COMPARING NOTE TAKING AND TEST PERFORMANCE

IN METHODS AND MODES OF NOTE TAKING CONDITIONS

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Table of Contents

List of Tables

CHAPTER I

INTRODUCTION

Lecture is a common instructional method for many educators (Wirt & Livingston, 2001), and note taking has been found to be an effective means for supporting learning during lecture (DiVesta & Gray, 1972: Kiewra & Frank, 1988; Peper & Mayer, 1978; Williams et al., 2013). However, researchers have found that students are poor note takers, and many only grasp around 25% of relevant lecture material (Boyle, 2010; O'Donnell & Dansereau, 1993). For this reason, more research is needed on the topic of note taking to establish note taking interventions.

The Functions of Note Taking

The literature supports two primary theories for why note taking increases student retention of lecture content (Di Vesta & Gray, 1972). The first manner in which students may benefit from the process of note taking is through the improved encoding of the lecture content. This perspective proposes that the actual act of note taking enhances understanding of lecture material. The second function of note taking is external storage, in which students benefit from having material to review after the lecture. However, it has been suggested that students learn most efficiently when engaging in both functions (Annis & Davis, 1975; Kiewra, et al., 1991).

Encoding. The function of encoding can be measured by comparing the recall of students who take notes during lecture to students who listen, but do not take notes, during lecture (Barnett, Divesta, & Rogozinski, 1981). Although the encoding function has a strong theoretical background, several studies have failed to capture significant differences between notes and no notes groups (Hartley, 1983; Kiewra, 1985) or find small effect sizes for note taking (Henk & Stahl, 1985; Kobayashi, 2005). Kobayashi (2005) stated that the mechanical demands of note taking, wide variety of outcome measures, and publication characteristics may explain the modest effect sizes of note taking.

External storage. The external storage function of note taking posits that having notes for later review helps students learn lecture information. By reviewing their notes after the lecture, students are presenting themselves with additional opportunities for encoding the information. To test the external storage hypothesis, Kiewra, DuBois, Christian and McShane (1988) had participants watch a video lecture without taking notes, then had them review in one of four conditions: complete text, linear outline, matrix outline, or mental review. This study emphasized the role of the function of external storage as the participants in the three review material groups outperformed the mental review group.

Integrative hypothesis. Other researchers have posited that there is a synergistic effect of the two functions of note taking. In one study, students who took notes and reviewed their notes outperformed students who took notes yet did not review them and students who did not take notes, but reviewed borrowed notes (Kiewra, Dubois, Christian, McShane, Meyerhoffer, & Roskelley, 1991). Annis and Davis (1975) found similar results when comparing seven note taking conditions. They indicated that a combination of taking notes and reviewing those notes or the instructor's notes is the most important characteristic for success.

Cognitive Representations for Note Taking Processes

Despite the general view that note taking is a positive student behavior that should promote content mastery, it is apparent that student note taking skills are often substandard. In particular, students often fail to record correct and personally meaningful notes (Kiewra & Benton, 1988; Kiewra, Benton & Lewis, 1987). Researchers have reported that students fail to take accurate notes because note taking requires multitasking (Piolat, Olive, & Kellogg, 2005).

These tasks include focusing on lecture content, extracting key points, and recording them while remaining focused on the presented material (Peverly et al., 2007; Piolat et al., 2005).

Methods of Note Taking

Two main methods of note taking include self-generated notes and guided notes. Guided notes are provided to students before the lecture and consist of an outline of lecture material with blanks for students to add their own notes. Self-generated notes are developed solely by the student. The literature presents mixed findings when considering which method produces the best performance (Kiewra, 1991; Larwin & Larwin, 2013; Neef, McCord, & Ferreri, 2006; Peverly et al., 2013; Williams, Weil, & Porter, 2012).

Guided notes. As note taking while attending to lecture is thought to be a cognitively demanding skill (Barbetta & Skaruppa, 1995; Kiewra & Benton, 1998; Kiewra et al., 1987; Piolat et al., 2005), some instructors provide students with the organizational structure of the lecture through guided notes. Cognitive Load Theory states that working memory is limited in capacity and when working memory is full, the learner can no longer comprehend incoming information (Sweller, Van Merrienboer, & Paas, 1998). In theory, the guided notes will reduce the cognitive demand of the note taking process by offering students the correct sequential order of the material as well as pinpointing the major topics. Researchers outline many theoretical benefits of guided notes, including that students are more easily able to select key points (Austin, Lee Thibeault, Carr, & Bailey, 2002; Neef et al., 2006) and are able to spend more time reflecting on presented material (Barbetta & Scaruppa, 1995).

There is also empirical evidence that supports the use of guided notes during lecture. Guided notes are related to an increase in total number of notes taken (Kiewra, 1991), and increased test scores (Larwin & Larwin, 2013; Peverly et al., 2013; Williams et al., 2012), and the quality of notes (Austin, Lee, & Carr, 2004). When students are provided with guided notes, they do not have to spend cognitive effort on determining the structure and key points of the lecture. In this way, students are better able to concentrate on the lecture material and guided notes reduce the number of lecture content that needs to be transcribed (Austin, et al., 2002; Neef et al., 2006).

Guided notes have also been linked to an improvement in self-regulatory processes. In one study, students who were supplied with lecture outlines spent more time studying for and scored higher on a lecture test than students who only listened to the lecture (Northcraft & Jernstedt, 1975). Finally, students seem to prefer guided notes over traditional note taking procedures (Austin et al. , 2002).

Self-generated notes. Educators who do not provide guided notes before a lecture may worry that the guided notes inhibit students from taking their own personally meaningful self-generated notes. Self-generated notes may encourage students to engage in deeper processing by increasing the required amount of germane cognitive load (Baddeley, 2012; Sweller, et al., 1998).

Self-generated note taking is also consistent with Wittrock's Generative Learning Model (Wittrock, 1990) that states that learning happens when individuals connect prior knowledge to new material. Self-generative notes may give students greater control over the note taking process, thereby, providing them with more chances to connect their prior experience to lecture content. Self-generated learning may allow students greater opportunities for drawing pictures or graphs, developing summaries, and creating examples. Learners may use note taking to engage in active processing of course content. One study found that students who took notes recalled more underlying concepts than students in a no notes condition, and that students in the no notes group produced more vague summaries than note takers (Peper & Mayer, 1978). This suggests that through note taking, students may connect new information to known information while listeners are more likely to encode item-specific concepts.

Mayer's Cognitive Theory of Multimedia Learning asserts that stimuli are processed through both visual and auditory channels and that individuals learn most efficiently when the learner makes connections between words and pictures (Mayer, 2005). Self-generated note taking gives students the opportunity to make their own visual aids to lecture material such as concept maps, flow charts, and pictures. In short, self-generated note takers are not bound to the structure of a pre-made outline.

When considering Craik and Lockhart's Depth of Processing, note takers can take notes that represent shallow processing as well as notes that represent deep processing. An example of shallow processing may be verbatim note taking while deeper processing would require summarizing and paraphrasing (Bretzing & Kulhavy, 1979). Not surprisingly, researchers found that students in summarizing and paraphrasing conditions outscored students in a verbatim notes condition on a quiz of content material (Bretzing & Kulhavy, 1979).

Modes of Note Taking

Another consideration that may impact the educational outcomes of students is their mode of note taking. There are many modes of note taking, but the current study examines note taking on computers and handwritten notes. Similar to the methods of note taking, both modes of note taking have theoretical support, and research has yet to determine a clear frontrunner for learning.

Handwritten notes. Most of the prevailing literature on note taking investigates handwritten notes. Students who take handwritten notes outperform students who only listen to the lecture on outcome measures (DiVesta & Gray, 1972; Kiewra & Benton, 1988; Peper & Mayer, 1978; Williams et al., 2013). When compared to taking notes on a computer, students generally prefer to take lecture notes by hand (Steimle, Brdiczka, & Muhlhauser, 2009). However, students who are proficient typists can type faster than they can write (Brown, 1988; Weintraub, Gilmour, & Weiss 2010), a finding that suggests laptops can be used for faster transcription of lecture notes. Finally, students who handwrite notes take less verbatim notes than students who type notes (Muller & Oppenheimer, 2014), suggesting that laptop note takers may engage in less deep processing than students who handwrite their notes.

Note taking on computers. Innovations in technology have led more students to own computers (89%; Smith & Caruso, 2010), and laptops have become the norm at many universities (Weaver & Nilson, 2005). However, students and instructors seem to have different opinions on laptop use in the classroom. Many instructors believe that students become distracted by mobile technology (Sharples, 2002), and the distraction may also disturb classmates (Fried, 2008). Several studies have supported this theory as students have been found to spend considerable cognitive effort during class time by browsing websites and engaging in online communication (Hembrook & Gay, 2003). Although laptop distractions are a real threat to learning, some researchers have emphasized the importance of integrating laptop use into the lecture (Kay & Lauricella, 2011), whereas others have suggested creating "laptop-free zones" within the classroom (Aguilar-Roca, Williams, & O'Dowd, 2012).

As laptop note taking is a more recent phenomenon, less research has been performed on the topic. However, it seems that the research that has been done bolsters the instructor's view that laptops commonly serve as a distraction. In an experiment by Sana and colleagues (2013) students in a multi-task condition performed 11% lower on a test than a regular typed notes condition. In a follow-up experiment students who sat behind laptop multi-taskers performed 17% lower than students who viewed a lecture and did not sit behind a laptop multi-tasker.

In a series of studies by Muller and Oppenheimer (2014), the argument of laptops versus paper and pencil notes was examined. In an initial study, findings revealed that computer note takers took more verbatim notes and a higher quantity of notes than participants in a handwritten notes condition. However, the handwritten notes group outperformed the computer notes group on conceptual application questions. In a second experiment, the researchers provided a simple intervention for verbatim note taking by instructing the participants in a typed notes condition to take notes in their own words. They found the intervention to be unsuccessful in improving the participants' ability to take personally meaningful notes.

Purpose of the Study

The purpose of the current study was to investigate the impact of varied methods and modes of note taking on student retention of lecture material and student note taking behavior. Specifically, the current study examined two primary research questions focused on examining differential performance outcomes based on note taking.

RQ1: Does note taking method impact note taking behavior and performance?

Based on the mixed findings literature, there is no definitive frontrunner between guided and self-generated note taking on performance (Kiewra, 1991; Larwin & Larwin, 2013; Neef et al., 2006; Peverly et al., 2013; Williams et al., 2012). Both methods have theoretical foundations. Self-generated note taking may encourage more active processing of material, whereas guided notes may reduce cognitive load.

Previous literature has examined both students who take guided notes and students who take self-generated notes to students who simply listen to a lecture. Both groups of guided note takers and self-generated note takers generally outperform listeners on outcome measures (Kiewra, 1991; Larwin & Larwin, 2013; Neef et al., 2006; Peverly et al., 2013; Williams et al., 2012). Therefore, it was hypothesized that both methods of note taking will outperform listeners on multiple-choice items and short answer items.

RQ2: Does note taking mode impact note taking behavior and performance?

The second research question examined two modes of note taking: typed notes and long hand notes. As computers are becoming more common in education, researchers have recently compared note taking on computers to handwritten notes. Students in the typed notes condition are hypothesized to outperform the handwritten notes group on quantity of notes. This hypothesis corresponds to the existing literature comparing typing to hand writing speed. Individuals who are proficient typists are able to type faster than handwrite (Brown, 1988; Weintraub & Gilmour, 2010).

RQ3: Is there an interaction effect between method and mode of note taking influences note taking behavior and performance?

The third research question merely examines if there was an interactive effect of the two main conditional manipulations (method and mode), such that there was an observed benefit from one of the specific conditions that was not accounted for by one of the main effects. This result would indicate (for example) if guided notes on the computer provided a benefit not observed for guided notes on paper.

