Question Everything: A Critical Examination of Faculty Beliefs Concerning Learning Strategy and Learning Styles

by
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Abstract

Students make many questions and decisions in academia concerning learning. One of the most critical among them is what learning strategy to use. In this study, faculty members from various Ontario (Canada) colleges and universities were surveyed to examine their opinions on learning strategy effectiveness and on whether learning styles exist as an advantage for learners. This study compares the opinions of faculty members on learning strategy to the evaluation of learning techniques outlined by John Dunlosky's research team (Dunlosky et al., 2013) and to the best evidence concerning learning styles as an advantage for learning (Pashler et al., 2008; Massa & Mayer, 2006). While several key factors were examined (for example, the faculty's highest degree, employment status, number of years teaching, and institution type), the results produced mixed evidence for faculty opinions against the best evidence. As well, demographic differences among the groups of teachers were not meaningful predictors of their opinions. Even though faculty opinions were not in line with recognized evidence, learning is a complicated situation, and theories will be presented to examine the disconnect between the instructors' opinions and the best evidence.

Keywords: learning strategies, learning, learning styles

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Chapter 1: Inspiration for This Project and Introduction

Inspiration for This Project

The inspiration for this project came from a love of teaching. In total, I have been teaching for about 15 years: seven years at Fanshawe College (partial load; three semesters a year and 3-4 courses per semester) and the last eight years at Cambrian College, currently in the role of coordinator of psychology.

I am passionate about teaching and am constantly inspired by my students as they push through incredible barriers, such as financial, mental (various pathologies, test or speaking anxiety), physical (developmental challenges), and more, to achieve their goals. The last few years have been particularly inspiring, watching students overcome challenges associated with the pandemic, including transitioning to (mostly) online learning, working in a pandemic pre and post vaccines, coping with isolation, and other physical/mental health challenges. I love watching students who report memory issues or test anxiety push through their fears, students who report hating and struggling with academic writing produce fantastic essays and seeing students, who have said they have public speaking anxiety, stand up in front of a whole class of 40 students, and deliver terrific oral presentations. These moments make teaching, a sometimes-challenging job, worthwhile.

I realized I needed to learn how to instruct when I started teaching. At first, the solution was to attend as many teacher-training sessions as possible and to gain mentorship. The first 2-3 semesters of my teaching career were all about surviving: not only learning how to teach but also creating courses from scratch, learning about how the online learning system works, and delivering materials and assessments verbally (and non-verbally) to students in class. At first, I did not have the time to look at the research on student success, explicitly learning or study strategies. The two terms, learning strategy (or technique) and study strategy (or technique), are interchanged within the framework for this research (Dunlosky et al., 2013) as well as other research. For example, while the title of the Dunlosky et al. (2013) paper is “Improving Students’ Learning With Effective Learning Techniques”, the authors interchange study and learning in the article: “but certainly summarization would be better than the study strategies students typically favor, such as highlighting and rereading” (p. 18). In addition, Dunlosky and colleagues’ (2013) framework for the rankings involved examining previous research, and seven references have the concept of ‘study strategies’ (for example: Carrier, 2003) and ‘learning strategies’ in their titles (Lee et al., 2010). Morehead et al. (2016), a research paper that used the framework of Dunlosky et al. (2013), also interchanged the words learning and study strategies. While the title of the article is “Instructor and student knowledge of study strategies”, the authors suggested that studying stimulates learning: “previous studies have examined students’ beliefs, habits and knowledge of strategies that promote effective learning” (p. 267). Therefore, in this research, the terminology learning strategy will be used rather than study strategy.

It took about a year, and I decided to dive deep into academic research on teaching. I started researching learning or study strategies and quickly realized that very few teacher trainers, and teacher training textbooks followed the literature. They strongly suggested various strategies (or techniques) not backed by academic research, such as studying from notes or re-reading the textbook. This shocked me as I was always told to focus on the textbook in my academic career as a student. As I started reading the various studies where, in an experimental design with controls, the researchers compared studying from notes or re-reading the textbook against practice testing, the former consistently lost, and the students who tested themselves not only performed better on the test, but they also remembered the material(s) for a much more extended period. I decided to change my tactics, and almost immediately, test scores improved, and student test anxiety seemed to decrease from the feedback I received.

I now incorporate a strategy entitled our “Weekly Recall Mock Tests,” where I quiz the students, using recall, on various concepts in my courses. For example, in “Introduction to Psychology,” I give the students a list of terms to study in week one. I mock-test them on those terms in week two and introduce a new set for week three. On week three, I start with the terms from week two (the first set) and add the concepts from week three. This process, adding and practice-testing, continues until we get to the actual test. Over the last decade, I have received an incredible number of stories from students who have used the practice testing technique, along with other evidence-based supported strategies discussed in our class and have reported a variety of success stories ranging from long-term recall to a reduction in text anxiety, to better time management. Students can indeed confirm what concepts they know/do not know, saving them time as they approach a test.

My next “aha” moment came when I investigated learning styles' research. The concept of a learning style was widely taught in almost every teacher-training workshop or textbook I had read, especially at the beginning of my career. Later in this paper, various literature definitions of a learning style will be presented, but the basic belief suggests that individuals learn more efficiently with a technique that matches their preferred style (Pashler et al., 2008). I explored and quickly found little to no evidence-based research to back up the theory, yet the concept is pushed heavily in academics and business (through various assessment tools). In my first year of teaching, there was even a workshop on learning styles, where the teacher-trainer gave a digital handout for instructors to use in their learning management systems (LMS). I accepted that learning styles existed and even uploaded the handout to my LMS and talked about it in my first and second years of teaching. After learning about the lack of evidence-based research, I quickly deleted the handout and moved toward educating my students on the lack of evidence. The talks were met with student confusion and even push-back, but the real repeal came from other teachers and teacher-trainers. It was met with resistance when I talked about the lack of evidence, even giving academic research articles that negate the concept of learning styles. The resistance has decreased in the last 5–6 years as the research on learning styles has gained traction, but I still feel like the myth of learning styles strongly persists.

For the reasons above, I wanted to investigate learning strategies and learning styles in a way that added to the research. While hundreds of academic journal articles probe learning strategies/styles, none compares Canadian college and university faculty to my knowledge. Canada has two distinct levels of post-secondary education: college and university. The Government of Ontario (2023) states, "Colleges offer certificate programs, diplomas, apprenticeships, and degrees. Universities offer undergraduate and graduate degrees and other professional programs. All programs vary in length and prerequisites — the pre-work or qualifications you need to be eligible for a program" (para. 3).

Introduction

What is Learning?

Learning is a very complex concept; when we hear the words learning, academics, or school, studying probably comes to mind. Learning takes place every day, whether in school or at work, and at every age ranging from babies learning to walk or understand language to listening to our favourite song and memorizing the lyrics or musicality. Houwer et al. (2013) even suggest that "even influential textbooks on learning do not always contain a definition of its subject matter" (p. 631), and the definition of learning is "difficult to define" (p. 631).

Houwer et al. (2013) reference how most definitions of learning involve a change in behavior due to experience but describe the interpretation as unsatisfactory. The caution in such a basic definition of learning is due to the challenges that a behavior change may not be necessary for learning to happen. An example given by the authors includes a loud noise that startles someone: the noise changes behavior through a reaction, but learning may not have occurred. Other examples include fatigue or lack of motivation, both change behavior, but may not include learning. Therefore, according to Houwer et al. (2013), "learning cannot be defined merely in terms of changes in behavior" (p. 632). The authors also refer to the behavioral change aspect of learning as sometimes being a specific mental process. Does a change in a specific mental process always involve a behavior change? Are both a mental process and behavioral change required for learning? Does this behavioral or mental change happen during the new learning experience, or can it happen over time? What are the criteria for learning to occur? According to Houwer et al. (2013), learning has three components: changes in behavior, regularity in the environment, and a causal relation between the first and second components. On the first component of behavior, the authors stress that the term behavior is very broad, and the behavior can include any response from the learner. For example, any observable response from the autonomic nervous system to even conscious thought. The second component, regularity, refers to "all states in the environment of the organism that entail more than the presence of a single stimulus or behavior at a single moment in time" (p. 634). The final component, the causal relation between the previous two components, means the behavior itself is a part or function of the environmental element or elements. The authors believe the causal relationship to be functional and not a force that causes the behavior itself (Houwer et al., 2013).

The concept of learning is a significant area of research in many disciplines, including psychology, neuroscience, and computer science or machine learning, but definitions vary, which can cause confusion across interdisciplinary research. For example, the discipline of psychology may define learning as trial and error, accident, imitation, a change in behavior or mental processes, acquiring information, or a process necessary for adaptation. The discipline of neuroscience may define learning as information input/processing/storage, as a process for acquiring memory/knowledge/new information, or adaptation. The discipline of computer science or machine learning may define learning as the ability to gain or develop new skills from existing examples, synthesize knowledge, and change the behavior of the machine due to gaining new knowledge (Barron et al., 2015). For a comprehensive paper on the various definitions of learning from multiple disciplines, please see Barron et al., 2015.

For brevity, learning can be defined as an experience that "causes a relatively permanent change in an individual's knowledge, or potential for behaviour. The change may be deliberate or unintentional, for better or worse, correct or incorrect, and conscious or unconscious" (Woolfolk et al., 2020, pp. 233-234).

Considering the constant change in the modern world, students are bombarded with an enormous amount of knowledge, and academic researchers have provided various theories to explain how learning works. To go over each learning theory in detail is beyond the scope of this paper; however, the following learning models will be discussed: behavioural, cognitive, social cognitive, and the learning sciences and constructivism.

Behavioural Theories of Learning

This branch of learning centers around the role of the environment, and there are two major theories: classical conditioning and operant conditioning. Pavlov, the founder of classical conditioning, believed that learning could happen via association. Pavlov's classic experiment found that pairing a previously neutral stimulus with a new stimulus after repeated exposure creates a physiological or emotional response. Later, when the new stimulus is alone, without the neutral stimulus, it can evoke the same physiological or emotional response. Pavlov famously used the example of dog food, making the animal salivate, and then pairing the food with a bell. Later, the bell alone made the dog salivate. Another example might be the sound of a dentist's drill creating anxiety or nervousness about getting in front of a group of people to speak. In these examples, learning happens due to associations between two stimuli.

In addition, BF Skinner, the founder of operant conditioning, believed that learning could happen due to reinforcement or punishment. First, reinforcement would indicate an increase in behaviour, while punishment would mean a decrease in behaviour. Second, reinforcement and punishment can have positive and negative categories. Positive implies an increase or decrease in behaviour due to the addition of a stimulus. Negative means an increase or decrease in behaviour due to the removal of a stimulus. Therefore, positive reinforcement would increase behaviour due to the addition of a stimulus. Negative reinforcement would be an increase in behaviour due to removing a stimulus. Positive punishment would be a decrease in behaviour due to the addition of a stimulus. Finally, negative punishment would be a decrease in behaviour due to removing a stimulus.

There is also the concept of “schedules of reinforcement” (see Table 1), where learning could occur due to a reinforcement's appearance.

Table 1

Reinforcement Schedules

Schedule	Definition
Continuous	Reinforcement after every response.
Fixed Interval	Reinforce behavior after a set number of responses.
Variable Interval	Reinforce after an unpredictable number of responses.
Fixed Ratio	Reinforce the response after a fixed time-period.
Variable Ratio	Reinforcement after an unpredictable time-period.

The strengths of the behavioural theories of learning include measurement as classical and operant conditioning, as well as the schedules of reinforcement, and can easily be measured. Critics of behavioural approaches point to learning vs. performance - whether learning is happening or if the response is only a reflex or something the individual is conducting. Finally, critics also point to ethics, specifically the possible misuse of rewards or punishment as a learning method, as they could harm learning (Myers & DeWall, 2020; Woolfolk et al., 2020).

Cognitive Theories of Learning

The cognitive view of learning "considers learning as an active mental process of acquiring, remembering, and using knowledge (Woolfolk et al., 2020, p. 267). While there are several cognitive theories of learning, one of the more popular revolves around information processing. The concept of information processing involves how humans encode information starting with input that is processed by sensory memory (sight, sounds, smells), working memory (where memory is held temporarily while processing sensory memory), short-term memory (holds a few items briefly), and long-term memory (relatively permanent storage of the memory system). Numerous factors contribute to the encoding, storage, and retrieval of information, such as attention, perception, and type of processing. For example, with processing, there is bottom-up (data-driven or object analyzed into components to decipher) or top-down (using context or already learned knowledge to decipher). Memories can also be coded in different methods: explicit memories (encoded through conscious, effortful processing) and implicit memories (encoded unconsciously).

The strengths of the cognitive approach to learning include practicality (which can be used in a variety of learning tasks) and measurability, as the theory is very experimentally based. The challenges to the cognitive approach are the difficulty in observing the encoding strategies and ignoring behavioural factors that could influence learning (Myers & DeWall, 2020; Woolfolk et al., 2020).

Social Cognitive Theory of Learning

The root of the social cognitive learning theory revolves around Albert Bandura, the theory's founder. Bandura believed that learning happens through observing others, thinking about the task, and replicating (Myers & DeWall, 2020; Woolfolk et al., 2020). Bandura believed that behaviourism had shortcomings:

> I found this behavioristic theorizing discordant with the obvious social reality that much of what we learn is through the power of social modelling. I could not imagine a culture in which its language; mores; familiar customs and practices; occupational competencies; and educational, religious, and political practices were gradually shaped in each new member by rewarding and punishing consequences of their trial-and-error-performances. (Bandura, 2007, p. 55).

While there are many factors to observational learning, one of Bandura’s more famous is the concept of self-efficacy. The idea of self-efficacy implies that the more confident a person believes in their capability to model behaviour, the more likely that person will attempt the behaviour.

The strengths of Bandura's theory are many, including integrating cognitive and social theories and the fact that humans learn from the environment in some capacity. Critics of Bandura's theory cite ignoring emotions, imagination, and creativity when explaining human learning (Myers & DeWall, 2020; Woolfolk et al., 2020)

The Learning Sciences and Constructivist Theories of Learning

Learning sciences could be interpreted as an interdisciplinary field combining many disciplines that research learning, including psychology, education, neuroscience, sociology and more. The learning sciences have five basic assumptions: (1) experts have deep knowledge, (2) learning comes from the learner, (3) effective learning environments must be created by the institution, (4) previous knowledge is essential, and (5) reflection is paramount to success.

Constructivist theories "emphasize[s] the active role of the learner in building understanding and making sense of information" (Woolfolk et al., 2020, p. 346). Constructivist theories accentuate two key concepts: the learner constructs their own knowledge, and the building of the knowledge comes from social interactions (Woolfolk et al., 2020). A summary of the general explanations of knowledge construction can be found in Table 2.

Table 2

How Knowledge is Created

Type	Assumptions about Learning and Knowledge	Example Theories
External Direction	Knowledge is acquired by constructing a representation of the outside world.	Information processing
Internal Direction	Knowledge is constructed by transforming, organizing, and reorganizing previous knowledge.	Piaget
Both External and Internal Direction	Knowledge is constructed based on social interactions and experience.	Vygotsky

Note. Adapted from Woolfolk et al. (2020, p. 349).

The strengths of constructivist theories include the ability to develop critical thinking, analysis, and evaluation skills due to the learner's active role in building their knowledge. The theory also focuses on reflection, a critical skill that allows learners to evaluate their competencies and adjust as necessary or required. Critics of constructivist theories point to the lack of structure as learners are encouraged to self-teach or self-learn, which could pose various challenges depending on the learner's ability to think, analyze, evaluate, and reflect (Woolfolk et al., 2020).

Students have many questions and decisions to make in academia concerning studying. What material should I study? In what order should I study the material? Should I study with a friend from class? Should I study in a group? Should I study alone? What time of day should I study? During the day? In the evening? How long should I study? When should I stop? So many questions, but perhaps the most critical inquiry is what strategy to use. What if specific study strategies are more effective than others? This paper approaches the literature critically and examines various learning strategies and their effectiveness.

