale. The difference was about two points for students with high levels of NFC (2 SDs above the NFC mean). In this figure, the levels of NFC are not actual values; they are predicted ones to show the interaction between NFC and argument complexity on mental effort. Under the revised model, with the interaction term included, the main effect term for weighing refutation score on mental effort was no longer significant. Main effects are not interpreted in the presence of an interaction.

*Second research question.* For the second research question of the study, regarding the impact of the AVDs on cognitive load compared to a linear list, as measured by the mental effort rating scale, the results were not significant (as reported above). The analysis showed that utilizing the AVD did not affect participants' cognitive load for the mental effort and the time spent on the thinking and integration process. Participants in the experimental groups who utilized the AVDs for the integration process did not report lower cognitive load than participants in the control groups.

# CHAPTER 5

# DISCUSSION

In this chapter, I present a discussion of the study's findings. I start the chapter with a summary of the findings in the context of the research questions. Then, I discuss the topics of cognitive load of argument-counterargument integration, the interaction effect with need for cognition, and the cognitive load and graphic organizers. I also discuss the theoretical significance of the results. The chapter also addresses limitations of this study, suggestions for future research, general discussion and educational implications.

## Summary of Findings

For the first research question "What is the cognitive load imposed by two different argument-counterargument integration strategies (weighing, and constructing a design claim)?" the results showed that individuals took a longer time in the strategies conditions, but there was not an effect of the conditions per se on the mental effort variable. However, when I examined the actual weighing refutations that were made, I found a significant relationship between the complexity of an essay (specifically, weighing refutation complexity) and cognitive load as measured by both time and the mental effort scale. Furthermore, as hypothesized weighing refutations involved more mental effort than design claims even when controlling for the complexity of the arguments. The results also revealed that there was a significant interaction effect between NFC and argument complexity on mental effort. Regarding the second research question, "What is the impact of using the AVDs on amount of cognitive load, compared to using a less diagrammatic structure (linear list)?" the results were not significant. The results showed that the AVDs did not reduce participants' cognitive load for either mental effort or time spent on the thinking and integration process compared to a linear list.

The findings are consistent with my prediction of the first part of the first hypothesis that weighing refutations had more cognitive load than design claims when controlling for the complexity of the arguments. The findings were also consistent with the second part of the first hypothesis in that there was a significant interaction effect for NFC. The results of the second hypothesis failed to confirm my prediction concerning whether AVDs would help reduce cognitive load compared to a linear list, as measured by the mental effort rating scale and time.

## Cognitive Load and Argumentation Integration Strategies

The goal of this study was to examine the cognitive load associated with utilizing two strategies of argument–counterargument integration as core aspects of critical thinking. Critical thinking skills include considering (integrating) multiple viewpoints or taking both sides of an issue into account (Angeli & Valanides, 2009; Willingham, 2007). One definition of critical thinking is "the ability to analyse facts, generate and organize ideas, defend opinions, make comparisons, draw inferences, evaluate arguments and solve problems" (Chance, 1986).

In this study, participants analyzed arguments and considered alternative views and developed their own point of view, writing an integrated essay. Then, I examined the cognitive load that is associated with the complexity of students' essays. Complexity of the essays in this study was measured by the complexity of the weighing refutations and design claims included in the essay. The weighing strategy entails considering arguments on one side of the issue and evaluating whether they are stronger than those on the other side. In particular, weighing two values at the same time and supporting one value over the other one. This is called the weighing refutations strategy. Design claims have to do with providing a creative solution that integrates both sides of an issue. It entails participants' ability to build up a final conclusion reflecting benefits of an alternative while attempting to lessen or eliminate negative consequences cited in a counterargument.

The overall pattern of the data suggested that participants in both conditions of weighing strategy and design claim reported higher cognitive load, in terms of time, than the control group. However, participants with more complex integrated essays that contained more complex weighing refutations reported higher cognitive load, as reported by mental effort in addition to time. Participants who produced more complex integrated essays that contained more complex design claims reported more cognitive load, but only as measured by the log of time, not the mental effort self-report.

In the weighing strategy, a larger number of disparate (non-integrative) elements must be coordinated and maintained in working memory (Nussbaum, 2008). In this study, students in the experimental groups experienced thinking about an analysis question and analyzed two critical questions at the bottom of the AVDs. Then, a student had to think and weigh six arguments and counterarguments that were offered in responses to the analysis question to form an integrated essay. This type of thinking represents and reflects the ability of "conceptual/integrative complexity" (Marry, 2002; Suedfeld, Tetlock & Streufert, 1992) and "integrative thinking" (Martin, 2007; Sill, 1996). This type of thinking has to do with whether a situation is cognitively evaluated and judged according to a single or multiple criteria (Tibon, 2000).

From a cognitive processing viewpoint, it is possible that this type of integrative thinking can overburden a student's working memory, considering that only a few elements of information can be processed in working memory at the same time (Kalyuga, Chandler, Touvinen & Sweller, 2001; Van Merrienboer & Sweller, 2005). Working memory is strongly related to reasoning abilities and directly affects reasoning tasks (Kyllonen & Christal, 1990). Integrating multiple relations occurs in working memory (Christoff et al., 2001; Krumm et al., 2008). Such integration requires more than perceptual or linguistic processing (Waltz et al., 1999). Waltz et al. also distinguished between the capacity required to comprehend single relations and the capacity to integrate multiple relations, emphasizing that integrating multiple relations requires much more capacity from a learner, which can be more resource demanding on a learner's working memory. Furthermore, considering counterargument integration as an important criterion for a sound argument and therefore informal reasoning, Means and Voss (1996) found that gifted children outperformed lower-ability level children in reasoning quality. They explained these results in light of working memory capacity.

For participants to make a weighing refutation, they have to weigh arguments on one side of the issue and evaluate whether they are stronger than those on the other side. If a student has to store in working memory some information related to one side of an issue, then shift to the other side of the issue trying to weigh and evaluate the evidence from both sides in a unified conclusion, this can cause mental effort and consumes time.

However, for participants to make design claim, it is possible that participants took more time to think of a complex design claim but not more mental effort because the process of constructing a design claim may operate "sequentially." In such cognitive processing, participants have to search for or attend to problems, search for a solution, evaluate the solution, and write it up. The sequential nature might make this process involve less intrinsic cognitive load but take a significant time to be accomplished. It also might be that the time measure was not a strong indication of cognitive load for those who utilized the design claim strategy.

According to CLT, it is easier to learn tasks that are low in element interactivity as they contain elements that can be learned in isolation or sequentially rather than simultaneously. This may result in a relatively low working memory load because the task can be learned without holding more than a few elements in working memory. In contrast, tasks high in element interactivity are more difficult to learn because more elements interact, requiring manipulating many elements in working memory at the same time, resulting in a relatively high working memory load (Ayres, 2006; Pollock et al., 2002; Sweller, 1994).