CHAPTER II

REVIEW OF THE LITERATURE

Learning through lecture is common at universities. The US Department of Education reported that 83% of post-secondary faculty use lectures as the primary instructional method in at least one of their courses (Wirt & Livingston, 2001). Not surprisingly, teachers frequently design tests from lecture content (Putnam, Deshler& Schumaker, 1993). Just as lecturing is the instructor's primary instructional method; note taking may be the students' most common technique to learn from lecture (Kobayashi, 2005). In a sample of 223 college students, 99% reported that they took lecture notes, and 96% reported that they believe note taking is essential to collegiate success (Palmatier & Bennett, 1974).

As early as 1925, researchers examined the benefits of note taking in academic environments (Crawford). Research regarding note taking and test performance indicates that students who take notes generally outperform students who do not take notes (DiVesta & Gray, 1972; Kiewra & Frank, 1988; Peper & Mayer, 1978; Williams et al., 2013). Rahim and Meon (2013) measured eight study skills and found note taking to have the third strongest correlation with grade point average, behind analytical thinking, problem solving and test taking. Other studies have highlighted the importance of note taking in academic achievement. After reviewing 57 studies of note taking, Kobayashi (2005) found a positive overall effect of note taking compared to listening. This finding is consistent with previous meta-analyses comparing note taking conditions to non-note taking conditions (Henk & Stahl, 1985; Ryan, 1982). One meta-analysis of 57 studies comparing the learning outcomes of these conditions found an effect size (d) of .22, which represents a magnitude between small and medium (Kobayashi, 2005). The finding that recording and reviewing notes is related to test performance has been replicated over the past five decades (Bretzing & Kulhavy, 1981; Fisher & Harris, 1973; Peverly, Brobst, Graham, & Shaw, 2003; Titsworth & Kiewra, 2004).

Although note taking is generally viewed as a fundamental study skill for most learners, many students are poor note takers and do not obtain the anticipated benefit from the act of note taking or note review (Kiewra, 1989). Many students are not aware of their lack of proficiency in note taking; one study found that only 20% of students reported note taking as a difficult task (Mortimore & Crozier, 2006). Reviews of note taking by Kiewra, Benton, and Lewis (1987) demonstrated that most students are merely able to record 25% of relevant lecture content. This finding was replicated by subsequent researchers (Boyle, 2010; O'Donnell & Dansereau, 1993). Students who are poor note takers do not properly select important concepts and content (Boyle, 2010), tend to be incomplete (Kiewra, 1991), and perform poorly on lecture assessments (Laidlaw, Skok, & McLaughlin, 1993).

Functions of Note Taking

The traditional representation of note taking entails two ways in which note taking benefits students. These two explanations for the benefits of note taking have been proposed as developing from promoting either encoding or external storage for essential content (Di Vesta & Gray, 1972). However, examining both functions as in an integrated model may also serve value as the literature documents a synergistic effect when both functions are performed.

Encoding. The encoding perspective on note taking highlights the importance of note taking during lecture; the process of note taking facilitates understanding of the presented material. Proponents of the encoding effect emphasize the learning benefits of note taking through active processing of lecture material and relating the material to prior knowledge (Bretzing & Kulhavy, 1979; Di Vesta & Gray, 1972; Peper & Mayer 1978). Additionally, Di

Vesta and Gray (1972) concluded that the encoding function of learning is the most important function for learning when compared to the external storage function. Howe (1970) agreed by stating that if the main function of note taking was external storage then it would be better to give students premade outlines to allow them to focus on the lecture without writing.

Encoding has been measured by comparing performance of outcome measures of students who take notes during a lecture to students who simply listen to the same lecture – neither group is allotted time to review their notes during assessment (Barnett et al., 1981). Hartley (1983) and Kiewra (1985) examined a combined total of 61 studies investigating the encoding effects of note taking. They noted that 35 of the studies advocated the importance of note taking from the encoding perspective while 23 of the studies did not support the value of that act of note taking. The final three studies actually implied the opposite; listeners outperformed the note taking conditions. The mixed results of studies investigating the functions of note taking may be related to the methods of each study (i.e. lecture length, format of lecture, revision time for notes).

In a study aimed at examining the meaningfulness of encoding students were asked to write notes on a meaningful prose text (Howe, 1970). One week later, the students were asked to recall the material without review. The items recorded in the students' initial set of notes had a 34% chance of being recalled, while items that were not recorded but were present within prose had a 4.7% chance of being recalled. This study provides evidence for the encoding function of note taking as the act of recording important information increased the likelihood that the information would be recalled on performance measure.

In one meta-analysis, Henk and Stahl (1985) gathered 14 studies that compared recall test performance of note taking conditions with listening conditions in lecture settings. They found a small positive mean effect size of 0.34. In a more recent meta-analysis Kobayashi (2005) examined the encoding function of 57 note taking studies and found a mean effect size of 0.22. As the encoding hypothesis has a strong theoretical foundation, Kobayashi outlines several reasons for the modest effect sizes of the meta-analysis and previous studies including the mechanical demands of note taking, type of learning performance measure, and publication characteristics.

External storage. Proponents of the external storage function of note taking state that the benefits of note taking arise from the ability to provide students with information derived from the lecture. This hypothesis is less concerned with the taking notes, and highlights the advantage of having notes for the purpose of later review. Research has documented support for external storage over the encoding function of note taking on both an immediate outcome measure (Fisher & Harris, 1973) and a delayed test (Carter & Van Matre, 1975).

In one study examining the external storage function of note taking, students watched a 19-minute video lecture without taking notes (Kiewra et al., 1988). A week later students returned and either reviewed in four conditions: complete text, linear outline, matrix outline, or mental review. All three groups who reviewed notes outperformed the group that only reviewed mentally on a performance measure. This study provides evidence for the external storage function of note taking as individuals who were provided with review material benefitted during the examination.

Integrative hypothesis. A third framework supports the additive benefit of the combining the functions of note taking. Supporters of this view recognize the benefit from both the process of taking notes and having those notes for later review. Kiewra and colleagues (1991) provided evidence of the additive hypothesis by indicating that students who took notes and reviewed them outperformed students who took notes without review (encoding) and students who listened to the lecture and reviewed borrowed notes.

Additional support comes from research by Annis and Davis (1975) who examined the seven note taking and review conditions in order to determine the importance of encoding and external storage. The seven conditions included: (a) take notes and review own notes, (b) take notes and review lecturer's notes, (c) take notes and mentally review, (d) take notes and review own notes and lecturer's notes, (e) provided with lecturer's notes and review lecturer's notes, (f) provided lecturer's notes and review mentally, (g) no note taking and no review time. Although the sample size was small (n = 85) for having 7 conditions, they found that the most important function for success on an outcome measure was a combination of taking notes (encoding) and reviewing those notes or the instructor's notes (external storage).

Cognitive Representations for Note Taking Processes

The complexity and demandingness of the note taking task may contribute to the observation that students fail to record accurate and personally meaningful notes (Kiewra & Benton, 1988; Kiewra, Benton, & Lewis, 1987). One proposed reason for students' struggle to engage in effective note taking is that it requires them to engage in a number of mental processes simultaneously (Piolat, Olive, & Kellogg, 2005). During note taking, students must attend to lecture content, select key points before information is lost from working memory, record the important concepts, and remain attentive to the lecture (Peverly, Ramaswamy, Brown, Sumowski, Alidoost, & Garner, 2007; Piolat, Olive, & Kellogg, 2005).

Models of working memory. One of the first widely accepted views of memory was Atkinson and Shiffrin's Multi-Store Model (1968). This model divided memory into three components: sensory memory, short term memory, and long term memory. According to the

Multi-Store Model, a stimulus first enters into sensory memory through the senses. Sensory memory has a large capacity, but a short duration of about half a second. If the information in sensory memory is attended to, it may enter short term memory. Short term memory has a limited capacity, a short duration, and stores information so that it may be manipulated. Finally, information in short term memory may be stored in long term memory through elaborative processing (i.e. rehearsal). Long term memory is permanent and is unlimited in capacity. Furthermore, information may return to working memory through the process of retrieval. The Multi-Store Model remains popular, yet many criticisms concerning its validity have developed (Baddeley, 2004; Healy & McNamara, 1996; Loftus & Bamber, 1990; Ranganath & Blumenfeld, 2005) and resulted adaptations of the Multi-Store model and alternative models of memory (Baddeley, 2012).

One adaptation highlighted an evolved version of short term memory deemed "working memory" (Baddeley, 2012). Whereas short term memory is viewed as a basic temporary store for information, working memory entails a mixture of storage and modification. This model, Baddeley's Working Memory Model, has been revised over the decades to overcome limitations, but the original model is constitutes three main components: the central executive, the visuo-spatial sketch pad, and the phonological loop (Baddeley & Hitch, 1974). The central executive is the control system of the model and is in charge of coordination of the other components, selecting stimuli to attend to, and shifting focus between tasks. The phonological loop stores and manipulates auditory information, while the visuo-spatial sketch pad stores and manipulates spatial and visual information. The most recent update to the model has added one new system, the episodic buffer, and addresses the relationship between working memory and long term memory (Baddeley, 2000). The episodic buffer integrates information from the visuo-spatial sketch pad and the phonological loop into a code that accounts for time sequencing.

In a study of 32 undergraduate students, Kiewra and Benton (1988) found that working memory ability is related to the quantity of notes a student takes and the number of main ideas the student records. Impressively, they found that working memory ability was a greater predictor of the quantity of notes of a learner than Grade Point Average. Prior research indicated a similar link between working memory capacity and note taking (Di Vesta & Gray, 1973). However, in a subsequent study of note taking and working memory involving 211 participants, Cohn, Cohn and Bradley (1995) did not find a relationship between note taking and working memory. Additionally, a recent study produced similar results: Peverly and colleagues (2013) as well as Peverly (2006) did not find a correlation between working memory and note taking ability, even though their theoretical stance would have predicted otherwise. The mixed findings within research of working memory and note taking are likely related to the different methodologies taken by the researchers (i.e., different measures of working memory).

In order to measure working memory some researchers have required participants to arrange randomly ordered words into sentences or randomly ordered sentences into paragraphs (Kiewra et al., 1987; Kiewra & Benton, 1988). Other researchers have used Daneman and Carpenter's (1980) listening span task to determine individual quality of working memory (Peverly et al., 2013), which requires participants to listen to a set of sentences and quickly tell if they make sense. Peverly and colleagues (2013) have questioned the ability for these tasks to accurately measure components of working memory.

Wittrock's Generative Learning Model

Wittrock (1990) proposed that learning is an active process in which learners construct their own knowledge. His model of generative learning involves of four processes: (a) attention, (b) motivation, (c) memory, and (d) generation. Through the process of attention the learner actively selects on what they will focus their attention. Motivation requires the learner to hold themselves accountable for the construction of relations between stimuli. Whereas previous cognitive/memory theories describe the process of learning as a "transference" of information to or within memory, the generative learning model establishes learning as the active creation of understanding. If one focuses on their own effort in relation to level of comprehension, then they will be more persistent within the context of learning. Memory is characterized by the development of patterns of association within a vast neural network. Learning takes place when individuals generate relations between different types of memory, including preconceptions, metacognitions, abstract knowledge, and new information. The Generative Learning Model has had strong empirical support since its initial development (Dee-Lucas & DiVesta, 1980; McFarland, Frey, & Rhodes, 1980; Slamecka & Graf, 1978; Wittrock,1974) and continues to remain a popular model decades later (Mayer & Fiorella, 2015).

Cognitive Load Theory

Cognitive Load Theory (CLT) may explain why students experience such difficulty during the process of note taking. CLT emphasizes the limitations of working memory during instruction (Sweller et al., 1998). When working memory reaches maximum capacity (i.e., the lecture is being presented at a quick pace or the content is difficult), the learner will struggle to comprehend any incoming information (Gathercole, Lamont, & Alloway, 2006). There are three types of cognitive load: intrinsic, extraneous, and germane (Sweller, et al., 1998). Intrinsic cognitive load is associated with the actual difficulty of the material and cannot be changed by the instructor. Extraneous cognitive load is produced by the way in which the material is presented and may be manipulated by the instructor. Germane cognitive load involves a "deeper" type of processing in which the learner develops interconnections between learned material. Instructors may not directly manipulate germane load, however, this type of load may be fostered by specific instruction and encouragement. The goal of instructors should be to reduce extraneous cognitive load while increasing germane cognitive load.