What is a Learning Strategy?

The definition of a learning strategy varies. First, Chamot (2004) stated that learning strategies are mindful thoughts and actions that students use to achieve a goal that requires metacognitive knowledge concerning their thinking strategies, what the goal entails, and their ability or abilities to accomplish it. Woolfolk et al. (2020) defined learning strategies as "a special kind of procedural knowledge – knowing how to approach learning tasks" (p. 307). Various authors (Rachal et al., 2007; Van Hout-Wolters, 1992) have defined learning strategies as having a goal-oriented focus to improve learning. Pressley et al. (1989) defined learning strategies as "processes (or sequences of processes) that, when matched to the requirement of tasks, facilitate performance" (p. 303).

Schellings (2011) agreed with the variety of definitions and terminology, referring to alternative terms such as methods, techniques, or skills to achieve a learning goal but also distinctions in the cognitive (executive section to acquire knowledge), metacognitive (regulative section to direct learning), and affective (self-management section) learning strategies. Donker et al. (2014) agreed with the distinctions, defining the cognitive strategy to "increase understanding" (p. 3) about a particular concept, the metacognitive strategy as a regulator of cognition, and the management strategy as "strategies to manage the aspects in the context which directly influence the learning process" (p. 3). According to the authors, all three levels have subcategories: for example, the cognitive strategy uses rehearsal, elaboration, and organization sections. The metacognitive strategy includes planning how to approach the learning, monitoring how the strategy or strategies work, and evaluating how well the techniques work after the task is completed. The management strategy includes the management of effort, peers/teachers, and environment.

Finally, Dansereau (1985) stated that an effective learning strategy is defined as a process to acquire, store, and utilize information but varies across four dimensions. First, the learning strategy can be primarily directed towards a specific goal or can have an indirect impact on learning. Second, the learning strategy can be fixed (algorithmic) or modified/changed (heuristic). Third, learning strategies can differ in scope, for example, applied to a large set of materials or a few words. Fourth, learning strategies can vary depending on their specific task.

How does learning differ from a learning strategy? As noted, defining learning can be challenging, with multiple definitions, agreements, and contradictions. Many definitions mentioned earlier in this document refer to some form of behavior change and interaction with the environment. While implementing learning strategies involves a form of behavior and interaction with the environment, the definition differs from learning itself. When using learning strategies, students are intending to influence the way they process information (Mayer, 1988). According to Mayer (1988), learning strategies could be used to focus attention on certain information and build connections between old and new knowledge. According to Flippo and Caverly (2000), "strategies have cognitive, metacognitive, and affective components" (p. 178), implying a behavior that is dependent on student motivation and previous knowledge. Therefore, to summarize, learning strategies could be viewed as behaviors or mental processes that facilitate learning (Weinstein et al., 1989).

While this research focuses on learning strategies and learning styles, the concept of memory must be addressed briefly. Cognitive researchers Daniel Willingham and Milton Dehn both stress the importance of being aware of memory and how it affects student success. In Willingham (2021), the author describes how thinking works, specifically citing the importance of understanding working memory (the holder of temporary information) and how thinking happens when working and long-term memory are accessed. Willingham makes the argument that understanding how to manipulate working memory is essential to thinking and learning. Similarly, in Dehn (2013), the author echoes Willingham's thesis but focuses on working memory and cognitive load, defined as the limited capacity of working memory, which can lead to learning challenges. Dehn (2013) suggests many cognitive load variables, such as the amount of material presented during a learning session, the sequencing of the material, previous knowledge of the learner, and how the material is organized. The author also examines teacher behaviors that are linked with cognitive load, including the faculty's language, length of the lesson, organization of instruction, elaboration of concepts, and the time allowed for processing. Similar solutions for cognitive load in the classroom were suggested by both authors, including the faculty providing examples, having only one source for the information at a time, providing materials in advance so students do not have to take extensive notes, presenting moderate problems to be solved (not too difficult), changing lecture pace, and keeping a diary of what works in the classroom. As evidenced by Willingham (2021) and Dehn (2013), the principle of working memory and its relationship to learning strategies must be kept at the forefront when implementing the strategies in the classroom. This dissertation will be divided into two sections: one addressing learning or study strategies and the other learning styles. First, concerning learning or study strategies, the inspiration and framework for this study came from Dunlosky et al. (2013), where the authors ranked various learning/study strategies. The first section will review the paper's methodology and summarize the authors' reasoning for the strategy rankings. Next, this research added supplemental learning/study strategies (flashcards, studying in groups, diagrams, and asking questions in class), and a brief literature review will be presented for each of them. At the end of section one, this paper will examine research on (1) whether students use evidence-based learning/study strategies, (2) whether instructors recommend evidence-based learning/study strategies and (3) whether heads of academic support centres endorse evidence-based learning/study strategies. The second section will focus on learning styles, starting with definitions, a breakdown of the various learning style instruments, the number of perceived learning styles, and the prevalence of learning style beliefs. Afterwards, this paper will examine the literature that questions the existence of learning styles as an advantage for learning, along with a list and prevalence of various neuromyths that are the consequences of believing in learning styles, and various explanations for the learning style belief being so prevalent in society.

Chapter 2: Literature Review—Study/Learning Strategy Effectiveness

Dunlosky et al. (2013) on the Topic of Learning Techniques

The inspiration and framework for this research project was Dunlosky et al. (2013), where the authors completed a comprehensive breakdown of 10 learning techniques, including (1) elaborative interrogation, (2) self-exploration, (3) summarization, (4) highlighting/underlining, (5) keyword mnemonic, (6) imagery for text, (7) re-reading, (8) practice testing, (9) distributed practice and (10) interleaved practice. Dunlosky et al. (2013) picked the strategies based on the following criteria:

- the literature stated improved student success
- the literature indicated students use them frequently
- the strategies could be used without any assistance or training
- the literature on each strategy was enough to assess efficacy and
- whether there was enough empirical evidence available to evaluate

Dunlosky et al. (2013) also stated that they examined educational-psychology textbooks as "teachers are most likely to learn about these techniques" (p. 5) using those types of resources but noted that the textbooks were limited. For each strategy, Dunlosky et al. (2013) elaborated on

- why the strategy works
- past research on each strategy
- the strengths and limitations and
- the strategy's performance in four criterion tasks (see below).

Afterward, Dunlosky et al. (2013) ranked the ten learning strategies into low, moderate, and high categories. Dunlosky et al.'s (2013) aim was "to encourage student use of the appropriate learning technique (or techniques) to accomplish a given instructional objective" (Dunlosky et al., 2013, p. 7). The researchers also gave an opinion on whether the bulk of the strategy research was completed in a lab (non-representative of education settings) or a classroom (representative of a traditional face-to-face educational settings).

The strategy evaluation included four categories: materials, learning conditions, student characteristics, and criterion tasks. First, the material category refers to "the specific content that students are expected to learn" (Dunlosky et al., 2013, p. 6). Examples included vocabulary, lecture contents, definitions, mathematical concepts, maps, and diagrams. Second, the learning condition category referred to "aspects of the context in which students are interacting with the to-be-learned materials" (Dunlosky and colleagues, 2013, p. 6). Examples included the learning environment (for example, noisy or quiet), amount of practice, open or closed book practice, reading or listening, type of practice tests, and group v. individual learning. Third, student characteristics refer to many individual influences, including age, prior knowledge, memory capacity, verbal ability, motivation, and confidence. Finally, the category of criterion tasks referred to retention and included cued v. free recall, recognition, problem-solving, argument development, essay writing, tests, and quizzes. Dunlosky et al. (2013) used the four criteria categories based on a book by Jenkins (1979), a framework that weighs information retention over other cognitive possibilities.

The high category was given if the strategy was generalized (ability to use technique across many environments) and improved student learning across many criterion tasks. The moderate category was given if the strategy was generalized across some variables but fell short of getting a high rating due to limited evidence of efficacy. The low category was given for several reasons, including limited benefits, requiring additional research, and weaker performance relative to other strategies. Dunlosky and colleagues (2013) also stated that the strategies given a low ranking could be helpful in specific contexts. Table 3 shows the breakdown of Dunlosky et al.'s (2013) rankings:

Table 3

Learning Strategy Assessment by Dunlosky et al. (2013)

Technique	Rank
Summarization	Low
Highlighting	Low
The keyword mnemonic	Low
Imagery	Low
Re-Reading	Low
Elaborative interrogation	Moderate
Interleaved practice	Moderate
Practice testing	High
Distributed practice	High

Finally, Dunlosky et al. (2013) cited numerous limitations to the scope of their research, including insufficient evidence in various generalizability categories (learners, materials, criterion tasks, issues for implementation, and educational contexts). For example, concerning educational contexts (how well the strategy has been researched in a real-life institutional setting), only highlighting and practice testing received a rating. In contrast, all the other strategies got an insufficient or partially insufficient rating. Dunlosky et al. (2013) also stated other challenges, such as using only in-person classroom-related techniques and how "an exhaustive review of the literature is beyond the scope of this article" (p. 30) for the keyword mnemonic, practicing testing, and distributed practice. The following section summarizes Dunlosky et al.'s (2013) conclusions by strategy, including a description, advantages/disadvantages, and effectiveness across the criteria mentioned earlier. All the Dunlosky strategies were used in this research, except self-explanation, a moderately rated technique by the authors, which involves "explaining how new information is related to known information or explaining steps taken during problem-solving" (Dunlosky et al., p. 6). The reason for the strategy omission in this research was the addition of non-Dunlosky strategies to keep the number of strategies in the survey from getting too long and cumbersome for the participants. Additional research will be included: both referenced in the Dunlosky paper and supplementary investigation where gaps were highlighted in the research article.

The Dunlosky et al. (2013) research article was chosen as the framework for this research due to being one of the most cited papers on learning/study strategies. As of February 2023, the paper had 3445 citations. The main author, John Dunlosky, has over 28,000 citations in his career (John Dunlosky, n.d.), with the second author, Katherine Rawson, having over 12,000 citations, according to Google Scholar (Katherine A. Rawson, n.d.).

The Dunlosky et al. (2013) article has not only been cited over 3000 times, but the framing has been used by many of the most referenced authors in the education field. For example, Jennifer McCabe, a researcher in the fields of cognitive psychology, memory, metacognition, and learning/study strategies (Goucher College, n.d.) has over 900 citations (Jennifer A. McCabe, n.d.) and cited the Dunlosky study/framework in several papers (for example, McCabe et al., 2021). Two other frequently cited authors in the learning/study strategies field, Kayla Morehead and Matthew Rhodes, have been cited regularly (405 and 6942; Kayla Morehead, n.d.; Matthew Rhodes, n.d.) and have used the Dunlosky frame in various articles (for example, Morehead et al., 2016). Andrew Elliot, a researcher in the field of achievement motivation with over 9,700 citations (Andrew J. Elliot, n.d.), used the Dunlosky rankings, specifically referring to retrieval being superior to re-reading (Wallace et al., 2022). Finally, Roger Azevedo, a researcher in metacognition and self-regulated learning (University of

Rochester, n.d.) with over 21,000 citations (Roger Azevedo, n.d.), has referenced Dunlosky in multiple articles (for example, Azevedo et al., 2012).

With over 3000 citations for the article (Dunlosky et al., 2013) and many authors using the framing, criticisms on the authors' ranking system were difficult to find. One article by Daniel and Chew (2013) discussed the limitations of academic research in general, citing Dunlosky and colleagues (2013) specifically. In the paper (Daniel & Chew, 2013), the authors' thesis discussed the limitation of research conducted in controlled classes as it "may [still] not apply to the full pedagogical context" (p. 364). The authors believed that learning is "a complex interaction of multiple factors" (p. 364), such as "the topic, the state of knowledge of the student, the mental mind-set of the student, the study strategies employed by the student, the pedagogical strategies employed by the teacher, the characteristics of the teacher, and the assessment method" (p. 364). Daniel and Chew (2013) further explained that learning variables would vary according to pedagogical context (from critical to counterproductive), their impact differs across academic situations, and the teacher must individualize the variables to their students' or class's individual circumstances. When citing Dunlosky et al. (2013), the authors addressed the spacing effect and Dunlosky's ranking of high effectiveness, pointing to the limitations in the Dunlosky article, such as the lack of specific guidelines (for example, no optimum exact timeline between lecture and test), its limitation for short-term memory, and how students may not have the time to study over a longer period (Daniel & Chew, 2013).

Finally, a meta-analysis of Dunlosky et al. (2013) was performed by Donoghue and Hattie (2021), where the authors looked at the studies (N = 242) used by Dunlosky et al. (2013) to establish their ranking system. The study gave some insight into the articles used by Dunlosky et al. (2013): first, the papers ranged from 1929-2014, most participants were post-secondary undergraduate students (65%), an average range of abilities (86%), included experimental and control groups (91%), and surface learning conditions (93%). When looking at the meta-analysis results against Dunlosky's rankings, the authors concluded that there was a confirmation of the major findings in Dunlosky et al. (2013). For example, many of the rankings corresponded to the effect sizes; however, "some of the low effects were very close estimates to the moderate" (p. 6), including mnemonics and re-reading. Donoghue and Hattie (2021) noted the self-reported limitations by the authors of Dunlosky et al. (2013) but stressed that 93% of the research used by Dunlosky et al. was surface learning, not deep learning, and perhaps the rankings do not align with deep level learning. Donoghue and Hattie (2021) also noted that a limitation of the rankings, or suggested use or disuse of the strategies, may depend much on the students' self-regulation.

Summarizing

Description: writing summaries/notes of various lengths from required textbooks or other sources for learning purposes.

Dunlosky learning strategy effectiveness rank: low

The technique name summarizes what it does: students write summaries or notes for the material they need to learn. Considering the large amount of information students get in each semester, condensing the material into small or more digestible amounts might be required. There are also some differences in the definitions of summarizing and note-taking. Summarizing implies identifying essential information within a source and re-writing the information in a more condensed form. Summarizing could indicate that the student has unlimited time, while note-taking could be interpreted as a time-constrained lecture. During a lecture, students are influenced by several cues and signals from the instructor, such as breaks in speaking fluency, stressing certain words while speaking, and physical cues, such as pointing to the screen or explicitly telling students to write something down (Titsworth, 2001).

Due to various strategies and consistent research design challenges, the technique gets a low rating from Dunlosky et al. (2013). First, every study has different methods of implementing the strategy, including single words, single sentences, short paragraphs, and long paragraphs. Second, the researchers mentioned how summarization research focuses on training students to write better summaries and the benefits of writing more efficient notes, suggesting an emphasis on quality rather than the quality of learning. Third, there is another problem with summarization: according to research, students are not good at taking notes (see literature review below). If the study does not train students to take effective notes, it could affect the quality of the notes and not necessarily the ineffective strategy.

Why are students not very efficient in taking notes? The most obvious reason students do not take efficient notes is how fast teachers talk v. how fast students can write. If a student writes approximately half of a word a second and the average teacher speaks at a rate of about 2-3 words a second, it can be problematic to take notes live during a lecture (Foulin, 1995). Another challenge with notetaking, students may believe they are good at it: Morehead et al. (2019) surveyed 312 undergraduate students and found that 89% stated that they take 'good notes'.

The modern challenge with student note-taking behavior is the introduction of technology in the form of computers, laptops and tablets. First, studies report that students like laptops in the classroom (Trimmel & Bachmann, 2004); however, Morehead et al. (2019b) found that 46% of undergraduate students took notes on a laptop compared to 86% who reported using longhand in a notebook. When asked why a certain percentage of students used both longhand and laptop use, they reported using a laptop when the faculty spoke too quickly (20% of participants), when PowerPoints were made available before the tutorial (20%), or it depended on the class (20%).