In this study, as measured by the cognitive load rating scale (Paas, 1992), which focuses on intrinsic cognitive load, participants who produced more complex essays using a weighing refutation strategy reported higher intrinsic cognitive load than students who produced more complex essays using a design claim strategy.  It is possible that the nature of weighing refutation task inherently imposes cognitive load as it requires from a learner to critically evaluate, judge, and think of two sides at the same time, to be able to give a final integrated conclusion about it. Intrinsic cognitive load is inherent in the nature of a task (Clark et al., 2006). It is related to the “complexity of a domain” (Paas, Van Gerven & Wouters, 2007) and it is determined by the extent to which various elements interact at any one time in order to successfully perform a task (Paas & Van Gog, 2006; Pollock et al., 2002).

The findings of this study are consistent with some other findings. Suedfeld et al. (1992) suggest that information overload is one of the variables that affect the complexity score as he measured it by degrees of differentiation and integration. After a comparison of data generating techniques, paragraph completion test, essays and interviews, Suedfeld et al. (1992) found small variation in complexity scores, but found that materials with higher complexity scores occurred after some thought or planning and under condition of no time constraints. Oppositely, materials of lower complexity scores were generated with little prior thought. Kuhn (2005) suggested that argumentation is resource demanding, emphasizing that cognitive resources might be the reason behind that some students were not able to engage in dialogic argument. Kuhn (1991) also emphasized that the ability to use rebuttals is a complex skill as it is involves integrating an original and alternative theory (Aufschnaiter et al., 2008: Kuhn, 1991).

This finding also provides supporting evidence for the explanations of Nussbaum (2008) for why the weighing strategy was the least used by participants who did engage in argument-counterargument integration. The most common used strategy was synthesis (constructing a design claim). Nussbaum speculated that cognitive load might be a factor.

## Interaction Effect for Need for Cognition

The findings of this study also revealed that there was a significant interaction effect with NFC (Cacioppo, Petty, & Kao, 1984) which means that the strength of a relationship between weighing refutation complexity and mental effort depended on the level of NFC. The data showed that the slopes of the weighing refutations complexity lines became steeper for higher levels of NFC. The interaction with NFC was not totally consistent with what I predicted in the hypotheses of the study. My initial hypothesis was "because need for cognition predicts the tendency to put forth cognitive effort, this hypothesis applies more to individuals with high need for cognition (i.e., there would be a significant positive interaction with need for cognition)." However, some low NFC students were able to generate complex refutations without exerting a lot of mental effort.

One question is why some students, at lower levels of NFC, did not exert more cognitive effort when they generated more complex WRs? After checking the data, I think that these results are due to other factors, such as that finding that low NFC students mainly had 0 and 1 scores on weighing, and there may not be a lot of difference in the mental effort of those levels as compared to WR complexity levels 2 and 3. It is also possible that those refutations are not considered as much as the ones by high NFC students.

Furthermore, high GPA can be a possible explanation for those students who have low NFC and were able to produce complex integrated essays with low cognitive load involved. The data of this study showed that the scores of NFC ranged from 32-81. From checking the demographic information of participants, I found that some students who were at low levels of NFC showed higher GPA scores. For example, one student had a score of 42 on the NFC scale, which represents a low score on that scale; however, this student has a GPA of 4.0 which represents the highest GPA. This student produced one of the most complex essays that contains three weighing refutations and reported a "rather low mental effort" on the mental effort scale. Another student whose score on

NFC was 37 has a GPA of 3.8 and also produced a complex essay that has one design claim while reporting a "rather low mental effort" on the cognitive load scale.

It is also possible that some other individual differences may account for why some low NFC students were able to easily make weighing refutations without reporting a lot of cognitive load. Some students may have an expertise of thinking critically and integrating two sides of an issue and that may help them to be familiar with argumentation and integration process. Such familiarity may have resulted in constructing an "argument schema" (Chinn & Anderson, 1998; Reznitskaya & Anderson, 2002). According to CLT, schema acquisition lessens working memory load. (Sweller, 1994). CLT also assumes that the expertise of the learner plays an essential role in determining the intrinsic cognitive load or the complexity of the material (Van Merrienboer, Kester & Paas, 2006).

## Cognitive Load and Graphic Organizers

According to research in educational psychology, graphic organizers facilitate learning and recall of information (e.g., DiCecco & Gleason, 2002; Kim, Vaughn, Wanzek & Wei, 2001; Robinson & Skinner, 1996). However, in this study the graphic organizers did not help in reducing students' cognitive load. The results of this study are also consistent with the findings of Robinson and Kiewra (1995). Robinson and Kiewra asked students how much effort they put into learning the information from different learning materials texts, text only, text plus outlines, or text plus graphic organizers. Their findings indicated that no differences were found among the study materials groups for amount of perceived effort.

Theoretically, these findings can be explained by considering the size of the linear list or the text that was used for the control group. It is possible that the text was too short to impose much cognitive load so that the graphic organizer was equally effective as the linear list. Holley and Dansereau (1984) and Alvermann (1986) mention that displays can be unnecessary when text is shorter than 2,500 words (cited in Robinson & Kiewra, 1995). The linear list of this study consisted of 195 words, which represents a short text. Robinson and Schraw (1994) suggested that one of the disadvantages of using short text is that it may decrease that advantage of using a matrix.

The findings of my study can be also explained by the organization of the linear list. The linear list that I used for this study with the control group was organized enough which may have helped students as much as the vee diagrams, at least in respect to minimizing the load of processing the information. Such organization may alleviate the load of working memory by saving the time and mental effort for identifying and searching for the relationship between the two sides of the issue. Robinson and Kiewra (1995) also reported that graphic organizers are helpful only when text is poorly organized.

## Theoretical Significance

The theoretical contribution of this study can be highlighted as follows: most research conducted based on the framework of CLT focuses on problem solving (statistics, geometry, and math) (e.g., Ayres, 2006; Paas, 1992; Sweller, 1988) and instructional design (e.g., Kalyuga et al., 2001; Paas & Van Merrienboer, 1994; Rourke & Sweller, 2009; Sweller, 1994). No research studies to date address the topic of cognitive load in the context of critical thinking. However, some studies examined the undemanding nature of a type of thinking that operates automatically and compared it to analytic processing (Franssens & DeNeys, 2009). Therefore, this study is assumed to take cognitive load theory a step further, applying its principles to the context of critical thinking. It was thought that general reasoning abilities and general working memory capacity are separate as they arise from quite different traditions (Kyllonen & Christal, 1990). However, this study and some other research (e.g. Kyllonen & Christal, 1990; Means &Voss, 1996) have showed that working memory capacity directly affects reasoning tasks.

Some research studies emphasized the cognitive demands of dialogic or written elaborated argumentation (Bernardi & Antolini, 1996; Coirier, et al., 1999; Kuhn, 2005; Nussbaum, 2008), explaining students' difficulties in engaging in argumentation processes in terms of cognitive overload on learners' working memory. Yet, no studies are reported in measuring the cognitive load associated with any argumentation processes (e.g., strategies or moves).