Evidence that cognitive load theory is relevant in note taking is well documented. For example, Peters ($n = 82$, 1972) studied the influence of note taking on recall when he presented a 1,600 word passage to participants at a normal or fast rate. He found that students who only listened to a lecture performed better on the outcome measure than students in a note taking condition. This finding indicates that the act of note taking may limit the amount of information an individual processes during a lecture. A subsequent study revealed that students who only listened during a lecture and recorded notes after the lecture outperformed students who took notes during lecture (Aiken, Thomas, & Shennum, 1975). The students in the former condition may have offset the cognitive load of note taking during lecture by postponing it.

Mayer's Cognitive Theory of Multimedia Learning

Inspired by Merlin Wittrock's Generative Learning Model, Mayer developed his own theory, the Cognitive Theory of Multimedia Learning, which emphasizes the role that multimedia plays in learning (Mayer, 2005). Like Wittrock (1990), Mayer asserted that learning happens when individuals build meaningful connections between prior knowledge and new information, and he added the caveat that the most efficient learning takes place when individuals develop relations between words and pictures (Mayer, 2009). The theory is derived from five basic assumptions: (a) dual-coding, (b) limited capacity of working memory, (c) memory stores, (d) cognitive processes (Sorden, 2013). The initial theory of dual coding was developed by Paivio (1986) and incorporates Baddeley's assumption that working memory has both auditory and visual channels (1986) and postulates that visual and auditory information are processed into different sets of mental codes that may be organized and manipulated. The idea of limited capacity of working memory is derived on Sweller's Cognitive Load Theory (Sweller et al., 1998), which states that working memory has a limited capacity in which stimuli may be manipulated. Mayer's twelve principles of multimedia instruction aim to reduce extraneous load, manage intrinsic cognitive load, and foster generative processing. The Cognitive Theory of Multimedia Learning also relies on the premise that memory can be broken down into three memory stores. These stores, sensory memory, working memory, and long term memory coincide with Atkinson and Shiffrin's Multi-Store Model (1968). Finally, Mayer (2010) suggested that meaningful learning, or "active processing" occurs when individuals engage in three processes within working memory when audio and visual information are presented. These processes are constructivist in nature and include selection, organization, and integration. Individuals engage in selection when they bring words/images into verbal/visual working memory. Organization happens when individuals mentally organize material into coherent mental representation through building internal connections. Lastly, individuals integrate by mentally connecting new information with relevant preexisting knowledge within long term memory. These five assumptions merge together to create support for Mayer's twelve principles of multimedia instruction. A few of which include the coherence principle, signaling principle, redundancy principle, spatial contiguity principle, and segmenting principle.

Depth of processing. Craik and Lockhart (1972) coined the term "depth of processing" to describe the phenomena that the ability to recall information is determined by the level of mental analysis an individual engaged in when committing a stimuli to memory. The depth of processing theory contradicts the Multi-Store Model of Memory (Atkinson & Shiffrin, 1968), which divides memory into three components, by suggesting that memory occurs through two different processes that vary in cognitive effort (Craik & Lockhart, 1972). The first type of processing, shallow processing, can be divided into two independent processes, structural processing and phonemic processing. In structural processing, an individual builds memory by encoding the physical properties of a stimulus (e.g., height, width, color). When a person encodes the verbal information or sound of a stimuli they are engaging in phonemic processing. In both types of shallow processing the learner is simply engaged in rehearsal, which leads to low or short term retention. Conversely, deep processing relies on the process of semantic encoding in which the learner processes the meaning of the stimulus and its connections to prior knowledge. Whereas individuals who engage in shallow processing use rehearsal to encode information, an individual who engages in deep processing engage in elaborative rehearsal, an active type of analysis.

Methods of Note Taking

There are two main methods of note taking: self-generated and guided. Guided note taking involves the use of an outline-type aid while self-generated note taking requires students to rely on their own strategies and organization. Both practices have their own strengths, and previous findings have been mixed when comparing the learning benefits of self-generated and guided notes conditions (Kiewra, 1991; Larwin & Larwin, 2013; Neef et al., 2006; Peverly et al., 2013; Williams et al., 2012).

Guided notes. One explanation of the difficulty that students experience during the process of note taking is that it is an intensely demanding cognitive skill (Barbetta & Skaruppa, 1995; Kiewra & Benton, 1998; Kiewra et al., 1987; Piolat et al., 2005). This coincides with Atkinson and Shiffrin's Multi-Store Model (1968) as well as Baddeley's Working Memory Model (Baddeley & Hitch, 1974). One way in which instructors may aid students in note taking (and the seemingly most popular note taking intervention), while intending to reduce extraneous cognitive load, is to provide them with guided notes before lecture. Guided notes come in many different configurations, but often take the form of outlines developed by the instructor. The outlines are intentionally left incomplete with blanks where students may fill in the key concepts, vocabulary words, short summary statements, definitions, and questions that will be addressed during the lecture (Stringfellow & Miller, 2005).

Barbetta and Scaruppa (1995) have suggested that there are advantages to guided notes for both students and instructors. Students benefit from guided notes by more easily determining key points and the best way to organize what they write. These researchers explain that guided notes help counterbalance the difficulties that students have when determining key lecture points and reduces the amount of time devoted to writing which leaves more time to contemplate course material. This coincides with the idea of Cognitive Load Theory; guided notes reduce extrinsic cognitive load by predetermining key lecture points and increases the chance for germane load by allowing more time for deep processing of lecture material. (Sweller et al., 1998). The benefits to instructors include the facilitation of preparedness, more easily locate at which point in the lecture they should begin, increase simplicity of test development, and ensure that the tests match the lecture content (Barbetta & Scaruppa, 1995).

Research has provided support for the theoretical usefulness of guided notes. Guided notes have been found linked to increased quantity of notes (Kiewra, 1991) and improved test performance (Kiewra, 1991; Larwin & Larwin, 2013; Peverly et al., 2013; Williams et al., 2012) and note quality (Austin et al., 2004). These incomplete outlines allow students to easily pinpoint the structure of the lecture, thereby reducing the burden in working memory (Lorch, Lorch, & Matthews, 1985). Guided notes may also increase the ability of the student to focus on the lecture, as it reduces the number of key points that need to be reproduced (Austin et al., 2002; Neef et al., 2006). As the important concepts are listed within the guided notes, students are not forced to spend cognitive resources to decipher which concepts are important, thereby, reducing cognitive load. Early research from Klemm (1976) compared the learning outcomes of students in a "skeletal notes" (similar to guided notes) condition and a control group. He found that there were significant differences in the number of test points per hour of studying with the skeletal group outperforming the control.

More recent research on guided notes has focused on students with learning disabilities. In a small study involving seven students with learning and behavior problems in a detention center, guided notes were found to be an effective strategy for improving academic performance (Hamilton, Seibert, Gardner, & Talbert-Johnson, 2000). Within this study, the guided notes were partially filled in notes with which the students were asked to "fill-in" through the help of complete notes shown through a projected transparency during lecture. Guided notes have also been found been found to be effective in improving the accuracy of notes and test scores of academically at-risk students in a remedial summer school class (Sweeney et al., 1999). In a small sample size (n = 6), students with learning disabilities benefited most from guided notes when the notes were accompanied with supervised review time (Lazarus, 1991).

However, not all studies have found benefits of guided notes. Austin and colleagues (2002) sought to describe the influence of guided notes on participation and quiz performance of 27 undergraduate participants in a behavior analysis course. Both conditions in the study viewed overhead transparencies that contained lecture information and one of the groups received guided notes that corresponded with the transparencies. They found that scores on quizzes were similar between the groups. The authors state that the nonsignificant finding may be related to the use of an immediate recall test instead of a delayed test or separate outcome measure. Additionally Konrad, Joseph, and Eveleigh (2009) conducted a meta-analysis of the effective of guided notes which led to inconsistent results due to the different methods and data collection procedures of each post-secondary investigation.

Varying the completeness of guided notes. Research suggests that the degree of completeness of guided notes may influence its effect on learning. In an early study Northcraft and Jernstedt (1975) compared four instructional strategies: (a) attending lecture and receiving outlines of the lecture material, (b) attending lecture and receiving examples of the lecture concepts, (c) attending lecture and receiving no supplementary materials, and (d) receiving a typed transcription of the lecture without attending lecture. Participants who attended the lecture and received either outlines or examples of lecture concepts outperformed the other two groups on an achievement measure.

More recent research by Katayama and Robinson (2000) found that students in a partial-notes group outperformed students in a complete notes group on an application test of material from a text, but their scores did not significantly differ on a test of facts. This finding mirrors prior research in which the completeness of study notes does not influence outcomes pertaining to knowledge of facts from a text or lecture (Robinson & Kiewra, 1995).

However, not all research supports the idea that guided notes are better than a completed set of notes. Neef and colleagues (2006) compared the effects of guided notes and full lecture notes on quiz performance for 46 graduate students in two sections of an introductory behavioral research methods course. They did not find consistent differences between the guided notes group and the completed notes group on students' mean quiz scores. These researchers hypothesize that their inability to find statistical difference between the two groups' quiz scores relates to multiple instructional methods (e.g. response cards, bonus point lottery) in both sections that may have veiled the benefits of guided notes compared to the complete set of notes.

Additional research supports the idea that the organization of guided notes is an important determinant of student success. Robinson and Kiewra (1995) highlight the benefits of outlines that use spatial format to indicate the relationship between concepts called Graphic Organizers. They found that students who studied text in a graphic organizer condition encoded more hierarchical relations and, thus, scored higher on an essay than students in traditional outline and text-only conditions.

Guided notes and self-regulation. Self-regulated learning refers to student's deliberate effort to manage and control learning tasks directed towards learning goals (Schunk & Zimmerman, 2003). Self-regulated learning has been found to be predictive of test performance (Zimmerman & Martinez-Pons, 1986). Several researchers have proposed ways in which self-regulated learning can be accomplished, including generating sample test questions (Jairam & Kiewra, 2009), self-questioning (King, 1992) checking work (Azevedo, Gurthie, & Seibert, 2004), and summarizing (King, 1992).

Guided notes have also been shown to improve students' self-regulatory processes. Northcraft and Jernstedt (1975) compared the learning outcomes of four groups. The first group attended lecture and received an outline of the lecture material. The second group attended the lecture and was provided with examples of the concepts in the lecture. The third group only listened to the lecture while the fourth group did not attend the lecture but received a typed transcript of it. The results indicated that students who received supplementary material in addition to listening to a lecture reported spending more time preparing for the exam relating to the lecture than students who received no supplementary materials or did not attend the lecture (Northcraft & Jernstedt, 1975). Additionally, Klemm's (1976) results suggest that the hours spent studying may be more effective for students who have an outline. In both studies guided notes were related to positive self regulation (an increase in time spent studying).

Student perceptions of guided notes. In general, researchers have found that students prefer guided notes over a lack of supplementary material. In an anonymous poll, Kelmm (1976) asked, "How do you compare the use of skeleton notes with the usual system of note-taking?" All students responded "Better Than" (3) or "Much Superior" (11), whereas no student responded with "Much Poorer," "Less Effective" or "Same As." In a study regarding the use of guided notes and students who took their own notes, researchers found little difference between the conditions on a measure of immediate recall (Austin et al., 2002). However, they found that majority of students reported that the guided notes were beneficial. 70% of the students in the note taking condition stated that the guided notes helped them listen and think about lecture material, 52% reported that they remembered more with guided notes, and 74% stated that the guided notes increased the amount of time that students were able to ask questions. Boon, Fore, and Saleem (2007) found similar results for students with and without disabilities in two 10th grade classes with most students (61.22%, n = 30) stating that guided notes helped them "learn more world history".