The debate surrounding notetaking is whether the processing of lecture material is stronger with a pen, as students may need to put in more effort to write than type. The research is mixed: Granberg and Witte (2005) found no significant differences between laptop and non-laptop sections in overall class grades, while Mueller and Oppenheimer (2014) found the pen/paper to be more efficient. Morehead et al. (2019a) replicated Mueller and Oppenheimer's (2014) study and found no significant differences between the pen and the keyboard concerning test grades. A meta-analysis conducted by Allen et al. (2020) looked at 14 studies (3,075 participants) on long-form vs. keyboard notetaking in the classroom and found that "students taking notes employing longhand written notes scored better on exams and course grades than students using laptop or electronic systems to take notes" (p. 148). Additionally, the authors noted such a gradual grade decrease with devices that the solution of "banning" (p. 151) was suggested, observing that "such a step, may be perceived as a teacher misbehavior; however, such a solution demonstrates some merit" (p. 151).

Unfortunately, while student laptop note accuracy vs. paper/pencil research is non-existent, some studies challenge the use of technology in class due to distractibility. In a study by Fried (2008), students reported significant time spent multitasking on laptops compared to the non-laptop group and, most importantly, both the laptop and non-laptop students in the class were distracted by the technology being in the classroom. Ravizza et al. (2017), in an aptly titled article called "Logged in and Zoned out", found that "non-academic internet use was common among students who brought laptops to class and was inversely related to class performance" (p. 171) even when controlling for student motivation, interest and intelligence. Finally, Regan et al. (2014) found that students who used laptops in the classroom took notes or were on-task only 37% of the time.

The other challenge with student notetaking in class is cognitive overload. In many classrooms, teachers expect students to watch a PowerPoint screen, listen to their words, watch visual prompts, and write simultaneously, which may not provide the best learning conditions. A literature review on note-taking accuracy suggested that students get about 60% of the necessary information (Locke, 1977), while first-year students get only 11% of the required material from notetaking (Hartley & Marshall, 1974). Kiewra et al. (1987) completed a research study examining the main and supporting ideas. While students got 90% of the main ideas, they only got 11% of the supporting ideas in their notes. Therefore, there is another challenge with any research design surrounding notetaking and retention. Using the Kiewra et al. (1987) study above, if students in that scenario were tested 50/50 on leading and supporting ideas, perhaps, students would not do as well on the test. But, if they were tested 70/30 on leading and supporting ideas, the results would indicate that students had great note-taking ability. Thus, the research has a significant challenge: it depends on how the research study defines the main and supporting ideas and the breakdown of those concepts on the test.

On learning conditions, Dunlosky et al. (2013) concluded that the number and variety of summaries could "influence learning and retention" (p. 16), including simple notes (only a header), single sentences, or complicated and in-depth paragraphs. Dunlosky et al. (2013) noted a debate about the length of summaries and what is needed to be considered efficient for learning, and whether the material to be learned should be present during the summarization process. Next, for the criteria of student characteristics, Dunlosky et al. (2013) noted that most of the research used undergraduate students and how general writing skills, interest in the subject, and prior knowledge could influence summarization effectiveness. On materials, the majority of the research mainly used prose passages on various subjects (not manipulated by the experimenters). Still, it noted that the "length, readability, and organization of the text might all influence a reader's ability to summarize it" (Dunlosky et al., 2013, p. 17).

In sum, the researchers were concerned about the large variety of text and suggested additional research must be performed to test the differences and confirm the efficacy of summarization. Finally, on criterion tasks, Dunlosky et al. (2013) stated that most research on summarization used retention and comprehension on various tests such as multiple-choice, cued recall, or free call. On a positive note, summarization could also increase metacognition as students could think about and reflect on the quality of their notes after an assessment. Dunlosky et al. (2013) highly praised summarizing research, stating that most academic research has been done in real-life classrooms under many different conditions.

Unfortunately, studies have shown summarization to have challenges, including different performances depending on the task type, such as application v. synthesis (Annis, 1985) and generative (essay or free recall) vs. multiple-choice (Bednall & Kehoe, 2011). Research from Brozo et al. (1985) also showed that training in summarization did not affect performance on high-stakes tests. Further, studies have demonstrated that summarization has robust test delays over several days or weeks (e.g., Bretzing & Kulhavy, 1981; Stein & Kirby, 1992), and summarization training remains after several weeks (Hare & Borchardt, 1984).

In summary, while Dunlosky et al. (2013) agree that summarization can be an effective strategy, success significantly depends on a competent skill set. The research suggests that "many learners (including children, high school students, and even some undergraduates) will require extensive training, which makes this strategy less feasible" (Dunlosky et al., 2013, p. 18).

Highlighting (or Underlining)

Description: marking potentially important sections of to-be-learned material

Dunlosky learning strategy effectiveness rank: low

Most students or teachers have used or seen material with a marked-up section, whether it was the usual yellow highlight or many colors. Highlighting or underlining, henceforth referred to as highlighting only, has been an established strategy when objectively looking at student textbooks and materials (Bell & Limber, 2010) and has been reported as a popular study method (Gurung et al., 2010). Dunlosky and colleagues (2013) suggest that students use highlighting as it is easy or straightforward to execute, does not require training, and assists with time management due to students highlighting while reading the material. The strategy is also cost-effective as highlighters are relatively low in cost.

The technique got a low rating since: "most studies have shown no benefit of highlighting (as it is typically used) over and above the benefit of simply reading, and thus the question concerning the generality of the benefits of highlighting to be largely moot" (Dunlosky et al., 2013, p. 20-21). The reason for highlighting being used as a learning strategy is the isolation effect, which suggests that a unique word, whether semantically or phonologically, will stand out and be remembered better than a less distinctive word. For example, if students had to memorize a list of words like 'cat, dog, elephant, chair, monkey, lion, and giraffe,' the word chair would stand out. The challenge is the lack of processing, as highlighting key material is a simple, effortless process, but more clarification is needed to achieve learning. Another challenge with highlighting, like summarizing notes, is expertise. Students need to decide what content should be highlighted. Studies have demonstrated that students perform better on assessments when the experimenter (or teacher) has highlighted the content than when students decide what to highlight (Nist & Hogrebe, 1987).

Further, the amount of highlighting, like summarizing, is another challenge as research has found variability in the amounts ranging from marking almost everything in the textbook to marking almost nothing (Idstein & Jenkins, 1972). Lorch et al. (1995) concluded that students are less likely to remember what was highlighted if too much was marked. Finally, highlighting much text takes less processing than marking a single word or short sentence, reducing recall (Dunlosky et al., 2013). Dunlosky et al. (2013) stated that while there have been objective looks at real-life student textbooks on whether highlighting was used, they question whether the research has looked at highlighting in a real world setting with different experimental designs (for example, student-generated or instructor-generated highlighting).

On the criteria of learning conditions, Dunlosky and colleagues (2013) stated that the failure of positive outcomes with highlighting has resulted in few studies addressing the variety of content needed to make conclusions on highlighting as a learning strategy. Dunlosky et al. (2013) stated a lack of results across many student criteria with no evidence of advantage in any category for student characteristics. On the materials criteria, Todd and Kesslier (1971) looked at various text lengths (44, 140, or 256 words) and found no significant effect of underlining at any length. Finally, for criterion tasks, Dunlosky and colleagues (2013) looked at the research and concluded that underlining had a detrimental effect on future inference making (Peterson, 1992). While students got significantly higher grades while highlighting for a multiple-choice test than a short-answer test (Kulhavy et al., 1975), there is the question of whether students in the short-answer group knew what to underline compared to the multiple-choice group (Schmidt, 1988).

In sum, Dunlosky et al. (2013) were concerned with the effectiveness of highlighting due to training. Dunlosky and colleagues (2013) mentioned a lack of research on training students to highlight more effectively but found two of three papers where training improved student performance (Amer, 1994; Hayati & Shariatifar, 2009). Dunlosky et al. (2013) concluded that "highlighting does little to boost performance" (p. 21), and while training could be implemented, it would be time-consuming and could influence higher-level tasks.

The Keyword Mnemonic

Description: using keywords or mental imagery for the association of concepts.

Dunlosky learning strategy effectiveness rank: low

What is a keyword mnemonic? Dunlosky and colleagues (2013) described the strategy as a mental image and focused their commentary on foreign-language vocabulary, text-based compression, and learning research. According to Atkinson (1975), the keyword mnemonic is a two-stage strategy. The student must identify something familiar in one word or concept (the keyword) and then form an image that helps remember a second word or concept. There are also two types of mnemonics: fact mnemonics and process mnemonics (Manalo, 2002). An example of a fact mnemonic would be how musicians remember the order of lines in a musical treble stave (E, G, B, D, F): every good boy deserves fudge. An example of a process mnemonic would be remembering how vowels work: "I before e, except after c."

Unlike previous strategies, Dunlosky et al. (2013) did not elaborate on why the strategy works in detail. On the materials criteria, Dunlosky et al. (2013) stated great benefits for language studies. On learning conditions, Dunlosky et al. (2013) cited a study by Hall (1988): students who had practice but no instruction on using the mnemonic strategy outperformed the group that could not easily generate their own even when provided the keyword by the researchers. Dunlosky et al. (2013) also found a challenge in the research, specifically that the large majority provided the keywords. When students generated the keywords themselves, there were mixed results on effectiveness. Among student characteristics, creativity is one of the most significant challenges for mnemonics. Mnemonics require students to develop visual associations, but it might create challenges if they are not creative. Also, younger students might have trouble with the strategy unless the keyword is associated with a picture or image provided by the teacher (Pressley & Levin, 1978). Finally, for criterion tasks, Dunlosky et al. (2013) were concerned that "the keyword mnemonic may not produce durable retention" (p. 22) as various studies (for a review, see Wang et al., 1992) showed compromised experimental designs. For example, in many of the studies, Dunlosky et al. (2013) researched, they used a practice test within their experimental design, which could significantly increase retrieval. Dunlosky et al. (2013) concluded that the representation of the research on mnemonics had been mixed: some have been depicted in natural academic settings while others have not.

In sum, Dunlosky et al. (2013) noted that while some promise exists for the keyword mnemonic, the lack of long-term retrieval and practice testing confounding most mnemonic experimental designs, the cons outweigh the pros for this technique.

Imagery

Description: forming mental images while reading or listening to a lecture.

Dunlosky learning strategy effectiveness rank: low

Imagery involves taking concepts learned in class and creating or forming mental images while listening to or reading the material. Depending on the student's imagination or if given instruction, imagery-based techniques can consist of simple, unrelated, or even complex images. Imagery can be used with or without other techniques, including "verbal rehearsal, repetition of items, cue-words, and concepts or verbal mnemonics such as rhythms of abbreviations" (De Beni & Moè, 2003, p. 309). A form of imagery, the method of loci (MoL), asks students to visualize a location where they can take an imaginary walk. Each key area has something that they want to remember along the way. The critical area along the walk could be linked as keywords to associate with the item/term you want to remember. In the best-case scenarios, the location's name could have letters similar to the item/term. While imagery was ranked low as a technique by Dunlosky et al. (2013), this more specific type could help eliminate some challenges as it uses user-specific, familiar locations. For example, McCabe (2015) had students use MoL and create their imaginary walk, based on on-campus locations, to remember a grocery list. The study demonstrated significant increases in recall when using the MoL method.

While the technique got a low rating from Dunlosky and colleagues (2013), there are benefits. For example, Dunlosky et al. (2013) referred to a study by Leutner et al. (2009) where tenth graders were divided into two groups: one that read a longer science text and was told to use imagery (experimental group) and one that read the text for comprehension (control group). The imagery group did significantly better on a test than the control group using no imagery. Dunlosky et al. (2013) suggested that imagery could efficiently organize memories, which could explain the results.

On the criteria of learning conditions, Dunlosky et al. (2013) stated that most research on imagery used primarily single sentences and instructions were given to participants when using longer text. Dunlosky et al. (2013) concluded that many researchers asked students to use imagery while reading and not while listening. The challenge with any research on imagery is how to confirm whether the student used imagery and, if so, how to measure it, as it depends on self-reporting from the student. For the criteria of student characteristics, academic papers on imagery have been done on various student ages and abilities and have shown some benefits for younger and college-age students. On materials, unfortunately, most studies used imagery-friendly texts and have varied in length significantly with mixed results and with most not manipulating the text in an experimental design. One study did manipulate the text, but the benefits of imagery happened only when the students listened to the text and not when they read it (De Beni & Moe, 2003). Finally, for criterion tasks, Dunlosky et al. (2013) suggested that the research has not thoroughly investigated the durability of imagery recall and stated that "the degree to which these long-term benefits are robust and generalize across a variety of criterion tasks is an open question" (p. 26). Dunlosky et al. (2013) also stated that many research studies on imagery had been performed in a real-life classroom.

In sum, Dunlosky et al. (2013) question the benefits of imagery and the amount of training necessary to achieve robust benefits. As the research surrounding imagery has used mostly imagery-friendly materials, similar to mnemonics, it might require more creative students to use the strategy, making the universality of the technique somewhat flawed.

Re-Reading

Description: after an initial reading, studying is done by reviewing and reading the material additional times.

Dunlosky learning strategy effectiveness rank: low

Re-reading the textbook or course material is a prevalent technique for students and is recommended by teachers (Morehead et al., 2016). According to Carrier (2003), 65% of college students used re-reading to study or prepare for tests. Across both Kornell and Bjork (2007) and Hartwig and Dunlosky (2012), 18% of students stated re-reading entire textbooks, and 62% reported re-reading sections of required material. Karpicke et al. (2009) found that 84% of students reported re-reading as a strategy they use, with 55% stating that the technique was their top-ranked choice. Re-reading has the advantage of little to no training and cost-effectiveness outside of purchasing the materials.

While the technique got a low rating, Dunlosky et al. (2013) proposed two reasons why re-reading improves learning. First, the quantitative hypothesis suggests that students simply keep adding to the amount of knowledge. In contrast, the qualitative hypothesis implies that re-reading affects higher and lower-level processing differently and allows for the increased organization of memories. Dunlosky et al. (2013) suggested that, while the research results are mixed, the qualitative hypothesis might be better for learning but, unfortunately, the article does not go into significant depth to explain the advantage of the qualitative hypothesis.

On the criteria of learning conditions, Dunlosky et al. (2013) stated that re-reading is robust as studies have been performed with warnings and no warning for students to study, different paces of reading, silent reading and auditory, different lag intervals between readings, and single as well as multiple texts. For the criteria of student characteristics, re-reading research is limited as, according to Dunlosky et al. (2013), only two studies have been performed on students outside of undergraduate studies. The authors also stated concern for the lack of re-reading effects on knowledge level, a challenge they described as "woefully underexplored" (Dunlosky et al., 2013, p. 28). A final concern regarding student characteristics was the lack of re-reading research on the different ability levels of participants. Dunlosky et al. (2013) were very positive on materials, stating various lengths and subjects in the literature on re-reading. Finally, for criterion tasks, the researchers concluded that most re-reading research measured some positive effects on free recall and cue-based tests (fill-in-the-blank) but less on multiple-choice tests. Sadly, Dunlosky et al. (2013) also stated that many research studies on re-reading have been outside education contexts, meaning almost no research has been done on re-reading and materials used in a specific course. Two studies (Carrier, 2003; Hartwig & Dunlosky, 2012) looked at re-reading using a representative education context, but both had mixed results.

Due to the challenges involving missing research areas, durability, and comparisons to other more effective techniques, Dunlosky et al. (2013) gave re-reading a low utility level. On the comparison challenge, several research studies have shown re-reading to be inferior to testing, especially with long-term retention (e.g., Carrier & Pashler, 1992; McDaniel et al., 2007; McDaniel et al., 2011; McDermott, et al., 2011; Roediger & Karpicke, 2006; for a review, see Roediger & Butler, 2011; for metanalytic evidence, see Rowland, 2014).

Interleaving

Description: mixing different types of materials during a study session.

Dunlosky learning strategy effectiveness rank: moderate

Interleaving involves the teacher or student 'mixing it up' or moving from concept to concept. The opposite would be blocking, where one specific chapter is taught, reviewed, assessed, and future chapters do not refer back to the material. The interleaved practice could also involve teaching one chapter, but different concepts are introduced for other assignments or assessments. The student or teacher could also move back and forth from one topic or chapter to another. Research indicates that the blocking technique might help recall and retention in the short term but not in the long term (Dunlosky et al., 2013). While research on this strategy is still in its infancy, it does not seem to have any significant disadvantages or issues for implementation. Students already have access to their materials and can quickly implement the strategy with little guidance.