Argumentation integration is an important aspect of sound argument and reasoning (Kuhn, 2005; Leitao, 2000; Santos & Santos, 1999). Studying the cognitive load that is associated with such integration is theoretically important as there are varieties of pedagogical goals associated with studying argumentation. Some researchers study argumentation by focusing on its dialogical dimension (Baker, 2002; Felton, 2004; Kuhn & Udell, 2007; Rips, 1998) others focus on the importance of argumentation in decision making (Amgoud & Prade, 2006; Freeley & Steinberg, 2000), in social activity (Willard, 1983), in persuasion (Bench-Capon, 2003; Pasquier, Rahwan, Dignum & Sonenberg, 2003), in problem solving (Veerman & Treasure, 1999), in knowledge building (Leitão, 2000), and in essay writing (Coirier et al., 1999; Eemeren & Grootendorst, 1999; Nussbaum, 2008; Nussbaum & Schraw, 2007). Learning the load that these integration strategies impose on learners' working memory can help facilitate and promote studying these other pedagogical goals. This study also adds to Nussbaum and Schraw's (2007) argument-counterargument integration framework by showing how some integration strategies are more demanding than others.

Moreover, the present study represents an attempt to interrelate the two concepts of cognitive load and argumentation processes, providing insights to the nature of reasoning and the nature of working memory functioning. That can increase our knowledge about the way learning and reasoning occurs in the human mind. It is very important to study the cognitive mechanisms that underlie different educational tasks. Research (Case, 1974) suggests that learners' performance on any given task is a function of three constraints: the mental strategy for approaching the task, the demand which the strategy puts on learners' mental capacity, and the learners' available mental capacity.

## Limitations and Further Research

A limitation of the current research study is that the external validity of this study can be affected by the educational level of the participants. The participants of this study were limited to college students, so the study might yield different results if it were to be implemented on different participants. Furthermore, the results of the study reflected students' responses relating to only one discussion question and students might have different opinions about different topics. In addition, one limitation of this study is that the study was conducted with college of education students, who are primarily female.

The study also relied on collecting data through self-reports and rating scale answers. Self reports might have validity problems as participants may give answers that do not represent their real situation in terms of how they think or believe. Self-reports can also bias can affect the results if participants give answers to make a favorable impression on the researchers (Leedy & Ormrod, 2005).

Although the results are consistent with some studies and the study has provided some answers to important questions, there is still need for further research. This study examined the cognitive load of the complexity of students' essays based on integration ability (Nussbaum, 2008; Nussbaum & Edwards, in press; Nussbaum & Schraw, 2007). However, other studies could examine the cognitive load of complexity based on degrees of integration and differentiation as suggested by Suedfeld, Tetlock and Streufert (1992). According to Suedfeld et al. (1992), differentiation refers to the perception of different dimensions of an issue and integration refers to development of conceptual connections among differentiated dimensions.

Further research should examine the relation between complexity and cognitive load when considering students' writing style and language fluency as moderator variables, considering that these variables may affect students' ability to form integrated essays. Writing style and language fluency may affect the complexity score and students' cognitive load in addition to the integrating strategies. Suedfeld et al. (1992) found that complexity scores were correlated with the total number of words, sentence length, and words with more than three syllables.

Further research studies should try to have students generate and construct their own arguments and counterarguments as a response to an analysis question. Then, the cognitive load, in terms of time and mental effort, that is associated with such integration process, including generating arguments, should be measured. In this dissertation study, I provided students with the arguments and counterarguments that represent response for the analysis question. Then students analyzed, evaluated and integrated these arguments and counterarguments and I measured the cognitive load that was associated with the integration process.

Furthermore, cognitive load as a research area holds great potential for psychologists that has yet to be fully discovered. This study focused on the intrinsic cognitive load involved in the integration process. The manner in which information was presented to students was through computers. Further research can examine if using computers caused any extraneous load on learners working memory that affected their performance. Research shows that extraneous load can be varied based on the manner in which information is presented (Clark et al., 2006; Paas et al., 2003a; Paas et al., 2003b; Van Merrienboer & Sweller, 2005).

Furthermore, more research is needed to examine the cognitive load of integration strategies with an attempt to control subject variables. In this study, I was able to control for participants' tendency to put forth cognitive effort by applying the need for cognition scale. Need for cognition represents cognitive motivation rather than intellectual ability (Dwyer, 2008). However, there are some other subject characteristics that represent casual factors that may affect cognitive load that a learner might experience when performing tasks such as cognitive abilities, age, cognitive style, and prior knowledge (Pass, 1992; Pass & Merrienboer, 1994; Pass et al., 2003 b).

These factors also might be related to working memory capacity and germane/useful load that a learner directs into learning task. Sweller (2010) emphasizes that germane cognitive load is related to learners' characteristics, illustrating that germane cognitive load is a function of the working memory resources that a learner dedicates to the interacting elements that cause intrinsic cognitive load of a task.

Lastly, further research studies should examine if thinking and arguing about different topics or issues can lead to different amount of intrinsic cognitive load. That can happen by measuring and comparing the cognitive load that is associated with different analysis questions for the same group of participants. The same individuals may think differently about different issues and questions. Baron (1988) revealed that individuals think more complexly (higher integrative complexity) when they have conflicting goals and values.

## General Discussion and Educational Implications

According to CLT, the cognitive load that a learner goes through during learning is caused by a combination of extraneous load, which is imposed by design of the instructional materials, and intrinsic load, which is imposed by the complexity of a domain or a task (Kester, Lehnen, Van Gerven & Kirschner, 2006; Sweller, 1988; Sweller & Chandler, 1994). One thing shown in this dissertation study is the complexity of thinking as represented by the weighing strategy is positively associated with intrinsic cognitive load as I measured by the cognitive load rating scale and time.

Cognitive load theory (CLT) (Sweller, 1988; Sweller & Chandler, 1994; Sweller, Van Merrienboer & Paas, 1998; Van Merrienboer & Sweller, 2005) is concerned with the way limited cognitive resources are used during learning tasks. From a practical standpoint, CLT enables us to understand how to apply working memory theory to the design of instruction (Bruning et al., 2004). The findings of this study suggest that students experience more cognitive load as represented by time and mental effort, educators should be aware of this kind of load when designing instructional activities that foster argumentation integration strategies and critical thinking. Weighing refutations strategy may require more scaffolding than constructing design claims strategy. Consideration of the costs and benefits of each side in weighing strategy may require more scaffolding. That is also suggested by Nussbaum and Edwards (in press). To that end, the findings of this study help in providing theoretical insight into the cognitive processes involved in using these strategies to develop critical thinking. That will guide the instructional efforts on how best to teach these strategies effectively.