Self-generated notes. Although guided notes may seem like a viable intervention for note taking, some instructors hesitate to provide guided notes believing that it may stunt development of students' own personally meaningful self-generated notes. Theoretically, self-generated notes are more personally relevant to students and may provide a more effective means for later study. In this way, students may engage in deeper processing by increasing the amount of germane cognitive load (Baddeley, 2012; Sweller et al., 1998). Researchers have repeatedly found that students who record and review notes outperform students who review borrowed notes or the instructor's lecture notes (Howe, 1970; Kiewra & Benton, 1991). Wittrock's Generative Learning Model (1990), Mayer's Cognitive Theory of Multimedia Learning (2005), and Craik and Lockhart's Depth of Processing (1972) may help explain the benefits of encoding and both hinge on the idea that learning is a "generative" process. Both perspectives differ from classical cognitive theories where learning is based on storing information, and, instead, emphasize the role of the learner in the acquisition of knowledge.

Research on note taking supports the idea that note takers engage in the active processing of lecture material. For example, Peper and Mayer (1978) found that note takers recalled more underlying concepts than non note takers and that non note takers recalled more technical symbols and produced more vague summaries than note takers. This work suggests that note takers are more likely to assimilate new information with past experiences while listeners are more likely to add simple facts to memory. In an additional study, note takers performed better than listeners on recall and essay test if they had low prior knowledge, but no significant difference was found for students with high prior knowledge (Shrager & Mayer, 1989). This evidence supports the conclusion that note taking fosters generative learning especially for less skilled learners.

Some note taking behaviors represent shallow processing whereas others depict deeper levels of processing. Verbatim note taking has been described as a shallow process while paraphrasing and summarizing main points have been equated with deeper, semantic processing

(Bretzing & Kulhavy, 1979). As hypothesized, individuals in the summarizing and paraphrasing conditions outscored students in a verbatim notes condition (Bretzing & Kulhavy, 1979). Jonassen (1986) considers concept maps, diagrams, and outlines to be additional means of generative processing as they incorporate the act of creating relationships and meaning between concepts.

Davis and Hult (1997) found empirical support for generative learning when they compared three groups of students who took notes during a 21-minute lecture (n = 79). One group wrote summaries of the presented material during three 4-minute pauses during the lecture. The second group only reviewed their notes during the lecture pauses. The third group, a control group, took notes without pauses. All students took an immediate posttest and a free-recall question and another posttest 12 days later. Findings indicated that the summary group scored significantly higher on both delayed measures than the control group, while the pause group and control group did not differ on any measure. This coincides with the Generative Learning Model (Wittrock, 1990), which emphasizes the importance of active construction of knowledge and the unique interpretations and inferences that individuals may draw from learning environments. During lecture, a student may create examples, draw pictures or graphs, or develop a summary in their own words as a means of generative processing (Wittrock, Marks, & Doctorow, 1975).

Modes of Note Taking

Just as the method of note taking may have an influence on the encoding of lecture information, different modes of note taking may influence student encoding during lecture. There are two main modes of note taking; note taking on computers and handwritten notes. Both modes of note taking have different strengths, but research has yet to definitively confirm which mode is better for lecture encoding.

Handwritten notes. Most of the literature on note taking only examines traditional handwritten notes. Handwriting notes has been shown to aid students in the encoding of lecture material when compared to students who simply listen to lecture (DiVesta & Gray, 1972; Kiewra, 1988; Peper & Mayer, 1978; Williams et al., 2013). Students tend to prefer to take lecture notes by hand (Steimle et al., 2009). Additionally, by handwriting notes, students may bypass the distractions that typically couple laptop use (Sharples, 2002).

Researchers have found a positive correlation between handwriting speed and typing speed (Brown, 1988; Weintraub & Gilmour, 2010), which exists beginning in primary school (Connelly, Gee, & Walsh, 2007). Furthermore, individuals who are proficient in the skill of typing can type faster than they can handwrite (Brown, 1988; Weintraub & Gilmour, 2010), suggesting that laptop can increase the transcription of notes during lecture.

Furthermore, when comparing students from a longhand note condition to a typed notes condition differences have been found from both the encoding and the external storage perspectives (Muller & Oppenheimer, 2014). From the encoding perspective, the typed notes group took more verbatim notes than students from the longhand notes group, resulting in lower test performance. When testing the external storage component of typed and longhand notes, the researchers allowed students to study their notes a week after the lecture. Students in the typed notes condition still performed worse on tests of factual content and conceptual understanding (Muller & Oppenheimer, 2014).

Note taking on computers. With recent innovations in technology, more students own computers (89%; Smith & Caruso, 2010) and laptops have become standard at many universities

(Weaver & Nilson, 2005). However, there seems to be a conflict of perceptions between instructors and students on whether laptops benefit or diminish lecture learning. Some instructors note the propensity of students to become distracted by mobile technology (Sharples, 2002) due to multitasking that may disturb classmates (Fried, 2008) with strong proponents of this consideration in popular media encouraging the banning of laptop use during class (McWilliams, 2005; Szaniszlo, 2006). The literature reinforces this belief as students who use laptops are likely to use them for non-class related reasons (Kay & Lauricella, 2011; Sovern, 2012) and suffer a decrease in test scores (Fried, 2008; Kraushaar & Novak, 2010). Hembrooke and Gay (2003) found that students spend cognitive effort during lecture by browsing unrelated websites, checking email, and engaging in communication including CHAT and IM.

Although some students report that laptops are a distraction (Kay & Lauricella, 2011), other students describe laptops as beneficial to class engagement (Barak, Lipson, & Lerman, 2006). More importantly, Fried (2008) reported that the level of laptop use is negatively related to students' self-reported understanding of lecture material and overall course performance.

Other researchers propose a difference between unstructured and structured use of laptops in classrooms (Kay & Lauricella, 2011). The unstructured use of laptops is characterized by a traditional lecture structure where the instructor generally ignores the presence of laptop use. Conversely, structured use of laptops represents classroom pedagogy where laptops are viewed as critical tools of learning and are used to facilitate learning activities. Research on the structured use of laptops in the classroom has suggested positive academic outcomes (Barak et atl., 2006; Kay, & Lauricella, 2011; Kolar, Sabatini, & Fink, 2002)

One study found that students tend to prefer taking lecture notes long hand than to use electronic tools for note taking (Steimle et al., 2009). Other researchers determined that students who use laptops (64%) and students who handwrite notes (82%) support policies restricting laptop use to specific zones within the classroom (Aguilar-Roca et al., 2012). Supporters of "laptop-free" zones have the opinion that laptops may cause distractions to surrounding students (Aguilar-Roca et al., 2012), while researchers hypothesize that student multitasking on computers is one of the leading causes of distraction (Sana et al., 2013).

In two experiments Sana and colleagues (2013) investigated the role of laptop use during lecture as it relates to test performance of users and nearby students. In the first study, 44 undergraduate participants enrolled in an introductory psychology course were asked to bring their laptops to the experiment. They were instructed to take notes during a PowerPoint lecture just as they normally would during their college courses. Half of the participants were instructed to complete 12 online tasks at their convenience during the lecture (multitask condition). After the 45-minute lecture, students were asked to email their notes to the experimenter, and were immediately given a 40-item multiple-choice exam. Twenty of the questions required factual knowledge of the material while 20 of the questions required application of the lecture material. The participants in the multitask condition scored 11% lower on the lecture comprehension test. The first experiment supports the idea that laptop use distracts student users, hence, lowering test scores.

In the second experiment, the researcher's goal was to determine if being in view of a multitasking peer would have a negative influence on a comprehension test. Like the previous experiment, the undergraduate students were asked to bring their laptops to the experiment (n = 39). However, all participants were assigned to a hand written notes group while undergraduate confederates multitasked on their computers during the lecture. Some of the participants were assigned to sit behind the confederate students who were multitasking. The multitasking tendencies of the confederates were in plain sight of the participants behind them. Other participants were assigned to sit behind other participants who also handwriting notes (not multitasking). The lecture and procedure in this experiment was the same as in the previous experiment. After collection of the notes, the confederates left the room and the participants were given the same comprehension test as the previous experiment. The results indicated that participants who sat behind multitasking peers scored significantly lower than students who sat behind students who took hand written notes. Ultimately, the students who sat behind multitasking students scored 17% lower than the other condition on the comprehension test.

Bui, Myerson, and Hale (2013) investigated the relationship between computer note taking and recall in three experiments. In the first experiment, 80 undergraduate participants were assigned to a note taking method (hand written or computer) and a note taking instruction (organize or transcribe). In the organize condition, the participants were asked to paraphrase their notes, while in the transcribe condition, they were asked to record as much of the lecture as possible. The results indicated that when individuals used a computer, they took a higher quantity of notes and scored higher on measures of recall than individuals who took notes by hand. Furthermore, participants who took notes with the computer and were instructed to transcribe the notes performed the better on both immediate free recall and immediate short answer tests when compared to the other three groups.

Next, the same researchers wanted to know if computer note taking continued to produce better results for students when the testing phase was delayed. In a 2 (organize, transcribe) X 2 (immediate, delay) design all students took notes on a computer while listening to a lecture. The immediate condition took the free recall and short answer tests after the lecture and distraction tasks. The delayed recall took the free recall and short answer tests after a 24-hour delay. Just as the first experiment, students in the transcription condition had better immediate test performance than those in the organize condition. However, this trend reversed on the delayed tests. When students took organized notes they performed significantly better on both the delayed free recall and delayed short answer tests than the students who were instructed to take verbatim notes (Bui et al., 2013).

In the third experiment, all participants took notes on computers during the lecture according to an instruction condition (organize, transcribe). Half of the students were given 5 minutes to study their notes after the distraction tasks while the other half was not given the opportunity to study their notes. Again, taking organized notes led to better performance on the delayed measures than transcribing notes when students were not given an opportunity to study. However, when participants were allowed to study, the students in the transcription condition showed the highest levels of recall on both delayed assessments (Bui et al., 2013).

The findings of Bui et al.'s (2013) studies seem to contradict the literature (i.e. levels of processing, generative processing) and several limitations of the research may explain the results. First, 96% of the students in the study reported that they were proficient typists. Individuals who cannot type well may not experience the same benefits of transcription. Next, the investigators state that their recall measures may not have required the deep processing or application of content. Students who transcribed the lectures may not have benefited if required to complete a recall measure requiring the synthesis or application of lecture content. A final limitation is related to the length of the lecture. The 11-minute lecture was shorter than most college lectures and the data collected may not have captured the role of attention and fatigue that are important in real-world situations.

Mueller and Oppenheimer (2014) presented a series of studies that shed light on the longhand or laptop debate. In their first study, 67 participants were divided into two conditions, laptop or notebook. All participants watched a 15-minute lecture and instructed to take notes as they would normally during a classroom lecture. After two distractor tests, participants responded to factual-recall questions and conceptual application questions. They found that participants in the laptop condition took more verbatim notes, and while the two groups did not significantly differ on the factual recall, the longhand notes group performed significantly higher on the conceptual application questions. This provides evidence that the quality of notes (e.g., self-generated, non-verbatim) outweighs the quantity of notes.

To counter the tendency for students to take verbatim notes on laptops during lecture, Muller and Oppenheimer (2014) led a second experiment (n = 151) in which a simple instructional intervention was introduced. This study replicated the first study while adding a third laptop-intervention condition in which the participants were instructed to, “take notes in your own words and don’t just write down word-for-word what the speaker is saying.” The findings of this study indicated that the intervention did not improve the participants’ ability to take personal notes.

As the first two experiments concerned the encoding effect of note taking, in their third study (n = 109), the experimenters wanted to gauge whether longhand notes would provide a better source of external storage for participants. For this investigation they used a 2 x 2 design (laptop/longhand) (study, no study). Participants listened to four prose passages, which lasted 7 minutes each and took notes according to their condition. A week later students in the study condition were given 10 minutes to study their notes before taking a 40-question outcome measure. Participants in the no study group took the quiz immediately without time for study.