Dunlosky et al. (2013) theorized that interleaving works for several reasons. First, when students move around from problem to problem, they practice identifying solutions and increasing their ability to discriminate among various challenges. The discrimination skillset boost also increases the likelihood that students will quickly determine that they need to use the solution that worked the first time when they find a solution for a particular problem. Second, as students move from topic to topic, it increases organization skills, expanding processing and assisting with comparing the two topics or challenges. Finally, the third reason revolves around how interleaving helps with long-term memory processing. When a student works on a challenge, moves to the next one, and sees a way to solve the first one, then moves back to solve the first challenge, the process enhances memory as the student must remember the solution while working on the first problem. Also, moving back and forth from different topics forces students to re-set and remember where they left off when re-starting a new topic, thus accessing memories and solidifying them.

On the criteria of learning conditions, Dunlosky et al. (2013) stated that interleaving correlates with other strategies, such as distributed practice and practice testing, both rated as high-utility strategies by the authors. Thus, interleaving can be used in any learning condition listed earlier, including the amount of practice, open v. closed tests, reading v. listening, or group v. individual learning. For the criteria of student characteristics, Dunlosky et al. (2013) stated that most research on interleaving was conducted on college-aged students and less on younger students, with mixed results. On materials, studies on interleaving have used various tasks ranging from simple to complex with mixed results save for mathematics and even painting styles. Finally, for criterion tasks, Dunlosky et al. (2013) suggested that "the materials that are the focus of instruction and practice are used as the criterion task. Thus, if students practice solving problems of a certain kind, the criterion task will involve solving different versions of that kind of problem" (p. 43). Dunlosky et al. (2013) also stated some concern about the benefits of interleaving over time as the research has mixed results. Dunlosky et al. (2013) also noted that the process of interleaving could be easily transferred to the classroom, and motivated students could perform the technique without instruction.

In sum, Dunlosky et al. (2013) consistently noted that the research on interleaving has just begun but has significant potential. Dunlosky et al. (2013) gave the technique a moderate rating due to the research's balanced/dramatic positive effects and its ability to be used with other effective strategies.

Elaborative Interrogation

Description: asking "why?" questions to generate an explanation for a concept.

Dunlosky learning strategy effectiveness rank: moderate

Why is this true? Why does this concept make sense? Why? As humans tend to be inquisitive and ask questions, it stands to reason that elaborative interrogation can improve learning. Asking questions can assist with a greater understanding of concepts and has many advantages, including increasing knowledge, not requiring much time or resources, and minimal training. In most studies on elaborative interrogation, the participants were given brief instructions (Dunlosky et al., (2013). The strategy is also advantageous with time management as it does not take long to ask a why question.

Dunlosky et al. (2013) stated that elaborative interrogation works using both previous and new knowledge. If a student asks a question about a new concept, they must access prior knowledge in some capacity to find an answer. Students must use some process or schemata to organize the new and old information and discriminate what is helpful with the new and old information. Dunlosky et al. (2013) also concluded that elaborative interrogation's benefits seem to be found in precise questions with higher prior knowledge and self-generated by the students.

On the criteria of learning conditions, Dunlosky et al. (2013) stated that elaborative interrogation works well with incidental and intentional learning instructions, both for an individual and within a group. For the criteria of student characteristics, Dunlosky et al. (2013) believe elaborative interrogation is robust and valuable for various students, including younger and older students. However, most of the research has been conducted on undergraduates. There is some question about whether younger students (kindergarten or first grade) can benefit from elaborative interrogation due to the requirement of having prior knowledge to answer the why question(s). Further research (Greene et al., 1996; Scruggs et al., 1994) has found that elaborative interrogation benefits students with learning disabilities for grades 4-12 and even mild cognitive disabilities (Scruggs et al., 1993) for grades 6-8. Of concern and consistent with the challenge of prior knowledge, Wood et al. (1993) found no advantage of elaborative interrogation with low-achieving students. Dunlosky et al. (2013) stressed the importance of prior knowledge as "an important moderator of elaborative interrogation effects, such that effects generally increase as prior knowledge increase" (p. 9). Concerning the previous knowledge requirement, another disadvantage of the technique might be access to resources to answer the question should previous knowledge not exist. On materials, Dunlosky et al. (2013) saw a positive with the number of different topics used in elaborative interrogation research. Still, they noted that the strategy might only be helpful for factual information. Finally, for criterion tasks, Dunlosky et al. (2013) concluded that elaborative interrogation has been tested using a variety of assessments. While the technique has proven helpful in short-delay tasks, further research is needed on longer-delay tasks. Dunlosky et al. (2013) also stated that most of the research studies on elaborative interrogation had been done in a laboratory setting instead of a real classroom.

In sum, Dunlosky et al. (2013) ranked elaborative interrogation moderate because the positives outweigh the negatives or missing research. The main challenge is the need for more research to determine its effects' generalizability, and the authors note that, with many strategies in their article, an exhaustive literature review is beyond the scope of the paper.

Distributed Practice

Description: spreading out studying over time.

Dunlosky learning strategy effectiveness rank: high

Distributed practice, or the 'spacing effect', refers to having time between learning and testing for students to encode and practice recall. For example, instead of having a lecture and a test or quiz the following week, the spacing effect suggests that lectures take place with enough time afterwards for students to process and use strategies to learn the concepts before the real test. The spacing effect is significant as the more time students have to encode and practice recalling the information, the better they tend to perform on tests. There are two types of schedules for the spacing effect. First, fixed schedule: where the gaps are equal in length (for example, every hour or week). Second, expanding schedule: the gaps become longer (study once, review at the end of class, then two weeks later, etc.). Research on which schedule is better is mixed but fixed might be more efficient for longer-term retention (Karpicke & Roediger, 2007).

A study by McDaniel et al. (2011) looked at the testing effect on 8th-grade students. Their initial experiment proved a vast testing effect as those students who had three quizzes spaced out did 13%-25% better on the summative unit exam. The more exciting result occurred when they looked at the quizzes' specific placement and effect (prior to the lecture, immediately after the lecture, and review quiz prior to the unit exam). The researchers found that the review quiz (closest to the final exam) had the most significant benefit.

On the criteria of learning conditions, Dunlosky et al. (2013) stated that the effect is robust, with moderate to significant improvements in memory across the research. Dunlosky et al. (2013) also discussed the lags between study sessions as not being “as simple as longer lags are better” (p. 37). The research indicated that the lags might depend on the student's learning strategy. For example, if the student uses re-reading (low utility), it might not produce the same results as practice testing (high utility) even if the distributed practice is implemented effectively. For the criteria of student characteristics, Dunlosky et al. (2013) concluded that most of the research on distributed practice used undergraduates as subjects. Still, positive effects could be found in others, such as clinical subjects (traumatic brain injuries, amnesia), children of all ages, and older adult learners. Dunlosky et al. (2013) also noted the lack of research in distributed practice on specific individual characteristics such as prior knowledge and motivation. On materials, Dunlosky et al. (2013) commented that the research on distributed practice has included many subjects and domains but tended to be more effective for recall involving more minor and complex tasks. Finally, for criterion tasks, Dunlosky et al. (2013) suggested vigorous effects over the study lags, significantly if the test is delayed after the study sessions rather than immediately.

In sum, Dunlosky et al. (2013) rated the strategy as moderate but noted significant obstacles: first, students tend to wait until the last minute and cram for a test. Micheal (1991) referred to the procrastination scallop, which describes how studying increases as the test or exam approaches. Second, without consistent reminders from teachers, students might see the value in distributed practice but not implement it. Finally, another challenge revolves around much of the research is being performed in a lab and not in a classroom. The lack of classroom research was addressed by Cepeda et al. (2009), that used many different lag periods for a test in a natural classroom environment: 0 (test given 20 minutes after the tutorial), one day, seven days, 28 days, 84 days, and 168 days. The best scores came after 28 days, with some benefits after one week. Lag period aside; the more critical question might be the students' study strategies during the distributed practice leading up to the test. If they use less effective strategies, distributed practice might not produce positive effects.

Practice Testing

Description: taking a practice test or tests before the real one.

Dunlosky learning strategy effectiveness rank: high

This technique involves teachers or students creating and completing mock or practice tests before the real one. The technique is one of the most time-efficient and can be done in various settings, such as in the classroom, online, at home, or even during commutes. Roediger et al. (2011) listed ten benefits of testing which can be found in Table 4.

Table 4

Ten Benefits of Testing (Roedinger et al., 2011)

	Benefit
1	The testing effect: retrieval aids later retention
2	Testing identifies gaps in knowledge
3	Testing causes students to learn more from the next learning episode
4	Testing produces better organization of knowledge
5	Testing improves the transfer of knowledge to new contexts
6	Testing can facilitate the retrieval of information that was not tested
7	Testing improves metacognitive monitoring
8	Testing prevents interference from prior material when learning new material
9	Testing provides feedback to instructors
10	Frequent testing encourages students to study

The following section will summarize Table 4 to further explain the benefits of testing, specifically the myths surrounding the limitations of testing (for example: testing does not improve the transfer of knowledge to new concepts).

Benefit 1: The Testing Effect—Retrieval Aids Later Retention

This benefit refers to the testing effect, which states that recall and long-term retention are significantly increased with testing. Critics of this benefit may say that it is not testing that helps but simply the re-learning/studying session the testing provides; however, the research has proven otherwise. Roediger et al. (2011) stated: "criticisms of the testing effect are often voiced, but dozens of studies have laid them to rest" (p. 6). When controlling for the study variable, students performed better in testing scenarios than in the studying/re-reading session alone. In many studies like Roediger and Karpicke (2006), the more a student is tested, the better the recall and long-term retention.

Benefit 2: Testing Identifies Gaps in Knowledge

Testing allows students to evaluate what they know and do not know, while other strategies do not have this advantage. When students are more aware of what they know and do not know, they can better gauge what to study and how much time or effort they may need to study.

Benefit 3: Testing Causes Students to Learn More from The Next Learning Episode

Benefit number three implies that if you test a student, give a tutorial about the material, and repeat, they tend to do better on the upcoming real test. Karpicke (2009) demonstrated that recall performance was best for the groups tested after each study session compared to groups with only multiple study sessions before testing.

Benefit 4: Testing Produces Better Organization of Knowledge

The fourth benefit revolves around chunking, a method for improved memory. When we test students, they learn to chunk, cluster, organize or categorize material, which helps with recall (Masson & McDaniel, 1981).

Benefit 5: Testing Improves the Transfer of Knowledge to New Contexts

Critics of the testing effect state that frequent testing may create a ‘kill and drill’ environment where students only learn facts and cannot transfer the knowledge to new contexts or concepts. Unfortunately, research contradicts that theory as practice testing improves knowledge transfer to new material or concepts. Roediger et al. (2011) referred to two types of transfers: near and far. Near transfer refers to the new material being like what was previously tested. Far transfer refers to the new material being very different from previously tested material. Studies like Butler (2010) demonstrated that examination improves far transfer as the group was tested three times, compared to the control group (studying and no tests), which did significantly better on an inferential test that forced the participants to transfer their previous knowledge to new concepts.

Benefit 6: Testing Can Facilitate the Retrieval Of Information That Was Not Tested

One of the biggest criticisms of testing is only being sure about student knowledge based on the material tested. If a teacher does not test students on specific concepts, the instructor cannot be confident if they know them. The theory was challenged by Chan et al. (2006), who coined the term retrieval-induced facilitation, showing how testing students assisted in recalling non-test material. They asked students to study a prose passage and divided them into the test group (two short tests), the restudy group (two sessions), and the control group that did nothing. The testing group performed two quick tests, but a subset from the passage was not included.

All groups completed the final test that included the non-tested material. The result: the test group performed significantly better than the restudy or the control group, despite not being tested on the previous material.

Benefit 7: Testing Improves Metacognitive Monitoring

Testing improves metacognitive knowledge as students are more aware of what they know and do not know, enhancing their ability to monitor and evaluate their study skills. The key concepts in this benefit are "monitor" and "evaluate," which are vital to the possibility of behavior change. While research is limited on whether targeted instruction on evidence-based study strategies can change student behavior, McCabe et al. (2021) had introductory psychology students receive SET training (spacing, elaboration and testing) at various points in the semester via their learning management system (LMS). The results showed that the "training was associated with positive shifts in SET strategy knowledge" (p. 257) but not behavioral change.

Benefit 8: Testing Prevents Interference from Prior Material When Learning New Material

This benefit revolves around proactive interference, implying that long tutorials or study sessions are ineffective as they could interfere with retrieving newer information. The idea is to stop during the study session and self-test to solidify the knowledge before moving on, thus reducing proactive interference.

Benefit 9: Testing Provides Feedback to Instructors

Research shows that teachers often overestimate their students' knowledge (Kelly, 1999). Knowing what concepts students get right and wrong on practice tests and actual tests will benefit the teacher and the students concerning feedback.

Benefit 10: Frequent Testing Encourages Students to Study

The final benefit is reasonably straightforward: giving students frequent practice tests could motivate students to study, especially if they see the benefits of testing. The advantages of practice testing can be referred to as the testing effect, which suggests that long-term memory is increased when tested. Several theories suggest that recalling an answer force strengthening memories in several ways. First, the context-change hypothesis: when tested, the circumstances or connections surrounding the retrieval items are coded or looked at differently, strengthening the memory (Block & Reed, 1978). For example, if a student got the answer correct or incorrect, they have a memory trace of attempting to answer the question/accessing memory to find the answer. Due to practice or real tests, the student has a memory of encoding and organizing the information and a memory of being asked about the question and recalling it. Even if the student got the practice question wrong, so long as a correction is made, a memory of trying to recall the answer is created along with a memory trace of the correction, thereby strengthening the probability of long-term retention. Second, encoding strategies: when tested, students may alter or change their encoding strategies to become more efficient at retrieving the memory. Finally, the increased effort: the test-expectancy theory (Rawson et al., 2002) suggests that when students are tested, they exert more effort, which could strengthen their memory. The theory also means that when students get answers wrong on a test, they realize the difficulty level and might increase their effort.

Are practice tests as effective as marked tests? Most studies surrounding the testing effect use mock or practice tests and have been shown to be effective. Adesope et al. (2017) completed a meta-analysis of practice testing. The technique was significantly more potent than re-reading or other studying techniques, indicating that practice tests can be as effective as real ones. Khanna (2015) tested whether the quizzes leading up to the exam had to be worth marks to be effective on the final exam. The author had three groups: no quizzes, graded quizzes, and ungraded quizzes on the final exam scores of introductory psychology students. The students also reported how they felt about the examinations in the course. The results: students who took ungraded pop quizzes outperformed those who took graded pop quizzes and those who took no quizzes on the final exam. Further, the group of students that took the ungraded pop quizzes felt the most positive about having quizzes in their classes.

How many practice tests is an interesting question. A meta-analysis of the testing effect by Adesope et al. (2017) reported that a single practice test, done about a week before the real one, had the same effects as several practice tests. Rawson and Dunlosky (2012) discussed the number of practice tests in a summary of recent research. They concluded that no precise number could be identified concerning the optimal number of practice tests. One conclusion they came to was that the number of practice tests was insignificant as long as students practiced until they got the answer correct and engaged in relearning afterward. Rawson & Dunlosky (2012) reported that at least three practice sessions seem to have benefits that outweigh the costs.

Concerning the criteria, testing is the most robust and researched strategy (Dunlosky et al., 2013). On the criteria of learning conditions, most testing research involved cued recall and free recall and a variety of other formats. Testing has also demonstrated advantages for comprehension, such as short-answer, inference-based questions, and cross-format examinations. For the criteria of student characteristics, Dunlosky et al. (2013) concluded that while the majority of testing research has been done on post-secondary students, a significant portion of studies has shown benefits for all ages, including kindergarten, preschoolers, elementary, middle, and high-school, upper-year post-secondary, and even older adult learners. Dunlosky et al.