Teaching teachers about the cognitive load of argument-counterargument integration is very important. Argumentation is considered a "path of knowing" (Kuhn, 2005) and related to many educational constructs. Argumentation showed direct relations with self explanation and elaboration (Chi, 2000; Chi, Bassok, Lewis, Reimann & Glaser, 1989; Lund, Molinar, Sejourne & Baker, 2007), scientific reasoning (Naylor et al., 2007; Nussbaum, Sinatra & Poliquin, 2008; Osborne, Erduran, Simon 2004; Simon, 2008), intrinsic motivation (Chinn, 2006) and critical thinking and reasoning (Kuhn,1991; Voss & Means, 1991). For these reasons, there is agreement that helping students learn how to argue about knowledge is vital for learning. Argumentation can help students to make meaning of what they learn in school through presenting and discussing their ideas and perspectives (Chinn, 2006).

For instructional design, teachers should distinguish the cases that require employing graphic organizers rather than text or linear lists. The design of graphic organizers takes time and effort from teachers or instructional designers. Teachers should know the right circumstances that using graphic organizers can be efficient.  In this study, a linear list may have helped students as much as the vee diagrams in reducing students' cognitive load. I attributed that result to the shortness and the organization of the linear list (Alvermann, 1986 as cited in Robinson & Kiewra, 1995; Holley & Dansereau, 1984). Therefore, graphic organizers might be more helpful in reducing students' cognitive load with longer and more complex materials that contain numerous concepts and facts. However, if content is short and well organized, it can be enough for achieving the instruction goal.

In sum, modern psychology has treated thinking as problem solving. However, "a concept of thinking that has argument as its core has in fact existed for  a very long time-much longer than psychology itself" (Kuhn,1992. p. 2). This study linked cognitive psychology and critical thinking, especially cognitive load theory with argument-counterargument integration. Focusing on working memory limitations as a defining aspect of cognitive load theory, the findings of this study support the notion that working memory capacity affects performance on reasoning tasks. In particular, cognitive load, in terms of time and mental effort that participants experienced, was different between the two argument-counterargument strategies that I examined in this study: weighing refutation strategy and constructing a design claim strategy. The study also examined the impact of utilizing graphic organizers on learners' cognitive load. The findings of this study have theoretical significance in addition to implications for educational practice. Educators should consider the intrinsic cognitive load when trying to develop instructional techniques for teaching critical thinking strategies such as weighing refutations and constructing a design claim.

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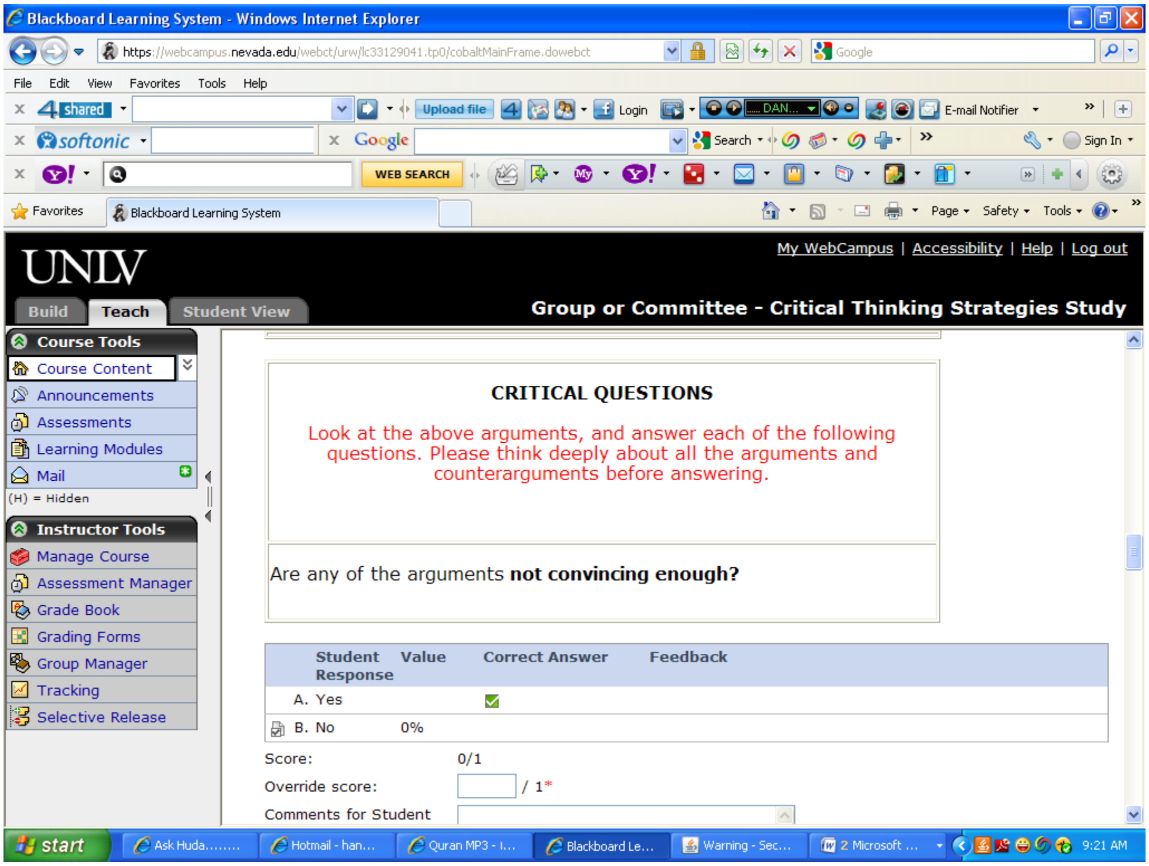
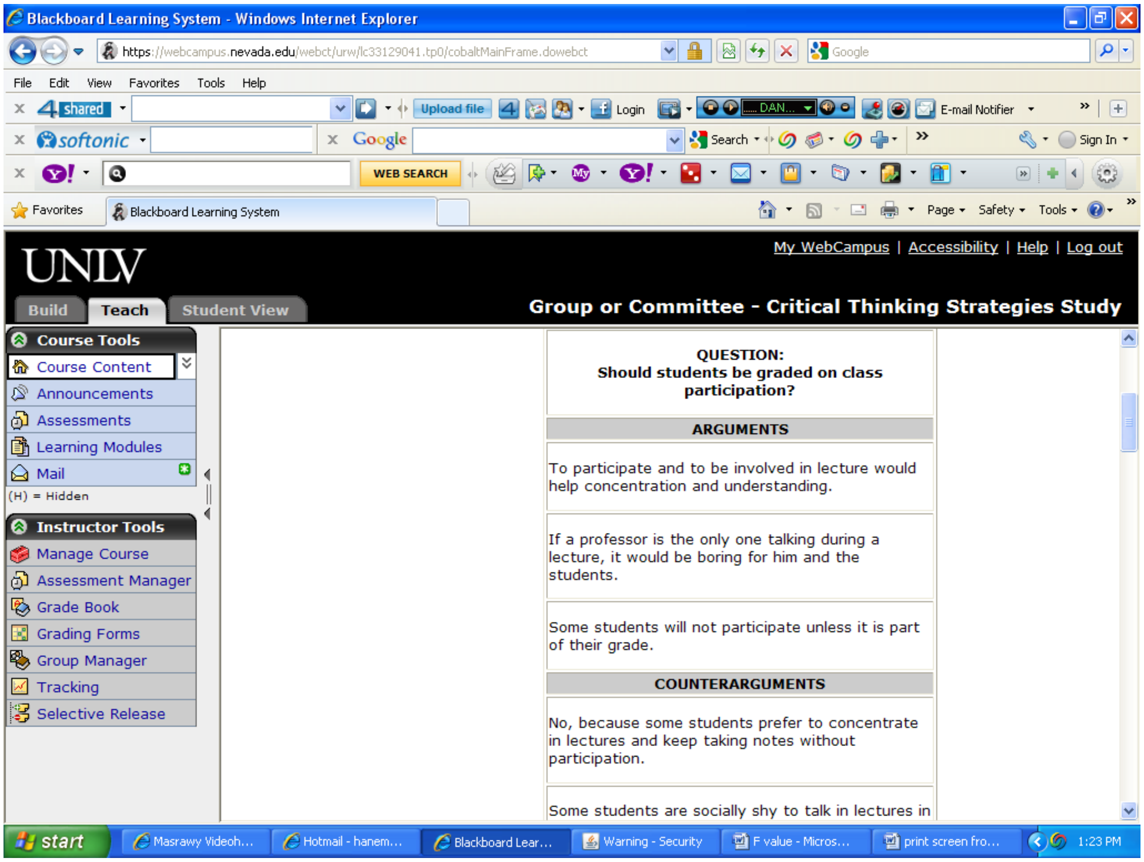
APPENDIX A