The researchers found again that the longhand note takers took a smaller quantity of notes than students who took notes on laptops, and differences in quiz performance were not found between the two no-study groups. There was a significant difference between students who studied with the longhand group outperforming the laptop group. This series of studies provides evidence that longhand notes have superior external storage and encoding functions to laptop notes.

Guided notes on computers. As guided notes may provide a way to decrease cognitive load and computers provide individuals with faster transcription speed, it follows that guided note taking on computers may be an effective means for learning. However, research on guided note taking on computers is limited. Kauffman, Zhao, and Yang (2011) compared the effects of three online note taking formats (conventional, online, and matrix) on learning from an online text in two experiments. Results from both studies indicate that the online matrix note takers outperformed the outline and conventional online note takers on a 50-item multiple-choice test of declarative knowledge of the text material. As both the matrix and outline conditions may be considered guided note materials, it is evident that more research is needed to understand the effectiveness of guided note taking on computers.

Additional Influences on Note Taking

An extensive body of literature exists which links quality of notes to test performance (Fisher & Harris, 1973; Kiewra, 1985; Kiewra et al., 1991; Titsworth & Kiewra, 2004).

Quantity of notes. Note takers outperform listeners on measures of achievement (DiVesta & Gray, 1972; Kiewra, 1988; Peper & Mayer, 1978; Williams et al., 2013), suggesting that as the quantity of notes increases performance also increases. Generally, students who take a greater quantity of notes perform higher on performance measures than students who take a smaller quantity of notes (Risch & Kiewra, 1990). This finding may be explained from the external storage function of note taking; as the quantity of notes increases there is more information to study at a later date (Bui et al., 2013). Additionally, A pilot study compared the learning and behavioral outcomes of a guided notes condition with a self-generated notes condition (Blankenship & Cassady, 2015). The researchers found that the self-generated notes condition took significantly more notes and scored higher on a short-answer outcome measure than the guided notes condition.

Meaningfulness of note taking. Verbatim note taking happens when students take notes word-for-word from the lecture, and has been described as a shallow type of processing (Bretzing & Kulhavy, 1979). While summarizing, paraphrasing, and concept mapping involve deeper depths of processing, verbatim note taking only requires shallow levels of processing (Craik & Lockhart, 1972; Kiewra, 1985). In one investigation, students who made an attempt to paraphrase the main ideas of a lecture performed significantly higher on an outcome measure than students who were required to take verbatim notes (Bretzing & Kulhavy, 1979).

Handwriting speed. Peverly and colleagues researched the relationship between handwriting speed, compositional fluency, and spelling ability to note taking. They found that all three variables were significantly correlated with note taking ability, while only handwriting speed was a predictor. A subsequent study of over 200 participants reinforced the idea that handwriting speed is positively correlated with note taking (Peverly et al.,2013). Handwriting speed was measured by a task used by Berniger, Mizokawa, and Bragg (1991) where individuals were asked to write as many letters of the alphabet as they could within a 30 second timeframe. Using three different measures of transcription speed, Peverly (2006) found a statistically significant relationship between handwriting speed and quality of lecture notes.

Working memory. Individual differences in working memory have also been linked to note taking ability (Kiewra & Benton, 1988; Kiewra et al., 1987). However, more recent research on working memory and note taking has not shown this correlation (Cohn et al., 1995; Peverly et. al., 2007). The contradictory differences in these findings may relate to the method in which working memory and note taking quality were measured or the note taking strategies of the students. Some note taking strategies may rely heavier on working memory than others, hiding a correlation between the two.

Note taking interventions. As note taking is a popular (Palmatier & Bennett, 1974) and effective (DiVesta & Gray, 1972; Kiewra, 1988; Peper & Mayer, 1978; Williams et al., 2013) learning strategy, but students are generally poor note takers (Kiewra, 1989), many researchers have attempted to develop note taking interventions. Note taking interventions may be divided into three categories: (a) guided notes, (b) pretraining, (c) giving verbal instructions of note taking strategy (Kobayashi, 2006).

As discussed previously, the literature on the effectiveness of guided notes is mixed. Some studies report positive benefits of note taking on test achievement (Kiewra, 1991; Peverly et al., 2013; Larwin & Larwin, 2013), quantity of notes (Kiewra, 1991), and self-regulation (Van Meter, Yokio, & Pressley, 1994). Other investigations indicate that guided notes produce statistically similar results to self-generated notes (Austin et al., 2002; Kiewra, 1988). Furthermore, theoretical implications of Wittrock's Generative Learning Model (1990), Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2005), and Craik and Lockhart's Depth of Processing (1972) support the act of self-generated or personally meaningful note taking rather than instructor created aids.

Aptitude by treatment interaction. In a meta-analysis that included 17 studies, Kobayashi (2006) found an effect size (*d*) of .02 between groups of students who received note taking interventions and students in control groups. However, in the same meta-analysis, results indicated that younger students (grade school level) benefited from interventions, while students in higher levels (college) did not benefit. One explanation for this finding may be that younger students are less practiced than older students at note taking strategies, thus having more opportunity to improve. This also may explain why individuals with learning disabilities have been found to benefit from interventions. It is well documented that individual differences influence the quality of students' notes and, their subsequent performance on academic measures.

The aptitude by treatment interaction represents the idea that the effectiveness of certain instructional strategies (e.g. note taking) is influenced by the specific abilities of individuals (Cronbach & Snow, 1977). According to this framework, students learn most efficiently when the instruction style is matched to their aptitude (Snow, 1989). Researchers have found evidence of the aptitude by treatment interaction for the instructional strategy of note taking. Peters' (1972) found that students who scored lower on measures of aptitude (a test of listening efficiency) performed better when a lecture was presented at a normal rate and when they were not required to take notes, while students who scored higher on the measure of aptitude did not experience a negative effect when they took notes. In a systematic review of nine studies involving note taking interventions and students with disabilities, Boyle and Rivera (2012) found that note taking interventions helped students to record more notes and recall more key concepts on measures of immediate and delayed recall.

Furthermore, researchers Shrager and Mayer (1989) compared students in a note taking group and a listening group. They found that students with low prior knowledge performed better on tests of recall and essay tests for the note taking group, a distinction that was not significant for the high prior knowledge group. Other research on the aptitude by treatment interaction includes students with learning disabilities. Research with this population suggests that even when students with learning disabilities are provided with an intervention (i.e. cues or direct instruction), they still underperform students without learning disabilities who viewed the same lecture content (Boyle, 2010).

Summary

Note taking is a common lecture-learning strategy (Kobayashi, 2005) that is poorly performed by students (Boyle, 2010; O'Donnell & Dansereau, 1993). Reasons for inefficient note taking include cognitive overload of working memory (Baddeley, 2012; Sweller et al., 1998) while interventions may be directed toward facilitating germane load by generative processing during note taking (Craik & Lockhart, 1972; Mayer, 2005; Wittrock, 1990) or decreasing the amount of extrinsic cognitive load (Sweller et al., 1998). Changing the method of note taking may alter the amount of extrinsic cognitive load, (i.e., self-generated or guided notes) while germane cognitive load may be altered by changing the mode of note taking (i.e., keyboarding or handwriting). More research is needed within the realm of note taking to provide interventions directed toward improving the quality of note taking strategies.

CHAPTER III

METHOD

Participants

Participants (n = 199) were recruited through a university subject pool, and participation in the study was one of several options available to satisfy a course credit. A power test was used to determine sample size through the software g*power (Faul, Erdfelder, Lang, & Buchner, 2007). Using the effect size of a similar previous study, g*power indicated that 145 participants would meet the effect size requirements to replicate prior research ($\eta_p^2 = .040$; Blankenship & Cassady, 2015). Therefore, data were collected on 200 participants with approximately equal numbers in each condition.

Data collection sessions were arranged through volunteer sign-ups on the university subject pool bulletin board. Interested participants selected a time that fit their schedule and were given directions for when and where to arrive. Each session took place in standard classroom settings, equipped with digital overhead video production materials (to enable video presentation). Each session included between 1 and 30 participants per session. Consistent with the sampling population, the participants were primarily female (85%) and Caucasian (90%). Of the students, 33% were freshman, 36% were sophomores, 23% were juniors, and 8% were seniors (See Table 1).

Table 1: Demographic Characteristics of Sample

	n	%
Gender		
Male	29	14.6
Female	170	85.4
Race		
Caucasian	179	90.4
Biracial	6	3
Black	7	3.5
Hispanic	5	2.5
Year in University		
Freshman	65	32.7
Sophmore	71	35.7
Junior	45	22.6
Senior	16	8

Materials

Materials included one 10-minute pre-recorded video lecture, one set of structured notes, blank paper provided for the unstructured note condition, a short quiz on the lecture content, and a set of distraction tasks.

Video lecture. The video lecture was titled "The Science of Sleep" and described biological processes of sleep and sleep disorders. The video lecture displayed via HDMI connected classwide video display so that all participants were able to see the video effectively. There were 6 main topics including, “The Stages of Sleep”, “Sleep Architecture”, “The Timing of Sleep”, “The Purpose of Sleep”, “Lack of Sleep”, and “Common Sleep Disorders”. The “Stages of Sleep” section described the four stages of sleep along with behaviors and characters unique to the stages. The “Sleep Architecture” topic presented information on how the sleep stages combine to make sleep. The “Timing of Sleep” portion included information on the circadian rhythm, melatonin, and the sleep-wake cycle. The “Lack of Sleep” section explained what happens to individuals’ physical and emotional well-being when they do not get enough sleep. Finally, the “Common Sleep Disorders” segment described two sleep disorders, insomnia and circadian rhythm disturbance, as well as their causes and symptoms. The video was 9 minutes 45 seconds in length.

Note taking materials. There were four note taking conditions, including two guided note taking groups (typed and handwritten) and two self-generated note taking groups (typed and handwritten). Both of the guided note taking groups received a four-page outline organized around the six main topics covered in the lecture (see Appendix A). Each section matched the organizational structure of the video, and had blanks and ample space for the students to fill-in information as they viewed the lecture. The participants in the handwritten guided notes condition received a hard copy of the outline. The participants in the typed guided notes condition received a digitized Microsoft Word version on a flash drive.

Individuals in the self-generated group received blank note taking paper (no lines). The self-generated handwritten group was given 4 blank pages of computer paper while the computer condition consisted of blank Microsoft word document that may be edited by students.

Outcome Measures. The outcome measure consisted of 19 short answer questions and 15 multiple-choice questions. The questions varied in intended difficulty ranging from content directly stated in the video (i.e., factual recall) to questions that require students to draw inferences or synthesize information from content provided (see Appendix B). The students answered the questions on a blank response form.

Distraction Tasks

Two activities were given to participants that were unrelated to primary research questions that were completed between the presentation of the video lecture and the performance test. First, a demographics form included questions regarding gender, age, race, GPA, university major, and academic status (see Appendix C). Second, a short survey on note taking preferences was given to students (see Appendix D). These surveys acted as a distraction task to protect against the recency effect of working memory (Murdock, 1962).

Procedure

Each testing session was randomly assigned to one of the five conditions; guided typed, guided handwritten, self-generated typed, self-generated handwritten, and a control group. When they entered the testing room, participants read and signed consent forms. Once the participants completed the consent form, they received their condition specific notes materials. Participants also received a unique number-letter identification code that they wrote on each form throughout the testing session so that their data could be linked for later analyses without providing personal identifying information.

Once the students had submitted their consent forms and had the assigned note materials, the video lecture was presented to the entire group via a HDMI connected classwide video display. In the four note taking conditions, the participants were encouraged to, “take notes as though you are a student in this class and the material will be part of your final exam.” The notes materials were available to them during the duration of the video lecture as well as an additional 3 minutes at the conclusion of the video (to finish note taking or add comments as needed). Notes materials were collected immediately after that 3-minute delay.