(2013) noted a discrepancy around individual student differences and different academic abilities, which they believe needs to be addressed in future research. On materials, a significant portion of the research used simple materials but was representative of real-life courses. According to Dunlosky et al. (2013), practice testing has also benefited material of various lengths and visual or special information such as maps. Finally, for criterion tasks, while most testing research has used cued recall, Dunlosky et al. (2013) concluded that effects could be found with various memory tests such as free-recall, recognition, fill-in-the-blank tests, short answer, multiple-choice, and comprehension tests. The researchers also stated that a significant portion of testing research had been done in real-life classroom settings using relevant materials and scenarios like an educational context. Unfortunately, a literature review of the types of questions used in the tests is beyond the scope of the Dunlosky et al. (2013) article and this researcher's literature review.

In summary, Dunlosky et al. (2013) stated that "testing effects have been demonstrated across an impressive range of practice-test formats, kinds of material, learner ages, outcome measures, and retention intervals. Thus, practice testing has broad applicability" (p. 35).

Other Study Strategies

This research added five additional study strategies not included in the Dunlosky et al. (2013) article, including cramming the night before a test, flashcards, studying in a group, diagrams, and asking questions in class. The strategy of cramming the night before a test was also added, but a literature review will not be performed in this paper. The additional strategies were added as they are popular strategies in the literature and the author's experience as an instructor. Like Dunlosky et al. (2013), a comprehensive investigation into each strategy is impossible, but general conclusions about the technique will be addressed.

Flashcards

Description: using small, rectangular cards that have a question on one side and the answer on the other.

Dunlosky learning strategy effectiveness rank: n/a

Flashcards are popular because they are small, easy to make, and now readily available via many modern textbooks and online textbook resources. Flashcard use suggests both the testing and spacing effect, both very effective study techniques, as students can test themselves at various times before the actual examination. Unfortunately, there are few studies on the effectiveness of flashcards because students have diverse ways to obtain and use flashcards. For example, students could have flashcards provided by their teacher or a fellow student via the internet or their textbook. Other research limitations can include how often the students use the flashcards and if the students can identify whether a flashcard is effective concerning its wording. Golding et al. (2012) had Introductory to Psychology students report flashcard use for three exams: 34.9% of students used flashcards for all exams, 55.2% used flashcards for two of three exams, and 69.9% used flashcards for at least one exam. Concerning averages across all three tests, students who used flashcards in all three exams beat those who did not use flashcards by only 2.7%. The more considerable difference was between those who used flashcards in all the exams and those who used them in one (+5.4%) and two exams (+5.6%). Upon further inspection of the specific exams, only the first test came out significant, with a +5.5% advantage for those using flashcards. There were no significant differences with using flashcards for the second or third exam, although the third test was approaching significance. The authors noted a limitation of student reporting, stating that they could exaggerate or simply not recall the flashcard use. On whether there is an advantage to students creating their own flashcards, the research is limited, but Pan et al. (2022) found a memory advantage when students created their own flashcards, as opposed to using pre-made ones. Zung et al. (2022) asked college students about creating their own flashcards, and only 26.8% reported creating their own, with 76.2% stating that they created their own to control the content on the flashcards.

Studying in Groups

Description: two or more students studying for an upcoming assessment.

Dunlosky learning strategy effectiveness rank: n/a

Studying in groups tends to be a popular strategy with students. For example, Hartwig and Dunlosky (2012) found that 50% of students reported studying with friends. Unfortunately, most research studies indicate significant challenges when studying in groups (see Basden et al., 1997; Clark et al., 2000; Finlay et al., 2000). According to the research on group studying, student encoding is disrupted via the retrieval disruption theory. When students learn a concept, they encode and recall it using a unique and specific method. It is doubtful that two students will have the same encoding and recall methods in groups. A review by McCabe and Lummis (2018) reported some positive aspects of studying in groups, including "improvements in breadth of perspective, motivation for learning, peer relationships, confidence in studying, and learning and retention" (p. 28). The study implied an essential variable in group studying: academic preparation. The authors talked about how groups could be influential by not studying/teaching the material but helping each other clarify the instructor's requirements. For example, students could go over the concepts on the test to improve clarity and help them know what to study.

Diagrams

Description: creating an image to enhance learning.

Dunlosky learning strategy effectiveness rank: n/a

While research studies have demonstrated the advantages of using diagrams (Mayer 1989, 2005), many reported disadvantages could affect the generalizability of the technique. Limitations include the relevance and skill set of the student (for a review, see Acevedo et al., 2009), the spatial grouping of the information with the diagram (Larkin & Simon, 1987), prior knowledge and spatial ability of the student (Mayer & Gallini, 1990; Mayer et al., 1995), and higher-level interpretation, which may only be achieved through disciplinary expertise (Ainsworth, 2006). The challenges do not necessarily undercut the strengths as a metanalysis by Hembree (1992) found advantages for learning across 16 studies using diagrams and word problems; however, De Bock et al. (2003) found problems with word problems/diagrams and geometry. Age and ability might also be a challenge for diagrams as a study technique, as Booth and Koedinger (2012) concluded that the method did not help students who are younger or have lower-abilities.

Asking Questions in Class

Description: a student asks for clarification of a concept.

Dunlosky learning strategy effectiveness rank: n/a

Asking questions is the heart of any investigation, but how often do students ask questions or participate in class? Not often, according to research: classroom observations (Dillon, 1988) and tutoring sessions (Graesser & Person, 1994) found that students asked few questions and, as grade level increased, students asked even fewer questions (Good et al., 1987). Pearson & West (1991) found that students asked only 3.3 questions per hour of class time. Various studies have also found that students ask very few spontaneous high-level cognitive questions (Carr, 1998; White & Gunstone, 1992). A study by Nunn (1996) reported that, in a 40-minute class period, only an average of one minute was spent on class discussions or student participation. A theorized reason for the lack of questions might be hesitation: in a study by Bowers (1986), 30% of students felt apprehension about participating in class more than once a week, while approximately 70% felt some trepidation occasionally. According to Howard and Henney (1998), only one-third of the class regularly participated, while half didn't participate at all. The authors also found that 92% of interactions were made by "roughly five 'talkers' – students who contributed twice or more to classroom discussion" (p. 389). In a similar finding, Howard et al. (1996) reported that 4 to 5 students accounted for 89% of all interactions.

Do students who ask questions or participate more frequently get higher grades? The results are mixed: Handelsman et al. (2005) found that students who participated often got higher grades, while O'Connor et al. (2017) found that words spoken "did not predict performance on the end-of-unit tests" (p. 11). Unfortunately, there are many control challenges with experiments that try to determine whether students who ask questions in class get higher grades than those who do not. First, what would be the minimum amount of time in discussion/participation for the effect to be significant? As the research suggests, teachers do not spend much time in discussions, nor do students ask questions often, so if a discussion lasts three minutes of a three-hour class, should the strategy be considered significant? Second, the type of instruction would come into play: was the discussion an open forum, did the instructor cold-call students individually, or did the teacher ask additional questions/follow-up, promoting more participation? Third, clarity of discussion points and content representation: can researchers measure whether the words used are accurate, assist with learning and if the student question or conversation was on-topic concerning a test question or assignment? In addition, the cohort effect could be in play: Reinsch and Wambsganss (1994) completed a clever study where participation was graded across two different classes (legal environment and commercial transactions) with control groups (no participation marks). They did find a significant increase in exam scores from the marked participation group for the legal environment class, but no differences between the commercial transaction groups. Further, do studies on participation or discussions control for GPA? Perhaps the students who participated more often have higher grades, which could explain the results.

Another significant methodological challenge with research on asking questions is participation vs. engagement. Engagement implies many student behaviours such as self-regulation and intrinsic motivation, such as mastery and deep learning styles. Participation implies asking and answering questions, working with other students on assessments or in-class activities, or simply attending class. A student can answer a question or participate in a discussion, but that does not mean they are engaged. For example, suppose a teacher had an evaluation called participation, defined as asking and answering one question in a discussion. The student could say something they believe the instructor expects to get the marks. Frymier and Houser (2015) tested participation vs. engagement by using a motivation and engagement scale and found the relationship to be weak or "negligible" (p. 10). Research on whether student questions enhance learning has mixed results and various methodological challenges.

Do Students Use Evidence-Based Study Strategies?

Karpicke et al. (2009) surveyed 177 students and asked them about their study techniques. They found persistent or continual reading was the most frequently listed (84%) and favoured (55%) technique. Further, re-writing notes were tied for the second favourite strategy, with practice problems, at 12.4%. All other strategies (flashcards, studying in groups, memorizing, mnemonics, outlines, highlighting, and thinking of real-life examples) were below 10%. Concerning testing, only 11% (19 of 177 students) reported testing themselves while studying. In the second part of the experiment, the researchers asked students to pick from three techniques after reading a chapter for a test: (1) restudy the entire chapter (or parts of it), (2) recall material (without the possibility of restudying), and (3) use some other study technique. The results showed that 78% would not want to test themselves via recall. When the authors asked those students who picked recall as a technique, only 8% reported it would help them on the exam. The remaining students indicated that it would help them with further study (i.e., give them feedback on what they need to study). These results imply that students may not know the power of testing themselves and how it improves recall and test scores. In a follow-up to the second part of the experiment, the authors kept the same questions with a slight alteration to the second option: (1) restudy the entire chapter (or parts of it), (2) recall material (but this time with the possibility of restudying), and (3) use some other study technique. The researchers thought this might increase the percentages due to students having the option of their favourite technique, re-reading. The percentages did increase (18% v. 42%), but most students (58%) did not want to test themselves even with the re-reading option.

The Karpicke et al. (2009) study implied that students do not know how powerful the testing effect is. The lack of knowledge about testing effectiveness was also noted in Kornell and Bjork (2007), which allowed students to switch from studying in pairs or being tested with feedback. Predictably, most students started in the study pairs but, after two trials, moved to the testing technique. In the end, 68% reported that they quizzed themselves while studying, but only 18% recognized that the method helped with learning. These results could indicate that students are not only hesitant to test themselves but, even after seeing positive results, they may not interpret the practice testing as even a moderate strategy for success.

Studies by Morehead et al. (2016) and Piza et al. (2019) asked teachers and students about their strategy knowledge. Concerning students, both articles asked which study strategies they used regularly, and the results can be found in Table 5. Ratings of Morehead et al. (2016) and Piza et al. (2019) were provided by different researchers. To examine the consistency of reported use, a Spearman Rank correlation was conducted. Results demonstrated no significant correlation between the two research articles, indicating no relationship between the student-reported strategy use.

Table 5

Student-Reported Learning Strategy Use

Strategy	Morehead et al. (2016)	Piza et al. (2019)
Test yourself	73%	72%
Flashcards	33%	54%
Recopy notes	33%	33%
Re-reading	48%	67%
Make outlines while reading	58%	53%
Outline or highlight	58%	53%
Make diagrams, charts, or pictures	47%	24%
Study with friends	40%	48%
Cramming the night before	43%	53%
Ask question or participate in class	35%	25%
Other	3%	4%

Morehead et al. (2016) reported mixed results concerning student knowledge of evidence-based study strategies, but Piza et al. (2019) stated that “students endorsed many study habits which violate evidence-based principles” (p. 1411).

Do Instructors Recommend Evidence-Based Study Strategies?

Whether teachers suggest evidence-based study strategies is a question that requires additional research. Two similar research articles will be examined: Morehead et al. (2016) and Piza et al. (2019). The former asked 147 teachers their opinions on study strategies, while the latter surveyed 205 faculty in the health field. Both articles used the Dunlosky et al. (2013) study as the scope for their research, and Piza et al. (2019) cited Morehead et al. (2016) as inspiration for the survey questions. Finally, both articles surveyed students and instructors, but the focus will be on the teachers only in this section.

Concerning whether study strategies were discussed in class, 79% of the Morehead et al. (2016) teachers reported 'yes' while 52% stated 'yes' in the Piza et al. (2019) paper. The next question, on how often teachers discuss strategies in class, can be found in Table 6. Ratings of Morehead et al. (2016) and Piza et al. (2019) were provided by different researchers. To examine the consistency of reported use, a Spearman Rank correlation was conducted. Results demonstrated a significant correlation ($r = .90$, $n = 5$, $p = 0.05$), indicating a strong relationship between the two research articles on how often strategies are discussed in class.

Table 6

Instructor Survey Responses—How Often are Strategies Discussed in Class?

Question	Morehead et al. (2016)	Piza et al. (2019)
A few times a week	8%	3%
About once a week	28%	23%
Before major assessments	30%	46%
About once a semester	25%	15%
Other	9%	17%

Both papers also asked which study strategies the instructors recommended from a list provided by the researchers, and the results can be found in Table 7. Ratings of Morehead et al.

(2016) and Piza et al. (2019) were provided by different researchers. To examine the consistency of reported use, a Spearman Rank correlation was conducted. Results demonstrated a significant correlation (r = .96, n = 9, p = 0.01), indicating a strong relationship between the two research articles on instructor recommended study strategies.

Table 7

Instructor Recommended Study Strategies

Strategy	Morehead et al. (2016)	Piza et al. (2019)
Testing	65%	68%
Asking questions in class	62%	68%
Study in groups	59%	46%
Re-reading	41%	31%
Make diagrams	34%	44%
Flashcards	25%	25%
Recopy notes	18%	8%
Other	15%	17%
Cram the night before a test	0%	2%
Make outlines while reading	n/a	37%
Highlight while reading	n/a	31%

While there were several other questions, one of the more exciting inquiries was why testing helps with learning, and the results can be found in Table 8. The question asked: if you think students should test themselves (either using a quiz at the end of a chapter, a practice quiz, a flashcard, or something else), why should they do so? Ratings of Morehead et al. (2016) and Piza et al. (2019) were provided by different researchers. In an attempt to examine the consistency of reported use, a Spearman Rank correlation was conducted. Results demonstrated a significant correlation (r = 1.00, n = 3, p = 0.01), indicating a strong relationship between the two research articles on why instructors believe students should test themselves.

Table 8

Instructor Answers to Why Students Should Test Themselves

Answer	Morehead et al. (2016)	Piza et al. (2019)
Learn more than through re-reading	19%	36%
Figure out how well they have learned the information	68%	53%
I do not think quizzing will necessarily benefit	12%	11%

Like the instructors in Morehead et al. (2016) and Piza et al. (2019), many studies (Hartwig & Dunlosky, 2012; Kornell & Son, 2009) reported that students use practice testing as a way to see how they are doing, not necessarily because they think it is a very effective way to learn. As evidenced in Table 8, the conclusion that testing helps identify how one is doing is problematic because both instructors and students may be aware of practice testing but may not know why the strategy is so effective.

To summarize the findings of Morehead et al. (2016), "overall, instructors (54%) were more likely to endorse the evidence-based outcome than students (48%), $t(432) = 2.38$, $p = .018$, $d = 0.25$. Thus, instructors demonstrated better knowledge of learning strategies than students. Still, the aggregate advantage was small" (p. 267). For Piza et al. (2019), "a substantial proportion of faculty recommended non-evidence-based study techniques to their students" and "of those faculty who did report that students should quiz themselves (89%), a minority (36%) said they did so for the evidence-based reason that testing promotes learning" (p. 4).

Do Heads of Academic Support Centres Endorse Evidence-Based Study Strategies?

McCabe (2018) examined whether the heads of academic support centres ($N = 77$) endorsed evidence-based learning strategies. The survey was in three sections: first, participants gave their top three learning strategies. In the second section of the survey, the researchers listed

36 specific learning strategies. They asked the participants to rank (on a 5-point scale, from never to always) how often they recommend the techniques and how effective they are. In the third and final part of the survey, the researchers wrote four learning scenarios reproduced from McCabe (2011) on dual-coding v. single-coding, testing v. re-study, spacing/interleaving v. massing/cramming, and generating v. non-generating. The results: in the first section of the survey, time management (58%) was the most common, followed by studying in groups as a distant second (17%). For the second part of the survey, instead of listing all 36 strategies, Table 9 will list the techniques in the Dunlosky et al. (2013) paper and any that appear in this study.