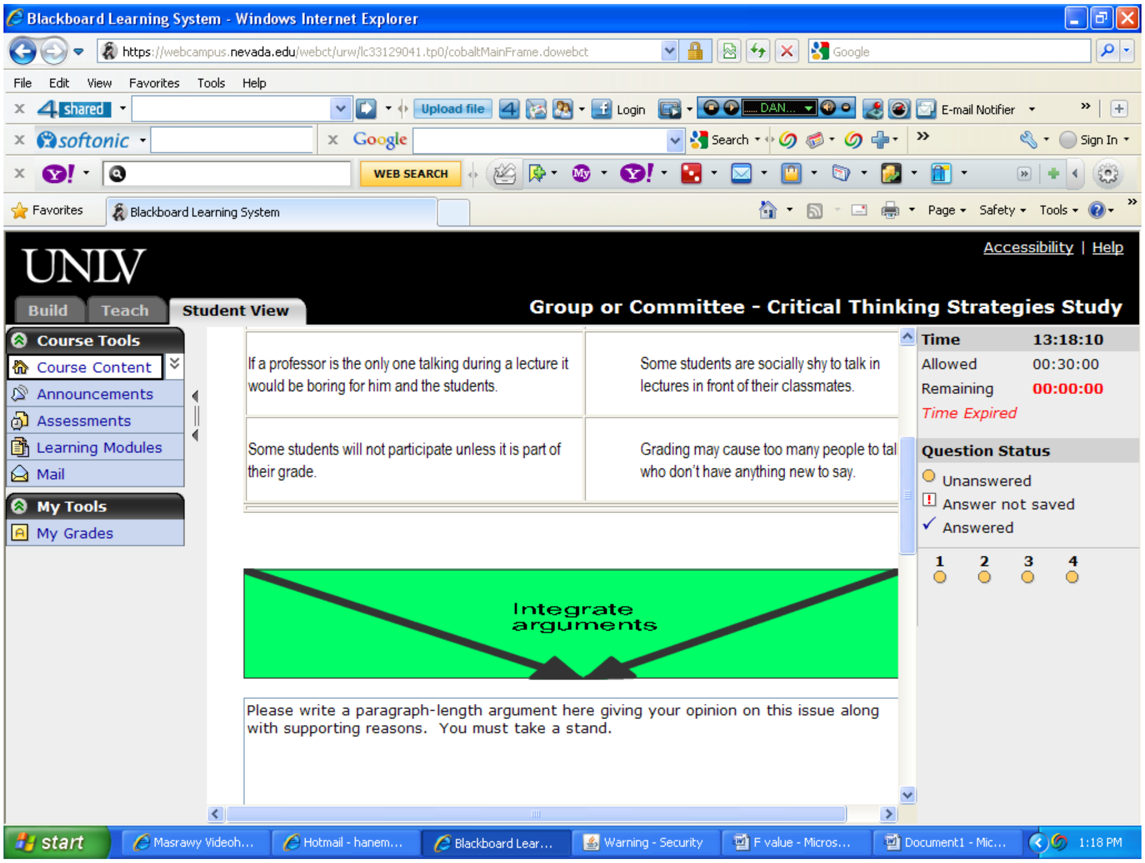
PICTURES FROM WEBCAMPUS




(*Appendix continues*)




*(Appendix continues)*



Blackboard Learning System - Windows Internet Explorer
UNLV
Accessibility | Help
Build
Teach
Student View
Group or Committee - Critical Thinking Strategies Study
Course Tools
Course Content
Announcements
Assessments
Learning Modules
Mail
My Tools
My Grades
If a professor is the only one talking during a lecture it would be boring for him and the students.
Some students are socially shy to talk in lectures in front of their classmates.
Some students will not participate unless it is part of their grade.
Grading may cause too many people to tal who don't have anything new to say.
Integrate arguments
Please write a paragraph-length argument here giving your opinion on this issue along with supporting reasons. You must take a stand.
Time 13:18:10
Allowed 00:30:00
Remaining 00:00:00
Time Expired
Question Status
Unanswered
Answer not saved
Answered
1 2 3 4

APPENDIX B

DEMOGRAPHIC SURVEY

Code No.________

Please complete the following demographic questions. Recall that all instruments are identified by number only and your complete confidentiality is assured.

1.What is your age? __________

2.What is your gender? Circle one. FEMALE MALE

3.Place a check next to the ethnicity listed below which best represents how you identify yourself:

_____ American Indian/Alaskan Native

_____ Asian/Asian American

_____ African American/Black

_____ Caucasian/White

_____ Hispanic/Latino/Chicano

_____ Other:______________

4.Circle your year in college: FRESHMAN SOPHOMORE JUNIOR SENIOR (GRADUATE STUDENT)

5.What is your college program/major? ______________________________

What is your current G.P.A.? ________

6.Do you intend to pursue a teaching certification? Circle one. YES NO

APPENDIX C

NEED FOR COGNITION SCALE (CACIOPPO, PETTY, & KAO, 1984)

Instructions: For each of the statements below, please indicate to what extent the statement is characteristic of you. Please use the following scale:

1=extremely uncharacteristic of you (not at all like you)

2=somewhat uncharacteristic

3=uncertain

4=somewhat characteristic

5=extremely characteristic of you (very much like you)

1. I would prefer complex to simple problems.
2. I like to have the responsibility of handling a situation that requires a lot of thinking.
3. Thinking is not my idea of fun.
4. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities
5. I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something.
6. I find satisfaction in deliberating hard and for long hours.
7. I only think as hard as I have to.
8. I prefer to think about small, daily projects than long-term ones.
9. I like tasks that require little thought once I've learned them.