The protocol for the typed groups differed slightly due to the nature of the mode of note taking. After signing the consent form, the typed notes groups (self-generated and guided) were given a flash drive containing either the blank Word document (self-generated) or the outline (guided). After the completion of the video and the 3-minute additional time, the students were instructed to save their word document directly over the document on the flash drive.

In the control group the students were instructed to, "watch and listen carefully to the video as if you are student in the class and the material will be part of your final exam." The students in the control group were not provided with any materials for taking notes. No students in the control condition were observed to take notes during the sessions.

After the participants' notes were collected, the note taking preferences survey and the demographics forms were given to the participants. These surveys served as a distraction task which provided a delay to protect against the recency effect of working memory. It took approximately 10 minutes for the participants to finish the surveys. After all of the participants had finished the surveys, the researcher collected them.

Next, the students received the short answer and multiple-choice questions regarding the lecture content. They were given instructions to work through the items in sequential order without looking at previous items. The questions took approximately 20 minutes for the participants to complete. After all of the students completed the outcome measures, the materials were collected and the session was concluded.

Coding of Notes

In all four conditions, notes were coded in terms of idea units. Each idea unit was considered to be one complete thought within a sentence or phrase (Bransford & Johnson, 1972). An example of an idea unit is "There are five stages of sleep". The same idea unit could be written in different ways, including "sleep has five stages", or "sleep = 5 stages." Each idea unit that was true to the lecture content counted as a "correct note." Each idea unit that was incorrect was coded as an "incorrect note" Each idea unit that contained accurate information that did not regard the actual lecture content was coded as an "additional note." Due to the scarcity of incorrect and additional notes, (less than 5 total in the entire sample) they were not included in the final analyses. There were two primary coding procedures, dependent upon the method of note taking (guided v. self-generated).

Guided notes. In the guided notes condition, all correct notes were added up to create a total notes variable. Notes that were already included in the outline were not counted in the total as the participants received them before the video lecture commenced.

Self-generated notes. In the self-generated conditions each note that represented a header listed in the outline of the guided notes group was coded as a "provided note." The provided notes represent the organizational structure of the lecture for the self-generated notes conditions that was already provided to the guided notes conditions. The provided notes and correct idea units were added together to create a total correct notes variable.

Interrater reliability was performed to determine the variance of the observed scores of note taking. The second rater was a doctoral candidate within the same department of the principal investigator, and had a solid understanding of the project. The second rater was trained by the principle investigator of the current study to code the data over a one-hour training session. Seventeen packets of notes from the varying conditions were included in the analysis. There was a strong positive correlation, $r(15) = .95$, $p < .01$. Any disagreements in the coding were reconciled verbally.

Scoring of Outcome Measures

The two outcome measures, the short answer quiz and the multiple-choice quiz, were coded separately. For the short answer quiz each answer was coded according to a score-book developed for the study. The short answer questions had different weights, ranging from 1-7 according to the number of potential correct statements. If the question was incorrect or left blank, the score was recorded as a zero. The scores for all the short answer questions were added together to create a total short answer score.

For the multiple-choice quiz, each question was coded as correct or incorrect. There was only one correct answer for each question. If the answer was correct, it was coded as a score of one. If the answer was incorrect, it was coded as a score of zero. If the answer were left blank, it was coded as missing data (N = 6). The scores for all of the multiple-choice questions were added together to create a total multiple choice score.

CHAPTER IV

RESULTS

The goal of the current study was to investigate the influence of methods and modes of note taking on retention of lecture material and note taking behavior. The research questions for this study centered on the individual and interactive effects of method (i.e., self-generated, guided) and mode (i.e., typed, handwritten) of note taking on note taking behavior and test performance.

RQ1: Does note taking method impact note taking behavior and performance?

RQ2: Does note taking mode impact note taking behavior and performance?

RQ3: Is there an interaction effect between method and mode of note taking influences note taking behavior and performance?

A 3x3 Multivariate Analysis of Variance (MANOVA) examined the main effects of note taking method (none, guided, self-generated) and note taking modality (none, computer, handwritten) as well as the interaction of the conditions on the two dependent measures of short answer and multiple choice question performance. The plan for the analysis was to identify if the multivariate effects indicated a significant difference among the various approaches to note taking. Next, to follow up a significant multivariate effect, a discriminant analysis was performed to examine differences in performance based on the identified significant condition. Finally, a 2x2 Analysis of Variance (ANOVA) was run to determine whether there were group differences in the quantity of notes. The 2x2 ANOVA compared the independent variables of method (guided and self-generated) to mode (handwritten and typed) on the dependent variable of quantity of notes. The control group was removed from this analysis given their inability to take notes.

Note Taking Preferences

As part of the distraction phase of the study, a note taking preferences questionnaire was distributed to the students. This was not a main focus of the study, but added to the overall study by offering insights into student perceptions of note taking and how note taking style influences performance on tests of lecture material. Previous studies have examined student note taking preferences according to both method and mode. Researchers have found that students generally prefer guided notes to self generated notes (Austin, Lee, Thibeault, Carr, & Bailey, 2002) and handwriting their notes over typing their notes (Steimle, Brdiczka, & Muhlhauser, 2009). The results of the note taking preference questionnaire in this study were consistent with prior research. The note taking preferences questionnaire examined four specific components: method and mode frequency, note taking practices, note taking quality, and note taking effectiveness.

Method and mode frequency. When comparing the frequency of use of the modes of note taking, students reported taking notes more often with pen and paper than with digital devices (e.g., laptop, tablet; see Table 2). Although over 60% of students stated that they tend to take notes with pen or paper either “often” or “always,” 45% of the students reported the same with laptop, and less than 10% of students reported taking notes on an electronic tablet at a similar frequency. There were also differences in the frequency of use of the methods of note taking. When considering the frequency of use of printed lecture outlines, 44.8% students reported using them “often” or “always.” However, only 17.6% of students reported using electronic outlines at a similar rate.

Table 2: Note Taking Method and Mode Frequency

When taking notes I tend to take notes with:	Never	Rarely	Sometimes	Often	Always
Pen and paper	1%	5.5%	32.3%	38.4%	21.7%
Laptop	5.5%	18.1%	31.2%	33.7%	11.1%
Electronic tablet	73.9%	9.7%	5.5%	6%	3.5%
Printed PowerPoint slides provided by the course instructor	25.6%	25.6%	31.2%	33.7%	11.1%
A Printed outline of the lecture provided by the course instructor	22.4%	30.7%	30.2%	11.1%	4.5%
Electronic copy of PowerPoint slides provided by the instructor	22.6%	24.1%	28.1%	19.1%	5%
Electronic outline of the lecture provided by the instructor	35.2%	26.6%	19.6%	11.6%	6%

Note taking practices. The questionnaire also assessed self-reported use of notes that were provided by instructors, obtained from fellow students, or created on their own. As demonstrated in Table 3, students reported that instructors "Sometimes" provided lecture notes and PowerPoint slides prior to class and predominantly rely upon their own notes when preparing for exams.

Table 3: Note Taking Practices

	Never	Rarely	Sometimes	Often	Always
My instructors provide lecture notes to students before class	11.1%	26.6%	40.8%	16.1%	4.5%
My instructors provide PowerPoint slides to me before class	6%	13.1%	44.2%	30.2%	5%
When I study for course exams, I rely on other students' lecture notes	46.2%	36.4%	9.7%	6.7%	1%
I have another student take lecture notes for me	85.1%	11.3%	3.1%	0%	.5%
When I study for course exams, I review my personal lecture notes	12.2%	1.5%	3.6%	19.4%	63.3%

Note taking quality. In the note taking quality section of the questionnaire, students indicated their perception of note taking quality when taking notes according to different methods and modalities. The responses illustrated the greatest number of students reported their notes were of high quality when taken with pen and paper, followed by those notes taken on laptops (see Table 5), with a small percentage deeming notes taken on tablets to be of similar quality. Students also reported higher confidence in note quality when using pre-printed PowerPoint slides or outlines as compared to electronic versions of similar materials.

Table 4: Note Taking Quality

My notes have a higher quality when I use:	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Pen and paper	6%	8.5%	13.1%	33.2%	38.7%
A laptop	6%	12.6%	19.6%	41.2%	20.1%
An electronic Tablet	27.6%	9.5%	5.5%	6%	3.5%
Printed PowerPoint slides provided by the course instructor	8.5%	11.6%	35.2%	27.6%	16.1%
A printed outline of the lecture provided by the course instructor	7.1%	9.1%	37.6%	31.5%	14.7%
Electronic PowerPoint slides provided by the course instructor	10.6%	17.1%	31.7%	31.7%	8.6%
An electronic outline of the lecture provided by the instructor	10.1%	17.1%	39.7%	25.1%	7%

Note taking effectiveness. The last portion of the questionnaire expanded the students' reported beliefs about the utility of lecture support materials. Students reported similar levels of perceived benefit for instructor-provided lecture support materials regardless of the format of delivery (see Table 4). Finally, a small percentage of reported that they understand lecture material best when they do not take notes, but focus on listening to the lecture. Collectively, these preference data suggest that learners identify the value of taking notes, and report value in supportive materials provided by instructors to guide their success in capturing essential lecture content.

Table 5: Note Taking Effectiveness

My understanding of lecture material is greatest when:	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
The instructor provides me with a printed outline of the lecture before class	2.5%	11.1%	25.6%	41.2%	18.1%
The instructor provides me with PowerPoint slides before class.	3.5%	14.1%	29.1%	39.7%	12.1%
The instructor provides me with an electronic outline of the lecture before class	2.5%	12.6%	27.1%	45.7%	10.6%
The instructor provides me with an electronic copy of the PowerPoint lectures before class	3.1%	13.8%	22.1%	45.2%	14.6%
I do not take notes, but focus on listening to lecture material	40.8%	26.1%	16.1%	12.1%	4%

Comparisons of Note Taking Conditions

The first analysis that was run was a 3x3 MANOVA to test for differences between groups on short answer and multiple-choice scores. The methods of note taking were no notes, guided notes, and self-generated notes. The note taking modes were no notes, computer notes, and handwritten notes.

Assumptions

There are several assumptions that must be satisfied before a MANOVA can be performed. The first three assumptions correspond with the design and measurements of the study. The first assumption is that there are two or more dependent variables that are measured at the continuous level. This assumption is met as the study contained three dependent variables (quantity, multiple choice, short answer), which were all continuous.

The next assumption is that the independent variables that consists of two or more categorical, independent groups. The assumption was met as the independent variables in this analysis consisted of the six conditions (guided computer, self-generated computer, guided handwritten, self-generated handwritten, and two control groups).

Another assumption of a MANOVA is that there are no univariate outliers in any independent variable for any of the dependent variables. As assessed through inspection of histograms for each group, there was at least one outlier total for each condition on both short answer and multiple-choice measures (Tabachnick & Fidell, 2013). After checking for data entry errors and measurement errors, it was decided that these outliers were genuinely unusual values that should be kept in the data for the analyses. One deciding factor for keeping the outliers is that the MANOVA is generally robust to them.

To test for multivariate normality, Mardia's test was calculated (Tabachnick & Fidell, 2013). Results of the Mardia's test were nonsignificant (p = .051). This indicated that the assumption of multivariate normality was met. For the assumption of no multicollinearity to be met, the dependent variables must be moderately correlated with each other. However, if the dependent variables are correlated too strongly, there may be multicollinearity issues (Tabachnick & Fidell, 2013). As assessed by Pearson correlations of short answer and multiple choice (r = .602, p = .000), short answer and sleep notes (r = .405, p < .000) and sleep notes and multiple choice (r = 106, p = .337), there was no threat of multicollinearity.

To meet the assumption of homogeneity of variance-covariance matrices, the variances and covariances should be similar. This was tested through the Box's M test of covariance

(Tabachnick & Fidell, 2013). There was homogeneity of variance-covariances matrices, as assessed by Box's test of equality of covariance matrices, $F(12, 163539) = 1.65$, $p = .071$.