Table 9

Frequency of Recommendation and Effectiveness Rating for Strategies in McCabe (2018)

Strategy	Frequency	Effectiveness
Summarization	4.14	4.21
Highlighting	3.55	3.33
The keyword mnemonic	3.60	3.73
Imagery	n/a	n/a
Re-Reading	3.38	3.18
Elaborative interrogation	n/a	n/a
Interleaved practice	3.34	3.55
Practice testing	4.27	4.47
Distributed practice	n/a	n/a
Studying in groups	3.99	4.00
Pictures/diagrams	3.97	4.00
Flashcards	3.53	3.60

Note. Frequency of recommendation was measured on a 1–5 scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always), as was perceived effectiveness (1 = not effective, 2 = slightly, 3 = moderately, 4 = very, 5 = extremely).

As demonstrated in Table 9, the strategies rated low by Dunlosky et al. (2013) got moderate (highlighting and keyword mnemonics) and high (summarizing notes) ratings from the heads of academic support centres. The interleaving practice mean score of 3.55 for effectiveness correlates well with the moderate rating of Dunlosky et al. (2013). Finally, practice testing got a mean score of 4.27, considered very effective by the participants in McCabe (2018) and Dunlosky et al. (2013).

Finally, McCabe (2018) gave four scenarios where the participants could choose between an evidence-based and a non-evidence-based strategy. The mean scores for three of the four scenarios helped the evidence-based technique (generating, testing, and dual-coding) but recommended mass or blocking studying (non-evidence-based) over interleaving (evidence-based). In summary, McCabe (2018) concluded that "the results present mixed evidence for the endorsement of strategies most likely to support student success, highlighting an opportunity to improve the communication between researchers and those on the front lines of student academic support" (p. 143).

In summary, the research paints a clear picture: instructor and student knowledge of academically supported learning strategies is mixed and can be viewed as a double-edged sword. Students might look to their teachers or institutions for guidance on learning. If they get incorrect information, the previous literature suggests that they might take that belief with them through their academic career, perhaps mentoring other students with the misinformation. When they graduate, maybe those students become teachers, promote the misinformation, and the cycle continues. With any challenge, there is also opportunity. Through research like Morehead et al. (2016), Piza et al. (2019), and McCabe (2018), awareness can be improved as to what learning strategies are more effective. The increased awareness might have many advantages, such as helping students achieve a higher ceiling and reducing academic struggles that could demotivate students, affecting their academic progress.

The next section of this paper will discuss learning styles and address whether learning styles exist as an advantage for learners. For a learning style to exist, many experiments would have to demonstrate an advantage for a learner when taught and tested in their perceived learning style. After an exhausting literature review on the topic, the most cited authors on learning style believe the concept does not give a learning advantage. Therefore, this section of paper will only focus on the literature that challenges the belief in learning styles while not addressing any possible advantages to believing in the concept.

Chapter 3: Literature Review—The Myth of Learning Styles

Pashler et al. (2008) suggested that the concept of 'type' theories or methods of classifying individuals into distinct groups can be traced back to psychoanalyst Carl Jung. Jung's (1964) concepts can be seen in the Myers-Briggs Type Indicator test on personality, but the argument of placing people into 'types' has found little empirical support (Druckman & Porter, 1991; Striker & Ross, 1964). While 'type' tests lack empirical evidence, the concept led to the idea of learning styles in the 1970s (Coffield et al., 2004).

Learning refers to how a student establishes and evolves various skills and abilities to retain information (Curry, 1983). Learning styles can be defined in multiple ways, but the underlying belief suggests that individuals learn more efficiently with a technique that matches their preferred style (Pashler et al., 2008). See Table 10 for various learning style definitions.

Table 10

Learning Style Definitions

Source	**Definition**
Pashler et al. (2008)	"The term learning styles refers to the view that different people learn information in different ways" (p. 106).
Reiner & Willingham (2010)	"Different students have different modes of learning, and their learning could be improved by matching one's teaching with that preferred learning style" (p. 33).
Newton (2015)	"The concept of 'Learning Styles' as an educational tool is fairly straightforward, and follows three steps: (1) individuals will express a preference regarding their 'style' of learning, (2) individuals show differences in their ability to learn about certain types of information (e.g., some may be better at learning to discriminate between sounds while others may be better at discriminating between pictures), and (3) the 'matching' of instructional design to an individual's Learning Style, as designated by one of the aforementioned classifications, will result in better educational outcomes" (p. 1).
Wininger & Redifer (2019)	"The term learning styles (also called learning modalities) generally refers to the idea that different students learn effectively when information is presented in specific ways" (p. 222).

Learning styles can also be categorized: as instructional preferences, information processing, and cognitive personality style (Curry 1983, 1987). First, instructional preferences are defined as the student's desired environment(s) and attitudes towards course delivery and assessments. Second, information processing refers to the delivery method or path from sensory to long-term memory. Finally, cognitive personality refers to enduring behavioral characteristics related to how students learn in different environments.

What are Learning Preferences?

Pask (1976) studied student problem-solving strategies and identified that students tended to prefer one or two strategies or techniques. Rezler and Rezmovic (1981) defined a learning preference as a choice of one technique over another. Woolfolk et al. (2020) defined learning preferences as "ways of studying and learning, such as using pictures instead of text, working with other people versus working alone, learning in structured or in unstructured situations, and so on" (p. 124).

Is There a Difference between Learning Style and Learning Preference?

The research on the differences between learning styles and learning preferences seems to indicate minimal if any, operational definition differences. First, Wells Higgs (1990) stated that learning preferences "may be considered as one facet of learning styles and refer to subjective feelings about certain learning strategies (p. 386). Cuthbert (2005) referred to a learning style, as used by Kolb's Learning Style Inventory, as "an individual's preference for understanding his/her experiences and transforming them into knowledge" (p. 236). Fleming (2005), the inventor of the VARK learning style model (visual, aural, read/write, and kinesthetic), also linked learning styles and learning preferences to the student's preference for gathering, organizing, and thinking about concepts. Robatin (2009) believed that a student's learning preferences depend on their learning style. Kinshuk Graf (2009) linked learning styles and learning preferences: "the area of learning styles is complex and many questions are still open, including a clear definition of learning styles, a comprehensive model which describes the most important learning style preferences, and the question about the stability of learning styles (p. 740)". Finally, Woolfolk et al. (2020) cautioned about using the term learning style and stated that learning preferences are a "more accurate label" (p. 124).

Coffield et al. (2004) stated that the field of learning styles is "not unified" (p. 1) and can be divided into three categories: theoretical, pedagogical, and commercial. First, theoretical refers to the empirical research on learning styles that started in the US and Western Europe in the early 20th century. The researchers pointed out that the field of learning styles is predominately "characterized by a very large number of small-scale applications of particular models to small samples of students in specific contexts" (p. 1), which can be a challenge in reviewing the research. Second, pedagogical implies how the research into learning styles can drive specific advice for teachers. Coffield et al. (2004) noted that the challenge with the research might be the number of different disciplines, such as psychology, sociology, education, and even business that may not necessarily communicate with each other in an interdisciplinary manner. The influences of each discipline might cause challenges in interpreting the research and advice given for pedagogy in the classroom. Finally, the commercial aspect, which Coffield et al. (2004) referred to as "large" and "influential" (p. 2), contains several popular and widely used instruments throughout the world. The authors stated concern for the instrument use due to the lack of welcomed criticism by the inventors, little explanations in professional development when using the models, and the differences in the instrument's purpose (some for theoretical purposes and some for practical purposes in the classroom). The following section will critically examine the literature on learning styles by reviewing the reliability/validity of the various instruments/models and the prevalence of learning style belief, all leading to research that challenges the existence of learning styles.

Learning Style Instruments

Coffield et al. (2004) performed a comprehensive report on learning styles, identifying 71 models. Most models were forced-choice and self-report questionnaires that place users in a category, and the authors categorized 13 as 'major' models. The criteria for selecting the major models included being widely quoted, based on an explicit theory, representative literature, leading to further external research, and frequently and widely used by practitioners such as teachers. Coffield et al. (2004) placed the models into four families of learning styles that can be seen in Table 11.

For each of the 13 models categorized as major, Coffield et al. (2004) evaluated them in 10 areas:

1. Origins and influence
2. Definition, description, and scope of the learning style instrument
3. Measurement by authors
4. Description of instrument
5. Reliability and validity
6. External evaluation
7. Reliability and validity
8. General comments
9. Implications for pedagogy
10. Empirical evidence for a pedagogical impact

Table 11

Families of Learning Styles According to Coffield et al. (2004)

Family	Models	
Constitutionally based	Dunn and Dunn	Marks
	Gregorc	Paivio
	Barlett	Richardson
	Betts	Sheehan
	Gordon	Torrance
Cognitive structure	Riding	Hunt
	Broverman	Kagan
	Cooper	Kogan
	Gardner et al.	Messick
	Guilford	Pettigrew
	Holzman and Klein Hudson	Witkin
Stable personality type	Apter	Epstein and Meier
	Jackson	Harrison-Branson, Miller
	Myers-Briggs	
Flexible stable learning preferences	Allinson and Hayes	Wierstra
	Herrmann	de Jong and Thijssen
	Honey and Mumford	Kaufmann
	Kolb	Kirton
	Felder and Silverman	McCarthy
	Hermanussen	
Learning approaches, strategies, orientations, and conceptions of learning	Entwistle	Pask
	Sternberg	Pintrich
	Vermunt	Smith
	Biggs	Garcia and McCeachie
	Conti and Kolody	Schmeck
	Grasha-Reichmann	Weinstein
	Hill	Zimmerman and Palmer
	Marton and Saljo	Whetton and Cameron
	McKenney and Keen	

While a detailed examination of Coffield et al.' (2004) conclusions is beyond the scope of this paper, please see Table 12 for an adapted version of the authors' reliability and validity conclusions. As shown in Table 12, according to Coffield et al. (2004), for the 13 major learning style models, only five (38.0%) had internal consistency, seven (53.8%) had test re-test reliability, four (30.7%) had construct validity, and four (30.7%) had predictive validity. Of the 13 major models, one (Jackson) had no evidence of reliability or validity, six models (Riding, Sternberg, Dunn and Dunn, Gregorc, Honey and Mumford, and Kolb) had none or one minimal criterion met, and only one (Allinson and Hayes) had all four columns meet the criteria. In summary, after spending over a year examining the literature on the 13 major models, Coffield et al. (2004) concluded, "we, therefore, advise against pedagogical intervention based solely on any of the learning style instruments" (p. 141).

Table 12

13 Learning-Styles Models (Coffield et al., 2004)

	Model	**Internal Consistency**	**Test-retest Reliability**	**Construct Validity**	**Predictive Validity**
1	Jackson	--	--	--	--
2	Riding	N	N	N	N
3	Sternberg	N	N	N	N
4	Dunn and Dunn	N	N	N	Y
5	Gregorc	N	N	N	Y
6	Honey and Mumford	N	Y	N	N
7	Kolb	--	Y	N	N
8	Entwistle	Y	--	Y	N
9	Herrmann	--	Y	Y	--
10	Myers-Briggs	Y	Y	N	N
11	Apter	Y	Y	--	Y
12	Vermunt	Y	Y	Y	N
13	Allinson and Hayes	Y	Y	Y	Y

Note. -- = no evidence; N = criterion not met; Y = criterion met

How Many Learning Styles Are There?

While visual, auditory, reading/writing, and kinesthetic might be the most frequently discussed, Coffield et al. (2004) examined 71 learning style models with a wide variety of specific learning styles (see Table 13 for an example abbreviated version). To the author's knowledge, no studies have been performed comparing the various learning styles and if they overlap.

Table 13

Learning Styles Discussed in Coffield et al. (2004)

Learning Styles	
Convergers vs. divergers	Meaning-directed vs. undirected
Verbalisers vs. imagers	Theorists vs. humanitarians
Holists vs. serialists	Activists vs. theorists
Deep vs. surface learning	Pragmatists vs. reflectors
Activists vs. reflectors	Organizers vs. innovators
Pragmatists vs. theorists	Concrete vs. abstract learners
Adaptors vs. innovators	Random vs. sequential learners
Assimilators vs. explorers	Initiators vs. reasoners
Field-dependent vs. field-independent	Intuitionists vs. analysts
Globalists vs. analysts	Extroverts vs. introverts
Assimilators vs. accommodators	Sensing vs. intuition
Imaginative vs. analytic learners	Thinking vs. feeling
Non-committers vs. plungers	Judging vs. perceiving
Common-sense vs. dynamic learners	Left-brainers vs. right-brainers

Prevalence of Learning Styles

Due to a large variety of studies on learning style prevalence, see Table 14 for a summary of the research, including the source, demographics, and prevalence of learning style belief. Selection of the research included selecting academic papers that were referenced in Pashler et al. (2008), searches of 'learning style prevalence' in various databases, and the use of three studies on learning strategies addressed earlier in this paper (McCabe, 2018; Morehead et al., 2016; Piza et al., 2019).

Table 14

Learning Style Prevalence

Source	Demographic	Results
Snider & Roehl (2007)	A survey of kindergarten through grade 12 teachers in the mid-west of the United States.	80% of instructors either exactly or somewhat believed in learning styles.
Dekker et al. (2012)	Primary and secondary teachers from the United Kingdom and the Netherlands.	Over 90% believed "individuals learn better when they receive information in the preferred learning style" (p. 4).
Howard-Jones (2014)	Reviewed studies of teachers in five countries.	Between 93% and 97% believed that students learn better when information is taught in their preferred learning style.
Dandy & Berndersky (2014)	Higher education faculty in the United States.	64% agreed with the statement 'does teaching to a student's learning style enhance learning'?
Simmonds (2014)	School teachers in the United Kingdom.	76% used learning styles in their classroom.
Newton (2015)	Research papers published (ERIC and PubMed databases) between 2013 and 2015.	89% of research papers endorsed the use of learning styles.
Morehead et al. (2016)	Instructors and students at Colorado State University (USA).	91% of instructors believed in learning styles, and 77% reported that they teach to accommodate.
McCabe (2018)	Seventy-seven heads of academic support centres in the United States.	Participants ranked the frequency of recommending that students study in a manner consistent with their learning strategy as 'sometimes' and its effectiveness as 'moderately'.
Wininger et al. (2019)	Reviewed 20 common texts in educational programs.	80% had a discussion of learning styles, half described learning styles as a preference, while the other half defined the concept as a style. One-quarter of the textbooks recommended matching the instruction to the student's preferred style.
Piza et al. (2019)	Health instructors at six universities in the USA.	91% reported that students have different learning styles, and 79% stated they teach to accommodate the difference.

As noted in Table 14, the belief in learning styles is highly prevalent in surveys of teachers, educational texts, and even heads of academic support centres recommending strategies to students. A review of 27 studies representing over 15,000 educators in 18 countries between 2009 and 2020 found that "self-reported belief in matching instruction to learning styles was high, with a weighted percentage of 89.1%, ranging from 58% to 97.6%." (Newton & Salvia, 2020, p. 1). The researchers also found that 79.7% of participants in the various studies stated that "they used, or planned to use, the approach of matching instruction" (Newton & Salvia, 2020, p. 11) to a student's learning style. Further, the authors found that instructor belief dropped by an average of 37% when educated with evidence disproving the myth.

What about non-educators? Do they believe in learning styles? A unique study by Nancekivell et al. (2020) looked at specific beliefs of educators and non-educators on the learning style myth. The researchers broke down the beliefs into two categories: first, essentialists are those who "believe that learning styles emerge early in childhood, have a biological or genetic basis, are instantiated in the brain, mark distinct kinds of learners, predict learning outcomes, and are not open to change" (p. 222). The second category would be nonessentialists defined as having a definition of learning styles that "may hold a looser conception in which learning styles are overlapping, non-discrete preferences that are informed by experience and may change with context overtime" (p. 222). The results: 66% of the participants were categorized as essentialists and 34% as nonessentialists. Also, the researchers found no demographic differences, including age, gender, and whether the participants worked in an education field.