(*Appendix continues)*

10. The idea of relying on thought to make my way to the top appeals to me.
11. I really enjoy a task that involves coming up with new solutions to problems.
12. Learning new ways to think doesn't excite me very much.
13. I prefer my life to be filled with puzzles that I must solve.
14. The notion of thinking abstractly is appealing to me.
15. I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.
16. I feel relief rather than satisfaction after completing a task that required a lot of mental effort.
17. It's enough for me that something gets the job done; I don't care how or why it works.
18. I usually end up deliberating about issues even when they do not affect me personally.

APPENDIX D

COGNITIVE LOAD RATING SCALE

THE PAAS (1992) COGNITIVE LOAD RATING SCALE

In writing my opinion using the preceding strategy I invested

1. Very, very low mental effort
2. Very low mental effort
3. Low mental effort
4. Rather low mental effort
5. Neither low nor high mental effort
6. Rather high mental effort
7. High mental effort
8. Very high mental effort
9. Very, very high mental effort

Paas, F. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive-load approach. *Journal of Educational Psychology*, *84*, 429-434.

Paas, F., Tuovinen, J., Tabbers, H., & Van Gerven, P.W.M. (2003b). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist, 38*, 63-71.

# APPENDIX E

## WEBCAMAPUS INSTRUCTION FOR TIME MEASURE

Students received instructions as follows:

The questions for this assessment will be presented to you one at a time.

Once a question has been answered or skipped, it cannot be revisited.

How long do you have to complete the assessment?

Your completion time is measured from when you click begin assessment to when you click finish. Question delivery: one at a time-no revisits and questions must be answered in the order given. Questions can be skipped; but once a question has been answered or skipped, it cannot be revisited. You have 30 Minute (s) to complete the assessment.

Note: your completion time is measured from when you click Begin Assessment to when you click Finish. Once the allotted time has expired, you may not be able to save any more questions, or, quizzes.

## APPENDIX F

## LINEAR LIST

Analysis Question: Should students be graded on class participation?

*Arguments,*

- To participate and to be involved in lecture would help concentration and understanding.
- If a professor is the only one talking during a lecture it would be boring for him/her and students.
- Many students will not participate unless it is part of their grade.

*Counterarguments*

- No, because some students prefer to concentrate in lectures and keep taking notes without participation.
- Some students are socially shy to talk in lectures in front of their classmates.
- Grading may cause too many people to talk who don't have anything new to say.
- *Integrate*

1- For weighing strategy: Are any of the arguments not as important as others? Are any of the arguments unlikely? Using your answers, explain why one side is stronger (and the other side is weaker)? Keep thinking about which arguments may be more or less important (or convincing) than those on the other side. Please write a paragraph-length argument explaining why arguments on one side of the issue are stronger (and the other side weaker). You must take a stand.

(*Appendix continues)*

2- For constructing design claims (synthesizing): Can you design a solution to any of the problems cited in the counterarguments? Is the creative solution practical? (Consider costs.). Please write a paragraph-length argument explaining why students should be graded for class participation, and how this can be done effectively.

3- For control group: Please write a paragraph-length argument here giving your opinion on this issue along with supporting reasons. You must take a stand

APPENDIX G

RECRUITMENT LETTER

In this study, you will participate in evaluating some arguments and counterarguments on an educational policy issue. You will be asked to read some various arguments, write several paragraphs, and complete some surveys on thinking patterns. This is an online study (conducted through WebCampus and the study is expected to require 30 to 60 minutes of your time.

It is worth one research credit. Participants must have had some previous experience taking exams in WebCampus. To participate in the study, you must do all of the following: Sign up through this Experiment Management System to participate in the experiment. Right after you sign up, email Ms. Hanem Shehab (at hanemshehab@hotmail.com), giving your name and WebCampus login (so that we may enroll you in the WebCampus section). ALLOW SUFFICIENT TIME FOR YOU TO BE ABLE TO COMPLETE THE STUDY BY FEBRUARY 15, 2010.

Anytime after you receive the information from Ms. Shehab go to the link she has provided and complete Part 1 and Part 2 of the study. For purposes of the study, each week starts on Monday and closes on Sunday (midnight).

APPENDIX H

COMPONENT SCORES RUBRIC FOR ESSAYS

A. Reasons that support one side of the issue (saying why this side is more convincing.)
B. Weighing refutations (saying that one side is more important than another, or one outcome is more likely than another, or that some outcome is not that important.)
C. Design claims (offering a claim regarding how a solution should be designed.
D. Reasons for design claims (reasons that justify the solution designed.)
E. Other side reasons (reasons that support the other side) (saying why this side is more convincing.)

Note: The different categories reflect different variables.

# APPENDIX I

## RUBRIC FOR WEIGHING REFUTATION COMPLEXITY

| Score | Criteria |
|---|---|
| 3 | Explicitly identified two values and says one is more important than the other (for example, a little discomfort from speaking is not as important as learning). |
| 2 | Refutes an argument by introducing a new condition, constraint, relationship, consequence or consideration that makes one side less (or more) likely or important. Or may deny the truth or applicability of a premise by providing a good reason. |
| 1 | (Also indicate which of the following apply, you may select more than one)________ |
| | a--Denies an argument but with no or weak support (for example may overgeneralize from personal experience). |
| | b--Brief or unclear. |
| | c--May generalize about the reasons on one side but without being very specific. |
| | d—makes a pseudocontrast that reflects only the presence or absence of one attribute (e.g., classes can be engaging or boring) rather than weighing two different attributes (e.g., engagement versus fear of speaking). |

APPENDIX J

RUBRIC FOR DESIGN CLAIMS COMPLEXITY

| Score | Criteria |
|---|---|
| 4 | Design claim more than simple and brief and addresses one or more of the given counterarguments. |
| 3 | A reason is given to justify the design claim but does not address a given counterargument (or the given counterargument mentioned very briefly). Reasons that are positive consequences (or prevention of negative consequences) would fall into this category.<br>The design claim is more than "simple and brief" (more than a half sentence), OR<br>The design claim is simple and brief but addresses a given counterargument. |
| 2 | A contrast is made to implicitly justify the design claim[a] (no supporting reasons), OR<br>The design claim is simple and brief but has a supporting reason. |
| 1 | Design claim with no justifying reasons or contrast. Does not address any counterarguments. |

[a]A contrast gives an opposing situation. Example of contrast: "Don't make the entire grade dependent on participation, just a small portion of it."