Multivariate effect. With the use of Wilks' statistic (Tabachnick & Fidell, 2013), the combined dependent variables were not significantly affected by method, $F(2, 186) = 1.579$, $p > .05$, but they were significantly affected by mode, $F(2,186) = 3.76$, $p < .05$. Wilk's lambda was chosen because it is the most commonly used test statistic for MANOVA (Everitt & Dunn, 1991). The interaction effect was not significant, $F(2, 186) = .183$, $p > .05$. The results reflected a weak, but significant effect identifying a performance difference based on mode of note taking (typed, handwritten, or control) on the performance measures, partial $\eta^2 = .039$. This was similar to the findings of the pilot study ($\eta_p^2 = .040$; Blankenship & Cassady, 2015).

Discriminant analysis follow up. When a MANOVA exposes significance between conditions on dependent variable(s), a discriminant analysis should be used to analyze how the independent variables are related to the dependent variables (Tabachnick & Fidell, 2013). Therefore, a discriminant analysis was performed to pinpoint group differences. The only significant grouping variable was the mode of note taking (computer, handwritten, or control) and the dependent variables were the short answer and multiple choice scores. Mode was chosen for exploration with the discriminant analysis as it was the only significant effect in the 3x3 MANOVA. Box's M for the discriminant analysis was nonsignificant ($p = .988$), revealing that the groups' covariance matrices are equal. The discriminant analysis produced one significant function to account for the group variations in the performance indicators of short answer and multiple choice test performance (Wilks $\lambda = .937$, Wilks λ Chi-square = 12.31, $df = 4$, Canonical correlation = .215, $p <. 001$). The structure coefficient loadings identifying the correlation between the predictors and the discriminant function demonstrated a significant relationship fro for multiple choice test performance (.832) but not for short answer performance (.063). Comparison of groups by examining the group centroids illustrated the computer group performance level on multiple choice items was significantly lower than both the control and handwritten item groups (see group means in Table 6).

Table 6: Means and Standard Deviations of Test Performance

		Test Performance	
Note Taking Condition	*n*	*Multiple Choice M(SD)*	*Short Answer M(SD)*
Handwritten			
Guided	33	19.36 (7.09)	12.45 (1.66)
Self-generated	52	17.43 (5.97)	12.44 (2.19)
Typed			
Guided	29	17.98 (6.83)	11.58 (2.29)
Self-generated	34	16.46 (6.56)	11.38 (2.46)
Control	44	16.06 (6.27)	12.09 (1.85)

Comparing Conditions on Quantity of Notes

Next, a 2x2 ANOVA was performed to determine if there were group differences on the total number of correct notes. This was calculated by adding together the number of correct idea units the participant recorded in their notes. The control group was left out of this analysis, as the control group was not permitted to take notes. The 2x2 ANOVA compared the main effects of modes of note taking (typed and handwritten) and the method of note taking (self-generated and guided) as well as the interaction.

There are several assumptions that must be met in order to perform a 2x2 ANOVA. First, there must be one dependent variable. In this analysis the dependent variable was total number of notes taken. Second there must be two independent variables. The independent variables were mode of note taking (computer or handwritten) and method of note taking (self-generated or guided). The third assumption is that there is independence of observations. This assumption was met, as there was no relationship between the observations in the independent variable conditions.

The fourth assumption is that there are no significant outliers in any cell of the experimental design. There was one outlier, as assessed through histograms that was over three standard deviations from the mean. After checking for data entry errors and measurement errors, it was determined that the value was genuinely unusual and was kept in the dataset for further analyses. The fifth assumption is that the residuals of the dependent variable are normally distributed. This assumption was met, as assessed by a nonsignificant Shapiro-Wilk's test ($p > .05$) (Tabachinick & Fidell, 2013). The final assumption is that the variances of the dependent variable residuals are equal. The assumption of homogeneity of variances was met, as assessed by Levene's test for equality of variances, $p = .131$.

There was no statistically significant interaction between method and mode of note taking for quantity of notes, $F(1, 147) = .012$, $p = .913$, partial $\eta^2 = .000$. There were several cases of missing data ($n = 5$) that were not included in the analysis. According to Howell (2010), when there is not a statistically significant interaction, the main effects should be reported. There was no statistical difference in quantity of notes for guided note and self-generated notes conditions, $F(1,147) = 2.34$, $p = .128$, partial $\eta^2 = .016$. There was a statistically significant main effect of mode of note taking, $F(1, 147) = 8.48$, $p = .004$, partial $\eta^2 = .055$. The results indicated that students in the computer conditions took 4.28 (95% CI, 1.37 to 7.19) more idea units than students in the handwritten notes condition. This was a statistically significant difference, $p < .005$. The marginal means for quantity of notes scores were $42.014 \pm .977$ for handwritten notes and 46.30 ± 1.099 for computer notes.

Table 7: Means and Standard Deviations of Quantity of Notes by Condition

Note Taking Condition	*n*	Quantity of Total Notes *M*	*SD*
Handwritten			
Guided	34	40.97	7.13
Self-generated	52	43.06	10.03
Total	86	42.23	9.01
Typed			
Guided	33	45.09	8.25
Self-generated	32	47.50	9.05
Total	65	46.42	8.86

CHAPTER V

DISCUSSION

The results of this study provided limited support for the expectations based on prior studies with note taking in lecture classrooms. Student reports on note taking preferences indicated that students take notes more frequently with pen and paper rather than laptops, and that students associated better note taking quality and learning outcomes for printed outlines over electronic outlines of lecture material. Those preferences did not carry over to actual performance. Student performance was not influence by the method (guided v. self-generated) of note taking as was predicted. However, the mode (computer v. handwritten) of note taking did influence student performance on multiple-choice items. Finally, the mode of note taking also influenced quantity of notes taken by participants. Students in the computer note taking condition took significantly more notes than students in the handwritten condition.

Note Taking Preferences

As with a previous study (Palmatier & Bennett, 1974), most students (99%) in this sample reported engaged in some form of note taking when in a lecture setting. Additionally, only 4% of students strongly agreed that their understanding of lecture material is greatest when they listen to a lecture without taking notes. This strengthens the idea that note taking is a common lecture learning technique (Kobayashi, 2005) that students perceive as important for collegiate success (Palmatier & Bennett, 1974).

When considering note taking method, many students reported using printed outlines of the lecture material at least “sometimes” (45.8%). An even greater number reported that their note have a higher quality when they used an outline of the lecture material (46%). The frequency of use of guided notes is partly controlled by the instructor. An instructor who does not provide guided notes does not give students the chance to use them during lecture. Additionally, most of students reported that their understanding of lecture material is greatest when the instructor provides an outline of the lecture before class. These preferences reveal an inclination towards guided notes over self-generated notes for almost half of the sample. This finding mirrors previous studies in which students perceive guided notes as beneficial to academic outcomes (Austin et al., 2002; Klemm, 1976).

As for mode of note taking, students reported higher frequencies of using pen and paper to take notes when compared to laptops and electronic tablets. They also indicated that their notes had higher quality and that their understanding of lecture material was greatest when using printed outlines rather than electronic outlines. These findings are similar to previous studies in which students generally prefer to take handwritten notes (Steimle et al., 2009).

Method of Note Taking

The current study found no significant differences in method of note taking on either test performance or note taking quantity. These findings are not surprising due to the mixed results of previous studies regarding guided notes versus self-generated notes (Kiewra, 1991; Larwin & Larwin, 2013; Neef et al., 2006; Peverly et al., 2013; Williams et al., 2012;). The nonsignificance may be explained through the differing theoretical benefits of the two methods.

Performance. Guided note taking have been proposed to benefit students through reducing the burden of the note taking process in working memory (Lorch et al., 1985). As the general structure and main points of the lecture are provided to them, students may spend their cognitive efforts on attending to understanding the concepts. More specifically, guided notes may decrease the extrinsic cognitive load of the learning experience by decreasing the amount of transcription required to record the lecture.

Theoretically, self-generated note taking may increase generative learning (Wittrock, 1990; Mayer 2005) and germane cognitive load (Sweller et al., 1998) and promote deeper processing of information (Craik & Lockhart, 1972). As students are developing their own notes and are not bound to the structure of an outline, they have limitless opportunity to create their own personally meaningful notes resulting in generative learning. Students are also able to benefit from developing their pictures, graphs, and concept maps which supports dual coding. Additionally, self-generated note taking may increase germane load by allowing them space to design their own summaries and concept maps where they may develop relations between lecture material. Finally, self-generated note taking may support deeper processing of lecture material as it requires the student to become an active agent in the note taking process. Instead of receiving an outline, they are the sole developer of their notes.

The nonsignificant difference between the methods of note taking may be a result of the differing theoretical benefits that each present. Guided notes may decrease extrinsic cognitive load and lessen the burden on working memory, and self-generated note taking may increase generative learning, germane cognitive load, and promote deeper understanding of information. However, it seems as the potential benefits of either method do not outperform the benefits of the other.

Surprisingly, neither method of note taking outperformed the control condition on either of the multiple choice or short answer quizzes. This contradicts much of the prior research on note taking which indicates that students who engage in note taking generally outperform students who only listen to the lecture (DiVesta and Gray, 1972; Kiewra & Frank, 1988; Peper & Mayer, 1978; Williams et al., 2013). This inconsistent finding may be due to the materials of the study (i.e. the lecture was short in duration or there was not a long enough delay between presentation of lecture material and testing). Furthermore, due to the short duration of the video, it is possible that students in the control condition may have been able to attend to the lecture material without using any cognitive effort for note taking. Thus, benefits of encoding during each note taking condition did not outweigh the benefits of solely listening to the lecture.

Quantity. Prior research has found that guided notes increase the quantity of notes taken by students (Kiewra, 1991). In this study, the guided notes group already had the main points within the outline, and those did not count towards their total notes score. The results indicated that there was not a significant difference regarding quantity of notes between the methods of note taking. The outline may have aided the guided notes participants to record other idea units, but not enough to outscore the self-generated notes condition.

Mode of Note Taking

This study found that note taking mode was instrumental in performance on the multiple choice measure as well as the quantity of notes taken. Interestingly, there seems to be contradictory findings between the current study and prior research on note taking quantity. This may be explained by the nature of the notes taken by the two conditions.

The students who typed their notes took a significantly greater quantity of notes than students in the handwritten condition. This confirms our initial hypothesis, corresponding to previous research in which proficient typists can type faster than they can handwrite (Brown, 1988; Weintraub & Gilmour, 2010). Interestingly, previous research has indicated that quantity of handwritten notes is positively correlated with test performance (Risch & Kiewra, 1990). Following these statements, students who type their notes could be predicted to take more notes and enjoy the benefits of higher performance at test. However, the current study found that although the participants in the computer condition took more notes, the participants who took handwritten notes outperformed them on a multiple choice test.

The type of notes taken may explain this seemingly contradictory finding. Computer note takers have been found to take more verbatim notes (Mueller & Oppenheimer, 2014), which are considered to represent shallow processing of material (Bretzing & Kulhavy, 1979). Therefore, although the computer note takers took more notes than the students who took handwritten notes, the notes may have been lower quality resulting in reduced encoding and lower score on the multiple choice measure.

Although the mode (typed v. handwritten) was a significant factor in multiple-choice scores, there was no difference between modes on short answer questions. This may be explained through the inherent differences in short answer and multiple choice questions. The short answer items may have been too easy to detect differences between the groups, or a there could have been an issue with presenting the short answer questions before the multiple-choice questions.

Interaction

The interaction between method and mode was also examined. The results indicate that there was no interaction between method and mode of note taking. This is not surprising as the question was exploratory in nature and there was not sufficient preexisting literature on the topic.