Do students believe in learning styles? Morehead et al. (2016) had 58%, and Piza et al. (2019) had 79% of students reporting a belief in learning styles. A study by Dandy and Bendersky (2014) explored student and faculty beliefs in learning and asked 164 undergraduate students and 81 faculty, "Does teaching to a student's learning style enhance learning?" The results showed a significant difference between the two groups: 64% of faculty reported yes, while 88% of students agreed with the question.

Do students have study strategies that align with their perceived learning style? In the colourfully titled research article, “Another nail in the coffin for learning styles?” (Husmann & O'Loughlin, 2019), the authors used the VARK model to help students identify their preferred learning style (visual, auditory, reading/writing, or kinesthetic). Ironically, the VARK questionnaire results showed that over 40% of the students scored strongly across all four learning style categories, which calls into question the validity of a single learning style. The study had two key conclusions: first, the student-reported study strategies did not align with their reported learning style. Second, only 32% of students had study strategies correlated with their perceived learning style. The findings indicate that even if students believe they have a learning style and would prefer to be taught using that style, their study habits or strategies do not match up. The second finding: even if students used strategies across the VARK categories, it did not result in higher grades. For example, the authors noted that students who stated they were visual learners did not get higher grades on anatomy, a visual subject, than other students who reported not being visual learners; although it could be argued that anatomy has both visual (the images of the body) and reading (the names of the body parts), implying two learning styles.

Another challenge with proving the existence of learning styles is self-reporting: for example, Rawson et al. (2017) had undergraduate engineering students use an objective measure to calculate homework – a smartpen. While there was a positive correlation between course grades and time spent on homework, there was no correlation between self-reported time doing homework and the objective time confirmed by the smartpen. The results demonstrate that student self-reporting is often unreliable (see also; Blumner & Richards, 1997; Schuman et al., 1985; for validity issues on student evaluation of teachers, see Spooren et al., 2013), which challenges self-perceptions on learning styles and their reported benefits.

Do Learning Styles Exist?

In an article by Kirschner (2017) entitled "Stop propagating the learning styles myth," the author stated that "nearly all studies that report evidence for learning styles fail to satisfy just about all of the criteria for scientific validity" (p. 166). The controversy encompassing learning styles surrounds the meshing (or matching) hypothesis, defined as enhanced learning that will occur when a student is taught in their preferred learning style (Pashler et al., 2008). Pashler et al. (2008) challenged the learning styles research by identifying several criteria that must be in place to confirm the hypothesis. First, the experimental design must have at least two groups (for example, visual and auditory learners). Second, a random assignment must occur where participants are assigned to at least two different learning methods. Third, all participants must be given the same task or assessment. Further, "the results need to show that the learning method that optimizes test performance of one learning-style group is different than the learning method that optimizes the test performance of a second learning-style group" (Pashler et al., 2008, p. 109).

Unfortunately, the authors of the previously mentioned research article found only three studies on learning styles with a proper experimental design. All failed to find evidence of an advantage when taught in the preferred learning style. First, Massa and Mayer (2006) performed three experiments, with all results challenging the learning style hypothesis. In the first two experiments, college (Experiment 1) and non-college adults (Experiment 2) were surveyed on their learning style preferences (visual or verbalizer). They performed a randomized computer tutorial and tested with text or images. There were no significant differences between the learning styles and achievement on the test in both experiments. In the last experiment (Experiment 3), college students received both help screens (text and images) or neither, but the results indicated no treatment effects. Second, Cook et al. (2009) examined if sensing learners (who prefer facts, data, and experimentation) and intuitive learners (who like looking for patterns, meaning, principles and theories) would result in significantly different test scores using randomized, controlled, and crossover trials. The hypothesis stated "that sensing–intuitive learning styles would interact with problem-first versus information-first instruction to influence knowledge test scores" (p. 87), but "no evidence was found to support this interaction" (p. 88). Finally, a laboratory experiment by Constantinidou and Baker (2002) used the Verbalizer–Visualizer Questionnaire to identify learning preferences to determine if the learning style increases information storage. The authors concluded, "that there is no relationship between a visual learning style and the actual learning of verbal items that are presented visually or auditorily" (p. 306). Pashler et al. (2008) is not the only research paper to examine multiple learning styles studies: Cuevas (2015) also noted that only 31 of 1400 articles that referenced learning styles (2009-2015) related the styles to an instructional method, a criterion critical to establish validity.

A review of all the literature that debunks the learning style hypothesis is beyond the scope of this paper, but key or noteworthy studies will be examined. First, Arbuthnott and Kratzig (2006) had 65 university students state which learning style they preferred via a single question ("What word would best describe the type of learner you are?") with five options: visual, verbal, kinesthetic, no preference and equal preference. Afterward, the participants completed a memory test in the three sensory modalities from the survey question and found no correlation between the test scores and the learning style preference. Knoll et al. (2017) asked 52 female participants to take the Verbalizer-Visualizer questionnaire to determine their preferred learning style. Afterward, they studied a list of word pairs and a list of picture pairs. Of interest for this study, participants were also asked to predict how well they had learned the word and picture pairs, which the authors labelled 'judgment of learning'.

The judgment of learning was a rating from 0 to 100 on the likelihood of recall or a confidence rating. While no significant differences were found in learning style preference and test scores, the authors did find a significant difference in the judgment of learning scores. When the participants were taught with their preferred method, they ranked their confidence significantly higher than when instructed with the other learning method. This study demonstrated that students may not be very efficient in determining their best method of instruction and might underestimate their learning gains when taught in a manner that does not align with their perceived strengths. Rogowsky et al. (2015) were inspired by Pashler et al. (2008), precisely the authors' experimental design suggestions for determining if learning styles genuinely exist. Rogowsky et al. (2015) had 121 college-educated adults choose their preferred learning style and presented them with a verbal comprehension test in two forms: oral and written. No significant relationship was found between learning style preference and test scores for the first experiment. For the second part of the experiment, the researchers randomly assigned the participants to two groups (digital audiobook and e-textbook). They then sent them a written comprehension test immediately and after two weeks. As with the first experiment, no significant relationship was found between the learning style preference and the instructional method for both conditions (immediate and delayed). Finally, while Rogowsky et al. (2015) used adult students, a follow-up (Rogowsky et al., 2020) used the same design but with fifthgrade students and found the same results: no significant relationship between preferred learning preferences and test scores.

Neuromyths and Learning

The learning style hypothesis can also be called a neuromyth, defined by *The Brain and Learning* project of the UK's Organization of Economic Co-operation and Development (OECD) as “a misconception generated by a misunderstanding, a misreading, or a misquoting of facts scientifically established (by brain research) to make a case for the use of brain research in education or other contexts” (OECD, 2002). Neuromyths come from overgeneralizations of research on the brain (MacDonald et al., 2017) and can happen in any discipline, including learning. Grospietsch and Mayer (2020) identified nine neuromyths concerning learning and memory (see Table 15).

This study used two neuroscience and learning styles questions, specifically regarding different brain regions and hemispheric dominance (see Appendix 1). Concerning specific parts of the brain being responsible for particular learning (for example, visual or auditory), neuroscience research has confirmed that structures in the brain are highly interconnected, and several areas contribute to learning (Gilmore et al., 2007). Regarding the hemispheres of the brain, even though they differ in function, they work together for many procedures and constantly communicate (Ansari, 2008).

Table 15

Neuromyths in Education and Learning

Scientific Kernel of Truth	Neuromyth
Learning style preferences: learners prefer receiving a specific mode of delivery.	Existence of learning styles: learning will increase when a student is taught in their preferred learning style.
Crossover in neural pathways: some pathways link the left and right hemispheres of the brain.	Brain gym effectiveness: interactions between left/right hemispheres of the brain can be improved with coordination exercises, thus enhancing learning.
Existence of cortical regions: the cerebellum has different regions for different functions.	Specific storage locations: information in the brain is stored in particular areas like a hard drive on a computer.
Hemispheric dominance: the brain's left or right hemisphere is more significantly involved in specific thinking processes than the other.	Differences in hemispheres: each individual uses a specific hemisphere of the brain to different degrees, and that difference explains learner differences.
Brain development: significant neural cell connection increases in the first year of life.	Early learning: the best learning occurs from birth until age three.
Hemispheric asymmetry: the two hemispheres of the brain are not identical.	Hemispheric specialty: left brain processes logic while the right brain processes creativity. Individuals must use deliberate effort to engage both hemispheres of the brain equally.
Sensitive phases in child development: only specific concepts can be learned more easily in childhood.	Critical periods: there are crucial time periods where children must be presented with stimuli so that learning will not be impaired for life.
Brain activity: imaging technology allows for measuring brain activity when learning.	We only use 10% of our brain.
Consolidation: new insights can be gained by sleep restructuring processes.	You can learn while sleeping: new concepts and content can be learned when sleeping (for example, listening to audiobooks when sleeping).

Note. Adapted from Grospitesch and Mayer (2020).

Prevalence of Neuromyths

See Table 16 for a partial summary of the research surrounding the prevalence of neuromyths, including the source, demographics, and the prevalence of neuromyth belief. The research included selecting academic papers referenced in Torrijos-Muelas et al. (2021) and searches of ‘neuromyths’ in various databases. For a comprehensive review of neuromyths, see Torrijos-Muelas et al. (2021).

Table 16

Neuromyth Prevalence

Source	Demographic	Results
MacDonald et al. (2017)	Participants (n = 3877): 3045 general public, 598 educators, and 234 with high neuroscience exposure.	Endorsement of neuromyths: general public (68%), educators (56%), and high neuroscience exposure (46%). Learning styles were between the two most commonly endorsed neuromyths, with an average of 82% across the three groups. Incorrect brain hemisphere learning was supported by 64% (general public), 49% (educators), and 32% (high neuroscience exposure).
Tardiff et al. (2015)	Teachers (n = 283): high school, college, first-year primary school teachers, and teacher trainers from Switzerland.	85% agreement on hemispheric dominance (‘some people use their left hemisphere whereas others use their right hemisphere) and 95% endorsed learning styles.
Dekker et al. (2012)	Primary and secondary school teachers from the UK and Netherlands (n = 242).	Incorrect endorsements (UK / Netherlands): learning styles (93% / 96%) and hemispheric dominance (91% / 86%).
Grospietsch and Mayer (2019)	Pre-service science teachers (n = 57) specializing in biology (Germany)	Endorsements: - Existence of learning styles: 95% - Information stored in one brain location: 95%
Grospietsch and Mayer (2020)	Pre-service science teachers (n = 550) specializing in biology (Germany).	Endorsements: - Existence of learning styles: 93% - Information stored in one brain location: 85% - Learning difference due to use of different hemispheres: 82% - Logic in the left hemisphere, creativity in the right hemisphere: 76%
Hughes et al. (2020)	Australian teacher (N = 228): early childhood education, primary/elementary, secondary/high school, and other educational settings (5%)	Endorsements: - Existence of learning styles: 79% - Information stored in one brain location: 85% - Some individuals are left or right-brained, and this helps explain differences in how we learn: 56%

Why are neuromyths so prevalent? First, Howard-Jones (2014) stated that professional vocabulary (neuroscience technical jargon) could cause a language barrier leading to interpretation errors by the general public. Second, Goswami (2006) suggested different proficiency levels when investigating a wide range of inquiries – from basic brain terminology to complex neuroscience. Third, Ansari and Coch (2006) implied that paywalls and the inaccessibility of empirical research cause the general public to rely on unqualified media to interpret complex concepts in the brain. Fourth, McCabe and Castel (2008) proposed that the general public craves explanation, even if the details are legitimate, partially true, or illegitimate. In addition, Ansari and Coch (2006) contended that the lack of overlap between neuroscience and education, or a need for interdisciplinarity between the two fields, could explain the misconceptions. Weisberg et al. (2008) and McCabe and Castel (2008) found that neuromyths are more likely to occur when accompanied by brain images and explanations, whether correct or incorrect. Weisberg et al. (2008) had three groups (novices, neuroscience students, and neuroscience experts) read short "descriptions of psychological phenomena followed by a good or bad explanation that did or did not contain logically irrelevant neuroscience information" (p.7). The results indicated that all the groups could tell the difference between good and bad explanations with or without the presence of a neuroscience explanation. The critical finding occurred with the novice and student groups that rated the explanation more favourably when presented with excellent or lousy neuroscience explanations.

What are the Consequences of Believing in Learning Styles?

1. ***Teacher Resources:*** due to the lack of time/resource challenges teachers face, education on the myth is vital, so instructors do not dedicate class time to identifying and accommodating learning styles (Wininger et al., 2019).

2. ***Student Impact:*** encoding information is critical for students, and with the learning style myth, there might be limited options. By definition, a learning style insists that a student use one encoding method: visual, auditory, or another. Dual coding, a process where a student uses verbal and non-verbal techniques, has provided increased memory (Clark & Paivio, 1991). If students believe only one encoding method exists, they might be disadvantaged.
3. ***Decreased Student Motivation/Confidence:*** if students believe that they failed a test due to their instructor not teaching to their learning style, it could decrease motivation as they are blaming the outcome on an external reason (teaching not aligned with learning style) and not an internal reason (lack of effort, not studying). Further, if students believe that the instructor taught in their learning style and failed the assessment, it could lead to decreased confidence and learned helplessness (Winniger et al., 2019). In addition, students could avoid career paths or lack confidence in courses that go against their learning style. For example, students that believe they are visual learners might avoid music courses or have reduced confidence when forced into a music class. Finally, learning styles encourage students to think they only have one way of learning. Thus, when confronted with alternative learning methods, students may avoid and lose an opportunity to develop coping strategies to deal with a challenge (Nancekivell et al., 2020).
4. ***Instructor Curriculum:*** as learning styles are very prevalent in research and educational textbooks (Newton, 2015; Wininger et al., 2019), incorporation into teacher training courses is wasting time that could be used on evidence-based curricula.

5. ***Giving Incorrect Academic Advice:*** as demonstrated in McCabe (2018), heads of academic support centres ranked the endorsement of learning styles (students should study in a manner consistent with their perceived learning preference) as *sometimes* (a 3 out of 5 on a Likert scale) and ranked its effectiveness as *moderate*. If teachers and advisors give students incorrect information, it could affect academic performance.

What Are the Reasons for the Learning Style Myth Being So Popular?

1. ***Kernels of Truth:*** Riener and Willingham (2010) reviewed three objective truths that assist in the prevalence of learning styles. First, "learners are different from each other, these differences affect their performance, and teachers should take these differences into account" (p. 33). While there are differences, the authors suggested more evidence-based strategies to assist students with learning outside of boxing them into a specific learning style. Second, suppose a student believes that they are a visual learner. In that case, they will show more interest in visual-related tasks or hobbies, thus creating the illusion that they are better with one specific learning style. Finally, a student could have greater experience or background knowledge in a particular subject, creating an environment where teachers and parents misinterpret the strength as a learning style.
2. ***Uniqueness:*** Pashler et al. (2008) suggested that parents want their children to "be seen and treated by educators as unique individuals" (p. 107), which leads to a variety of learning style categories.
3. ***Confirmation bias:*** society tends to seek proof that validates their beliefs, which could also play a role in advancing and maintaining the learning styles myth. Suppose a teacher or parent sees a student improve a particular learning style, or a student perceives they are

progressing with a specific learning style. In that case, they might not want to seek evidence that disproves the strategy or belief (Newton, 2015).