TABLES

Table 1

*Summary of the Variables of the Study*

| Variable Type | Variable |
|---|---|
| Independent (treatment) variables | Two argument-counterargument integration strategies versus a control.<br>AVDs versus a linear text. |
| Dependent variables | Mental effort scale<br>Time to complete task |
| Control variables | Need for cognition<br>Argument complexity |

Table 2

*Means and Standard Deviations of Variables Used in Statistical Analysis (N = 285)*

| Variable | M | SD | Skewness | Kurtosis |
|---|---|---|---|---|
| Mental Effort | 5.33 | 1.38 | -0.37 | 1.02 |
| Time through Integration[a] | 565.46 | 293.77 | 1.44 | 2.43 |
| Time through Integration- log | 2.70 | 0.21 | 0.04 | 0.06 |
| Need for Cognition | 59.90 | 0.53 | -0.28 | 0.21 |
| Weighing Refutation | 0.31 | 0.64 | 2.17 | 4.47 |
| Complexity of Weighing Ref. | 0.48 | 1.07 | 2.79 | 9.01 |
| Reasons | 1.59 | 0.94 | 0.05 | -0.82 |
| Design Claims | 0.32 | 0.53 | 1.40 | 1.03 |
| Complexity of Design Claim | .78 | 1.45 | 2.11 | 4.54 |
| Reasons of Design Claims | 0.13 | 0.43 | 5.50 | 27.60 |
| Other Side Reasons | 0.11 | 0.32 | 2.50 | 4.10 |

*[a]Time in seconds.

Table 3

*Between Rater Correlations and Agreement for the Argument Complexity Variables*

| Variable | Agreement |
|---|---|
| Reasons | 0.58 |
| Other Side Reasons | 0.74 |
| Design Claim | 0.85 |
| Reasons for Design Claim | 0.88 |
| Weighing Refutation | 0.72 |

Table 4

*Analysis of Variance of Argument Variables by Condition*

| Source | *df* | *F* | $\eta^2$ | *p* |
|---|---|---|---|---|
| | | Reasons | | |
| Strategies | 2 | 3.39* | .02 | .04 |
| AVD | 1 | 0.02 | .00 | .89 |
| Strategies *AVDs | 2 | 0.48 | .003 | .62 |
| Error | 278 | (0.88) | | |
| | | Weighing Refutations | | |
| Strategies | 2 | 35.98** | .21 | .00 |
| AVD | 1 | 1.12 | .004 | .29 |
| Strategies * AVDs | 2 | 0.25 | .002 | .78 |
| Error | 278 | (0.94) | | |
| | | Design Claims | | |
| Strategies | 2 | 81.90** | .37 | .00 |
| AVD | 1 | 0.12 | .00 | .73 |
| Strategies *AVDs | 2 | 2.71 | .02 | .07 |
| Error | 278 | (0.18) | | |
| | | Reasons for Design Claims | | |
| Strategies | 2 | 24.17** | .15 | .00 |
| AVD | 1 | 1.17 | .004 | .28 |
| Strategies * AVDs | 2 | 2.29 | .02 | .10 |
| Error | 278 | (0.16) | | |

*(Table continues)*

| | | | | |
|---|---|---|---|---|
| | | Other Side Reasons | | |
| Strategies | 2 | 1.20 | .009 | .30 |
| AVD | 1 | 3.09 | .01 | .08 |
| Strategies *AVDs | 2 | 0.23 | .002 | .79 |
| Error | 278 | (0.10) | | |

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

*$p < .05$. **$p < .01$.

Table 5

*Marginal Means of Argument Variables by Strategy Conditions*

| Variable (2,278) | Control Condition | Design Claim Condition | Weighing Refutation Condition | F |
|---|---|---|---|---|
| Reasons | 1.78 | 1.43 | 1.54 | 3.39* |
| Weighing Refutation | 0.13 | 0.09 | 0.72[ab] | 35.98** |
| Design Claims | 0.18 | 0.78[a] | 0.02[ab] | 81.90** |
| Reasons of Design Claims | 0.02 | 0.37[a] | 0.01[b] | 24.17** |
| Other Side Reasons | 0.13 | 0 .07 | 0.13 | 1.20 |

[a]Significantly different from control condition at $p < .01$ level (LSD).

[b]Significantly different from design claim condition at $p < .01$ level (LSD).

$*p < .05$. $**p < .01$.

Table 6

*Analysis of Variance of Cognitive Load Measures by Condition*

| Source | *df* | *F* | $\eta^2$ | *p* |
|---|---|---|---|---|
| | | Mental effort | | |
| Strategies | 2 | 1.40 | .01 | .25 |
| AVDs | 1 | 0.05 | .00 | .82 |
| Strategies* AVDs | 2 | 0.02 | .00 | .98 |
| Error | 277 | (1.80) | | |
| | | Time (Log) | | |
| Strategies | 2 | 27.34 | .17 | .00** |
| AVDs | 1 | 0.03 | .00 | .87 |
| Strategies * AVDs | 2 | 0.66 | .005 | .52 |
| Error | 277 | (0.04) | | |

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

**$p$ < .01.

Table 7

*Main Effects of Complexity Score of Weighing Refutations and Design Claim on Cognitive Load Variables (N = 285)*

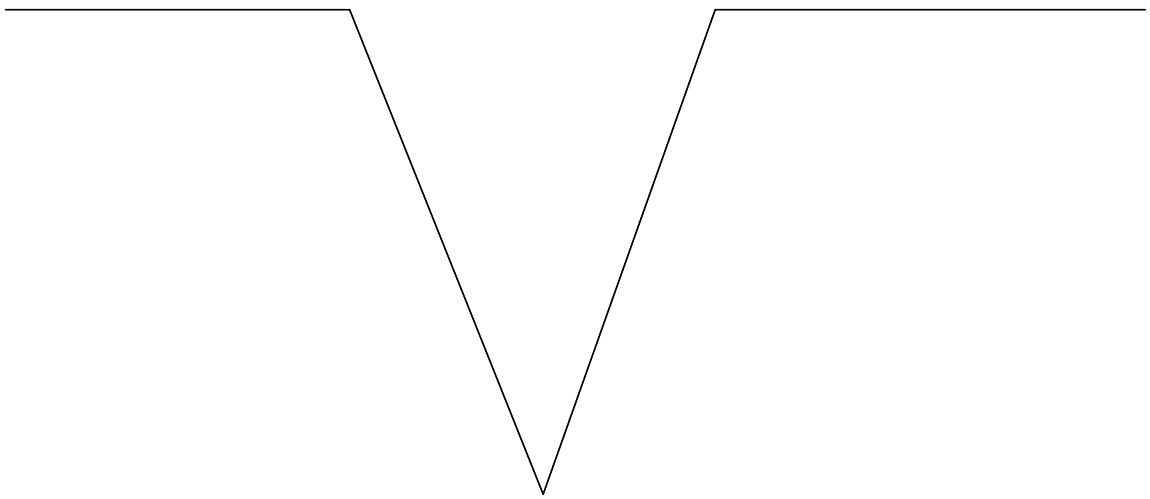
| | Mental Effort | | Time (Log) | |
|---|---|---|---|---|
| Complexity Score | F (1, 280) | $\eta^2$ | F (1, 280) | $\eta^2$ |
| Weighing Refutation | 9.09** | .03 | 30.96** | .10 |
| Design Claim | 0.22 | .001 | 8.02** | .03 |