Implications

The current study examined the influence of differing methods and modes of note taking on student note taking behavior and performance on outcome measures of lecture material. Students indicated preferences for certain forms of methods and modes of note taking over others. Only mode of note taking, not method, was found to be influential to performance on measures of student retention of lecture material. However, instructors can use information regarding both method and mode from this study to develop note taking interventions to increase student retention of lecture material.

Students seem to prefer printed outlines to other combined methods and modes of note taking. This is in line with previous research which has found that students generally prefer taking guided notes (Austin et al., 2002; Klemm, 1967; Salem, 2007) and handwriting their notes (Steimle et al., 2009). However, less than half of the students in this study reported that their instructors present them with printed outlines before lecture. Instructors may use this information to promote learning by providing students with printed outlines before class (or electronic copies in enough advance for students to print them). If students are presented with their ideal form of note taking, they may be encouraged to attend to the lecture and focus on their note taking.

However, previous researchers have found that even though individuals have preferences in how information is presented to them the preferences do not always lead to the best performance results (Pashler, McDaniel, Rohrer, Bjork, 2008). This mirrors the findings of the current study. Students generally preferred guided notes over self-generated notes, however, there was not a significant difference between each group's test scores.

It is important to note that this study only investigated the encoding function of note taking, not the external storage component of note taking. Although method was not instrumental for performance on the outcome measures from the encoding perspective, if the students had been given time to study their notes there may have been significant differences between groups. Several early studies found that students who received outlines spent a greater amount of time studying than students who did not receive supplementary material (Klemm, 1975; Northcraft & Jernstedt, 1975).

Similar implications can be made for the mode of note taking. Students in the computer notes condition took a greater quantity of notes than students in the handwritten notes condition. Previous research has found that students who take more notes perform better on performance measures than students who take less notes (Risch & Kiewra, 1990). Theoretically, students who take notes are able to better engage in the external storage function as they have more information to study after the lecture (Bui et al., 2013). Therefore, if there may have been detectable differences between the groups if the participants had been given an opportunity to study their notes before the examination period.

Limitations and Future Directions

It is important to consider several limitations within the current study. First, the video lecture may not have presented enough content to students for the detection of differences between groups on the outcome measures. The video was also much shorter in duration than a typical lecture, which may have resulted in lower ecological validity of the study.

Next, only the encoding function of note taking was examined. Most of the participants reported that they studied their own personal notes before class examinations. When students review their notes, they are engaging in the external storage function of note taking. It is possible that a certain method or mode of note taking would promote the review of notes more than others, resulting in differences on a delayed retention test.

Additionally, the short delay of the testing period after the video lecture may have influenced the results of the study. During college courses, lecture material may be presented weeks before an examination takes place. Future research should examine the external storage function of note taking of the various combinations of note taking method and modality.

The division of the outcome measures may have undermined differences between the note taking conditions. For this study, multiple test and short answer measures were chosen as they are common test formats for college courses. However, a previous found significant differences between conditions of note taking on measures that require deeper processing but not processing of basic facts (Katayama & Robinson, 2000). Future research should investigate the role of method and mode in performance on differing tasks requiring different levels of processing.

One of the main arguments against computer use in the classroom is that they are distracting to students (Aguilar-Roca et al., 2012; Kay & Lauricella, 2011). In this study, participants in the computer conditions knew that they (and their screens) were within view of the researcher at all times. Therefore, they may have been less inclined to engage in distracting tasks on their computer (i.e. checking mail) than they would have been in a typical college classroom. This may have reduced the ecological validity of the current study.

Another limitation of the current study is that students were not required to take a prior knowledge test of lecture material before the video lecture was presented. There may have been some students who had some knowledge about the material in the video before the study that would have impacted the scores on the outcome measures. In order to grasp how much prior knowledge each student had, a quiz over the lecture material could have been given to the participants before the video lecture was played. However, this could have caused differences in scores on the outcome measure through the testing effect (Carpenter, Pashler, & Vul, 2006)

Finally, the coding of note taking may have failed to identify the differences among the groups in regard to the quality of note taking. The note coding of the current study investigated the quantity, not necessarily the quantity of note taking. Even though note taking quantity has been positively correlated with test performance (Risch & Kiewra, 1990), other research has indicated that the quality of notes is more important to performance than quantity of notes (Mueller & Oppenheimer, 2014). Verbatim note taking, a known factor in impacting the quality of note taking, was not investigated in the current study. There may have been other differences in note taking behavior (i.e. development of graphs or examples) that were not evidenced by the coding system.

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Appendices

Appendix A

Guided Notes

Participant ID: The Science of Sleep: Structured Notes

The Stages of Sleep

Defining Sleep:

Stages	Characteristics
Awake State	
Stage 1	
Stage 2	
Stage 3	
REM Stage	

Sleep Architecture

The Timing of Sleep

The Purposes of Sleep

1.

2.

Lack of Sleep

Lack of sleep may cause:

Common Sleep Disorders

Appendix B

The Science of Sleep Quiz

Instructions: This exam has two sections: short answer and multiple choice. After turning a page **DO NOT** flip back to change your answers on previous pages.

Section One: Short Answer

1. What determines which sleep state you are in?

2. What is “paradoxical sleep?”

3. What is one way that you might be able to tell if an individual is in the REM stage of sleep?

4. You make a phone call to your friend who is sleeping. The friend says, “You just woke me up from the best dream!” Which stage of sleep was your friend likely to have been in when you made the call?

5. You make a phone call to your friend who is sleeping. The friend says, “I wasn’t sleeping when you called, I was closing my eyes for a second.” Which stage of sleep was your friend likely to have been in when you made the call?

6. What is sleep architecture?

7. On average, how many sleep cycles does an individual experience per night?

8. Why are people more likely to remember dreams that occur later in the night?

9. What is a circadian rhythm?

10. How long is an average individual’s circadian rhythm?

11. What is the environmental modulator for sleep?

12. Your friend is complaining about not being able to fall asleep. You notice that every night before bed, they are on their phone texting. Write a couple of sentences explaining why their behavior may be obstructing their sleep.

13. What is the purpose of the superchiasmatic nucleus?

14. Pretend you were trapped in an underground bunker for several months with no way of knowing the time of day. What would happen to your circadian rhythm?

15. Name and explain the possible purposes of sleep.

16. The video stated seven problems that may happen due to the lack of sleep. List as many from the video as you can:

17. Identify causes of insomnia offered in the video. List as many from them as you remember:

18. A friend complains that they have been unable to sleep well for months because they are so stressed about school and work. They say that every time they are in bed they worry about all of their upcoming deadlines. What type of insomnia might your friend have?

19. List characteristics of a person who may have a circadian rhythm disturbance.

Section Two: Multiple Choice

1. What are stages of sleep defined by?

   a. The amount of time a person has been sleeping
   b. The frequency of the brainwaves that occur in each stage
   c. The number of sleep cycles that occur
   d. The frequency of eye movements

2. During a class lecture, Dr. Hess notices one of his students is asleep. Dr. Hess calls the students name, and the student immediately wakes up. The embarrassed student then promises that he had never been asleep at all. This student was most likely in which stage of sleep?

   a. Stage 1
   b. Stage 2
   c. Stage 3
   d. REM Stage

3. During a sleep exam at a doctor's office, Phyllis begins to recite lines from her favorite movie. Phyllis is in which stage of sleep?

   e. Stage 1
   f. Stage 2
   g. Stage 3
   h. REM Stage

4. REM sleep is also called Paradoxical sleep because

a. The eye movements during REM sleep mimic many eye movements that occur during normal daytime routines
b. Dreams occur during this stage which are most similar to real life and daily activities
c. People who are awaken during this stage are not sure if they were ever really sleeping
d. The brainwaves during REM sleep are similar to those during wake periods

5. On average, how many sleep cycles are experienced during one night's sleep

a. 2-3 cycles
b. 4-5 cycles
c. 5-6 cycles
d. more than 7 cycles

6. As a person sleeps, which stage increases in length?

a. Stage 1
b. Stage 2
c. Stage 3
d. REM Stage

7. After studying with the use of a bright computer screen for several hours, Clarice feels fully awake, even though it is time for her to sleep. What hormone might Clarice be lacking?

a. Melatonin
b. Adenosine
c. Testosterone
d. Serotonin

8. When a person is exposed to light, their ____________________ produces less ____________________.

a. Thalamus: adrenaline
b. Superchiasmatic nucleus; melatonin
c. Hypothalamus; adenosine
d. Frontal lobe; serotonin

9. In order to raise awareness of issues regarding horse blindness, Natalie wears a blindfold for one month. At the end of the month, how long will Natalie's circadian rhythms last?

a. a little longer than 12 hours
b. almost 24 hours
c. a little longer than 24 hours
d. Lasts almost 48 hours

10. Which is most true regarding the purpose of sleep?

a. It protects us from predators
b. It gives our brains time to restore
c. It encourages us to be productive during hours with sunlight
d. Scientists are unsure of the exact purpose of sleep

11. Which of the following is NOT true regarding lack of sleep?

a. It causes cognitive impairment
b. People become more prone to accidents
c. When falling asleep after a lack of sleep, more REM disturbances occur
d. It suppresses a person's immune system

12. Which is the most common sleep disorder?

a. Insomnia
b. Restless leg syndrome
c. Narcolepsy
d. Circadian rhythm disturbance

13. Which is NOT a common cause of insomnia?

a. A noisy environment
b. Daytime napping
c. Consuming melatonin before bedtime
d. Smoking before bed

14. Julianne has been preparing for a difficult comprehensive exam for several months. Every night, Julianne lays in bed worrying about the exam and is unable to sleep. What sleep disorder is she likely to have?

a. Psychophysiological insomnia
b. Restless leg syndrome
c. Narcolepsy
d. Circadian rhythm disturbance

15. What symptom characterizes circadian rhythm disturbance?

a. Falling asleep when anxious
b. Sleeping during the day, while being awake during the night
c. Frequently waking up during the night
d. The inability to focus during daytime activities

When you have completed the last item, please DO NOT review your items. Just raise your hand to indicate you are finished to the experimenter.

Appendix C

Demographic Form

The following items provide us with basic information on all participants in the study. For each, please provide the answer that best fits your own explanation for yourself.

Gender: ______ male _______ female _______other

Age: ________

Race: ________________________________

University GPA (cumulative, best recollection): _________________

What were your college entrance examination scores?
(e.g. Scholastic Aptitude Test (SAT) Score or ACT)

SAT Verbal Score: ________

SAT Math Score: ________

SAT Total Score: ________

ACT Composite Score (if applicable): ________

University Major: _____________________________________

Year in University (Freshman, Sophomore, Junior, Senior): ____________________

Have you ever received any formal note taking training? If so, when and what kind?

Appendix D

For each of the following items, please select the interval that best describes your note taking preferences and note taking habits within academic courses.

When taking notes I tend to take notes with:	Never	Rarely	Sometimes	Often	All of the Time
Pen and paper					
A laptop					
An electronic tablet					
Printed PowerPoint slides provided by the course instructor					
A printed outline of the lecture provided by the course instructor					
An electronic copy of PowerPoint slides provided by the instructor					
An electronic outline of the lecture provided by the instructor					

My notes have a higher quality when I use:	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
Pen and paper					
A laptop					
An electronic tablet					
Printed PowerPoint slides provided by the course instructor					
A printed outline of the lecture provided by the course instructor					
An electronic copy of PowerPoint slides provided by the course instructor					
An electronic outline of the lecture provided by the instructor					

	Never	Rarely	Sometimes	Often	Always
My instructors provide lecture notes to students before class					
My instructors provide PowerPoint slide to before class					
When I study for course exams, I rely on other students' lecture notes					
I have another student take lecture notes for me.					
When I study for course examine, I review my personal lecture notes					

My understanding of lecture materials is greatest when:	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
The instructor provides me with a printed outline of the lecture before class					
The instructor provides me with printed PowerPoint slides before class.					
The instructor provides me with an outline of the lecture before class					
The instructor provides me with an electronic copy of the PowerPoints before class					
I do not take notes during class, but focus on listening to lecture materials.					