[a]Time through integration-log

**p* < .05. ***p* < .01.

**Fig. 1 Graphic Organizer (AVD)**

**ARGUMENTS** **QUESTION** **COUNTERARGUMENTS**



**CRITICAL QUESTIONS**

Look at all the above arguments, and answer each of the following questions?

| | **Circle Yes or No** | **Which Argument?** |
|---|---|---|
| Are any of the arguments<br><br>**not as important** as others? | Yes No | |
| Are any of the arguments **unlikely?** | Yes No | |
| Is there a **creative solution** to any problem raised? | Yes No | |
| Is the creative solution **practical**? (Consider costs.) | Yes No | |
| For any argument, can you think of any **examples to the contrary?** Or **other likely explanations?** | *Yes* *No* | |

**INTEGRATE**

Using your answers, explain why is one side stronger (and the other side is weaker)?

**Fig. 2 Weighing Strategy**

| ARGUMENTS | QUESTION | COUNTERARGUMENT |
|---|---|---|
| To participate and to be involved in lecture would help concentration and understanding | Should students be graded on class participation? | No, because some students prefer to concentrate in lectures and keep taking notes without participation |
| If a professor is the only one talking during a lecture, it would be boring for him/her and students | | Some students are socially shy to talk in lectures in front of their classmates |
| Many students will not participate unless it is part of their grade | | Grading may cause too many people to talk who don't have anything new to say. |

**CRITICAL QUESTIONS**

Look at all the above arguments, and answer each of the following questions?

| | Circle YES or NO | | Which Argument**?** **Explain** |
|---|---|---|---|
| Are any of the arguments on one side more important than those on the other side? | Yes | No | |
| Are any of the arguments not convincing enough? Explain**.** | Yes | No | |

*(Figure continues on next page.)*

## INTEGRATE

Please keep thinking about which arguments may be more or less important (or convincing) than those on the other side. Please write a paragraph-length argument explaining why arguments on one side of the issue are stronger (and the other side weaker).

**Fig. 3 Design Claim Strategy**

| ARGUMENTS | QUESTION | COUNTERARGUMENT |
|---|---|---|
| To participate and to be involved in lecture would help concentration and understanding | Should students be graded on class participation? | No, because some students prefer to concentrate in lectures and keep taking notes without participation |
| If a professor is the only one talking during a lecture, it would be boring for him/her and students | | Some students are socially shy to talk in lectures in front of their classmates |
| Many students will not participate unless it is part of their grade | | Grading may cause too many people to talk who don't have anything new to say. |

**CRITICAL QUESTIONS**

Look at all the above arguments, and answer each of the following questions?

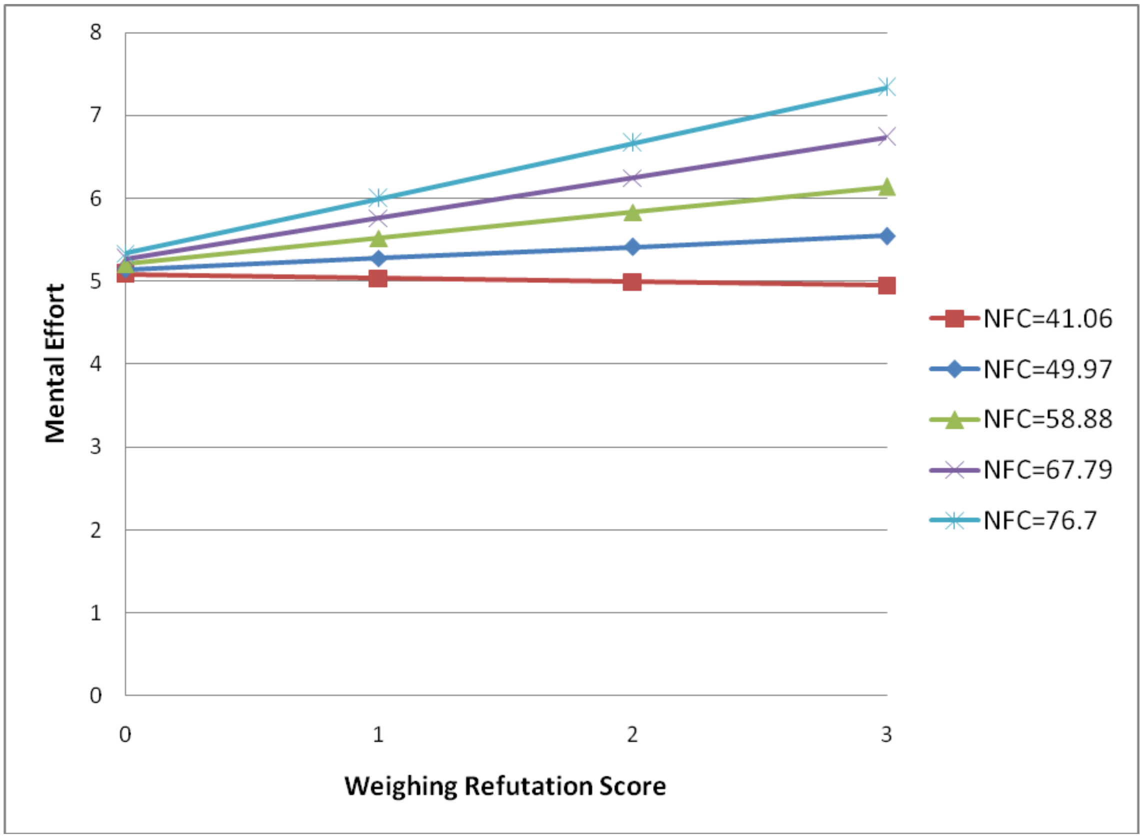
| | **Circle YES or NO** | | **Which Argument? Explain** |
|---|---|---|---|
| Do you have any ideas that would alleviate the problems mentioned in the counterarguments? | Yes | No | |
| Are your ideas practical? (Consider costs.) | Yes | No | |

*(Figure continues on next page.)*

## INTEGRATE

Please write a paragraph-length argument explaining why students should be graded for class participation, and how this can be done effectively.

**Fig.4.** Relationship of mental effort, need for cognition, & weighing refutation score. The lines for the different NFC levels reflect the mean NFC score (58.88), one SD above or below the mean (49.97 and 67.79) and two SDs above or below the mean (41.06 and 76.7).



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