4. ***False Interpretations:*** teachers may notice differences between students but falsely interpret the results. For example, teachers may crave improvement in their students. When they see some students move quicker, they interpret that they are better at the specific learning styles without considering other variables. Unfortunately, teachers may not be very effective at determining their student's learning styles. Papadatou-Pastou et al. (2018) asked 189 students in grades five and six to determine their learning styles using a forced-choice questionnaire for a visual, auditory, or kinesthetic learner category. The students' teachers were asked, "Which is the learning style of each of your students' with the same three options?" The results demonstrated no significant correlations, meaning that the teachers could not "assess the LS [learning styles] of their students accurately" (p. 1).
5. ***Ease:*** when a student has trouble or fails a course, it is much easier to point to a specific learning style as the possible issue and not the multitude of external reasons that can become complicated to interpret.
6. ***Appeal:*** Pashler et al. (2008) stated that it is natural for teachers, parents, and even students to believe that, when taught in a tailored manner that correlates with their learning style, improvement can be seen quickly.
7. ***Profit:*** Woolfolk (2017) believed that the popularity of learning styles, despite objective evidence, is due to commercial educational companies vehemently promoting and pushing learning style tools to academic institutions.\

8. ***Research Promotion of the Myth:*** Newton (2015) looked at research papers published (ERIC and PubMed databases) between 2013 and 2015 and found that 89% of research papers endorsed the use of learning styles. Another challenge is the proportion of research articles validating versus invalidating learning style tools: for example, Newton and Salvi (2020) found that a meta-analysis in 1995 (Dunn et al., 1995) validating the Dunn and Dunn Learning Styles Model was cited 610 times but a study by Kavale et al. (1998), a rebuttal questioning the validity of the model, was mentioned only 60 times. Therefore, if more research articles validating the learning style myth are cited than those opposing it, it increases in popularity in search engines and keeps the learning style myth alive and thriving.

Summary

Various research articles (Gardner & Dalsing, 1986; Vaughan, 1977) have noted that myths are deep-seated and persist due to the reinforcement of multiple elements, such as the media and parents. The concept of learning styles is an example of an ingrained myth that has persisted even in academic circles despite objective evidence against its existence. Another factor in this myth could revolve around the scapegoat theory that suggests that when something goes wrong, humans need to blame someone or something (Myers & DeWall, 2020). When a student begins to struggle academically, it is conceivable that parents and teachers need to find a reason that is external to themselves. Teachers may not want to blame themselves; instead, they might communicate that the student's learning style does not match their teaching style to explain the academic struggles. Parents might not want to blame themselves; instead, they might communicate that the teacher or institution has failed their child. The challenges are clear from examining the research: there is a widespread belief in learning styles, not only in the general public but, more critically, among instructors and even teachers with a background in neuroscience. This belief can cause misinformation that could reduce the academic ceiling for students and demotivate them as they do not believe they can learn outside of a perceived limitation that does not exist. Through the research identified in this paper, there is much opportunity to increase awareness to change perceptions and, hopefully, reduce or eliminate the myth.

Chapter 4: Research Methodology

Research Questions

1. How do faculty rate the effectiveness of various study strategies?

2. What factors contribute to the effectiveness ratings of the study strategies?

3. Do faculty believe in learning styles as an advantage for student learning?

4. Do faculty have beliefs in various neuromyths?

5. What factors contribute to a belief in learning styles and neuromyths?

Participants

Seven Ontario (Canada) academic institutions, including three colleges and four universities, were surveyed (see Appendix 1) on perceptions of study/learning strategies and learning styles. The three colleges included Cambrian College (Sudbury), Humber College (Toronto), and Fanshawe College (London). The four universities included the University of Toronto (Toronto), Laurentian University (Sudbury), York University (Toronto), and Western University (London). The institutions were chosen as they represent a larger pool of participants. The researcher used the institution's public internet directories to download the names/emails of the faculty members and implement Microsoft Word mail merge to send out invitation emails (see Appendix A) with a total of 7015 emails sent out. No deadline was given on the invitations, and the survey remained open for 30 days before closing.

Materials

The survey had six sections: (1) invitation, (2) descriptive questions, (3) study strategies questions, (4) ranking study strategies and strategy scenario questions, (5) learning style questions, (6) a thank you and an optional opportunity to receive the results via entering an email address. None of the questions in the survey had opportunities for participants to give examples or comments.

Section one included the project title, researcher, contact information and eight questions that participants might ask concerning the research. Questions included (1) purpose, (2) what participants must do, (3) any possible adverse effects of participation, (4) benefits of participation, (5 and 6) confidentiality, (7) whether the project has received ethical clearance and (8) withdraw possibilities.

Section two included demographic questions such as (1) the highest level of education, (2) whether the participant has a degree in education, (3) employment status, (4) the number of years teaching, (5) the highest level of teaching, (6) subject area, (7) any teacher-training certificates obtained outside of a degree in education, and (8) gender.

Section three included questions on (1) strategy recommendation to students, (2) frequency of strategy recommendation, and (3) whether the participant thought their students used the recommended strategy.

Section four started by asking participants to rate 14 strategies, nine from Dunlosky et al. (2013), plus five others on a 5-point scale: very poor, poor, moderate, effective, and very effective. Asking questions in class, studying with friends, making diagrams, and cramming were strategies added due to the researcher's personal experiences as an instructor, specifically, strategies reported by students. The 14 strategies included:

- Cramming lots of information the night before the test
- Summarizing material into notes
- Interleaved practice (moving around from concept/chapter to chapter while studying)
- Practice testing

• Using flashcards

• Distributed practice (increasing time to practice before a test)

• Highlighting

• Keyword mnemonic

• Imagery

• Re-reading textbooks, articles, notes

• Elaborative interrogation (asking questions about course material)

• Making diagrams, charts, or pictures

• Studying with friends

• Asking questions or verbally participating during class

Afterward, two scenario questions were adapted from Morehead et al. (2016): the first asking instructors why students should test themselves. The options included an evidence-based answer (learn more than through re-reading) and two non-evidence- based answers (to figure out how well they learned the information; testing will not benefit students).

5. If you think students should quiz themselves (either using a quiz at the end of a chapter, a practice quiz, flashcards or something else), why should they do so?

- They will learn more that way than through re-reading

- To figure out how well they have learned the information they're studying

- I do not think quizzing will necessarily benefit students

The second scenario involved interleaving, where instructors were asked to rate the value of two strategies, one evidence-based (student moved back and forth from chapter to chapter) and one non-evidence-based (block studying).

6. Students have three chapters of material to learn. Student A studies one chapter at a time. Student B moves around, studying a little chapter one, then a little from chapter two, and a little from chapter three. Both students study the same amount of time. Please rate the value of the strategy.

	Not at all beneficial	Somewhat beneficial	Very beneficial
Student A	[ ]	[ ]	[ ]
Student B	[ ]	[ ]	[ ]

Section five included the learning styles questions starting with (1) whether faculty believed in learning styles, (2) whether instructors taught to accommodate the differences, and (3) how confident the teachers were in their learning style belief. In addition, instructors ranked seven statements, adapted from Dekker et al. (2012) and Nancekivell et al. (2020), on a 5-point scale: strongly disagree, disagree, neutral, agree, and strongly agree. Questions included:

1) Learning styles are determined at birth.

2) Learning styles can change.

3) Those with different learning styles use different brain regions to learn.

4) Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.

5) Learning styles predict the type of career someone will have.

6) Learning styles predict the kinds of teachers from whom they learn best.

7) Students use learning strategies that link up with their perceived learning style.

Ethical Considerations

Ethics Approval

As the research was conducted before entering this program, the project was approved by Cambrian College's Research Ethics Board (REB) on May 20, 2022. The researcher is a full-time faculty at Cambrian College, and the institution's REB deemed the magnitude of possible harms or level of risk for the participants as low or minimum. After initial approval by Cambrian College, the researcher obtained REB approval from three other institutions: Humber College (approved on June 9th, 2022), Fanshawe College (May 28, 2022), and Western University (June 8, 2022). The other institutions (York University, University of Toronto, and Laurentian University) were contacted by the researcher concerning an REB application but was informed that an REB review was unnecessary due to Cambrian College's approval and the use of public directories for participant information. Both Humber College and Fanshawe College required that institution-specific contact information be added for the surveys going out to their faculty. All other institutions approved the general invitation. All approved REB forms can be found in Appendix B.

Informed Consent

Faculty participants were directed to an online survey where the first page contained the consent form. The form included questions and answers (see Appendix A) concerning consent (see Table 17):

Table 17

Consent Form Questions

Question #	Question
1	What is the purpose of the project?
2	What will I have to do?
3	Will there be any negative effects of taking part in the study?
4	What benefits will the study have for the participants?
5	How will confidentiality be assured?
6	Who will have access to the information that I provide?
7	Has this project received appropriate ethical clearance?
8	How can I withdraw from the project?

Confidentiality and Anonymity

The survey was distributed via GoogleForms, a secure web application for building surveys and data collection. The survey was completely anonymous.

Debriefing

After the final section on learning styles, participants clicked a link to complete the survey. This link submitted the survey and brought faculty participants to another Google Form where they had the option of inputting their email address to obtain the results once the project was completed.

Chapter 5: Results

The results will be divided into two sections: those dealing with learning strategies and those addressing learning styles. Within each section, the results will be organized by the independent variable. Respondents' education (highest degree obtained) will be addressed first. Followed by whether respondents have a degree in education, the employment status of respondents (full-time or part-time), their teaching experience in years, whether they teach at a Canadian college or university, the subject that they teach, whether they have had any additional teacher training outside of a degree in education, and the gender of the participant. Faculty were also asked if they recommend study strategies to their students, how often they recommend them, and if they believe students use their recommended study techniques.

Characteristics of the Participants

This section examines the characteristics of the research sample – the participants who completed the questionnaire. A total of 7015 emails were sent to faculty from various institutions, with 544 completing the survey (response rate of 7.8%). A descriptive summary is found in Table 18. Most (45.2%) of the faculty surveyed had a Ph.D. as their highest degree, followed by a master's degree (35.4%), bachelor's degree (13.7%) and a trade school degree (5.7%). The participants were asked whether they had a degree in education, with 23% reporting yes. The instructors were asked about their employment status, and 68.1% reported being full-time faculty, with 31.9% stating they were part-time. Most (32.7%) of respondents reported 0-5 years of teaching experience, followed by 11-15 years (20.2%), 6-10 years (18.6%), 20+ years (15.6%) and 16-20 years (12.9%). Concerning the institution type at which they taught, most reported a university (58.3%), followed by a college (41.7%). On the subject area, the majority stated that they taught in a social science field (33.0%), followed by a science field (25.3%), business (15.6%), languages (7.9%), creative arts (7.9%), computers (5.4%) and trades (4.9%). Next, additional teacher training: only 51% of the faculty answered the question as to whether they had any teacher training courses outside of a degree in education. While the survey offered six options for the number of training courses or workshops (1-5, 6-10, 11-15, 16-20, 21+), 44.7% indicated no additional teacher training. Due to the lack of input, the data were recoded: those faculty that reported no training formed one category (92.4%) and those with any amount of training/workshop experience another (7.6%). The faculty were also asked about their identified gender, and 53.2% responded male and 46.8%, female. The faculty participants were also asked if they recommend study strategies to their students, and 89.5% reported yes, while 10.5% stated no. An inquiry was made concerning the frequency of strategy recommendation to students, and most of the faculty participants reported before an assessment (40.6%), about once a class (36.6%), a few times a class (14.0%), and 8.8% stated that they do not recommend study techniques. When faculty were asked their opinion on if students use their recommended strategies, there was a close split between students using the techniques in all their classes (39.6%) and only the faculty's class (38.0%), with 14.1% reporting that students do not use their recommended strategies and 8.3% of instructor participants stating they do not recommend study strategies.

Table 18

Descriptive Statistics of Instructors Sampled

Variable	Percentage	Variable	Percentage
Level of Highest Degree		*Additional Teacher Training (Outside of Education)*	
Ph.D.	45.2%	Some training	7.6%
Master's Degree	35.4%	No training	92.4%
Bachelor's Degree	13.7%		
Trade School	5.7%	*Gender*	
		Male	53.2%
Degree in Education		Female	46.8%
Yes	23%		
No	77%	*Recommendation of Learning Strategies*	
		Yes	89.5%
Employment Status		No	10.5%
Part-Time	31.9%		
Full-Time	68.1%	*Frequency of Learning Strategy Recommendation*	
		A few times a class	14.0%
Number of Years Teaching		About once a class	36.6%
0-5 years	32.7%	Before assessment	40.6%
6-10 years	18.6%	Do not recommend	8.8% (*)
11-15 years	20.2%		
16-20 years	12.9%	*Student Use Faculty Recommended Strategies*	
20+ years	15.6%	Yes – all classes	39.6%
		Yes – only my class	38.0%
Institution Type		No	14.1%
College	41.7%	Do not recommend	8.3% (*)
University	58.3%		
Teaching Subject Area			
Sciences	25.3%		
Social Sciences	33.0%		
Languages	7.9%		
Business	15.6%		
Computers	5.4%		
Creative Arts	7.9%		
Trades	4.9%		

Note. (*): faculty reported not recommending study strategies.

Results—Learning Strategies

Instructors' responses to survey questions on the effectiveness of learning strategies are summarized in Table 19. Participants were asked to rate the effectiveness of various strategies as very poor (score of 1), poor (score of 2), moderate (score of 3), effective (score of 4) and very effective (score of 5). The mean rating for each strategy is reported, as is the percentage of respondents selecting each effectiveness rating. The table features the learning strategies in the three categories based on the rankings (low, moderate, and high effectiveness) from Dunlosky et al. (2013) and supplemental techniques (labelled as 'other strategies'), which were added to this study. Dunlosky et al. (2013) looked at various learning strategies that were either rated as easy to use or frequently used (by students) and categorized their effectiveness as low, moderate, or high. The rankings were based on previous research for each strategy in four categories: learning conditions, student characteristics, materials used, and criterion tasks/assessments. Henceforth, any strategy or ranking that was used in the Dunlosky et al. (2013) study will be referred to as a 'Dunlosky' strategy or ranking.

As demonstrated in Table 19, the strategy of cramming had the lowest mean effectiveness score from participants in this research (1.5), with the next highest strategy (interleaving) receiving a mean score of 3.2. In fact, nine strategies (interleaving, highlighting, mnemonics, flashcards, re-reading, imagery, studying with friends, distributed practice, and practice testing) all had mean scores ranging from 3.2 to 3.9 or the moderate effectiveness category. The strategies with means scores above four included diagrams (4.1), elaborate interrogation (4.2) and the highest-ranked strategy in this study, asking questions in class (4.4).

Concerning the Dunlosky ranked categories, starting with the low category strategies, highlighting (3.2), mnemonics (3.3), re-reading (3.3), and imagery (3.7) were all given moderate mean scores by the faculty in this study. The other Dunlosky low strategy was summarizing notes: it was given an effective mean rating of 4.1. For the moderate Dunlosky strategies, interleaving was given a moderate mean score of 3.2, while elaborate interrogation was given a mean score of 4.2, placing the technique in the effective category. Lastly, for the high Dunlosky strategies, both distributed practice (3.7) and practice testing (3.9) were given high moderate mean scores, almost approaching the effective category. For the added strategies in this study, cramming was given the lowest mean score (1.5), both flashcards (3.3) and studying with friends (3.7) were given moderate mean scores, and both diagrams (4.09) and asking questions in class (4.4) were given effective scores, the latter being the highest rated strategy in this study. Overall, strategies rated by Dunlosky as having low effectiveness received a mean rating of 3.6, while those rated as having medium effectiveness received a mean of 3.7, and those having high effectiveness received a mean of 3.8. Strategies not in Dunlosky's three categories received a mean rating of 3.4 (in the moderate effectiveness category), although the mean score could be affected by the strategy of cramming, which received the lowest rating of all the strategies in this research (1.5).

Table 19

Instructor Views on Strategy Effectiveness

Strategy – Low Effectiveness (*)	Mean	SD	VP	PR	MOD	EFF	VE
Summarizing	4.09	.74	--	1.7%	18.2%	49.5%	30.6%
Highlighting	3.22	.99	5.1%	15.6%	39.5%	31.1%	8.6%
Mnemonics	3.30	1.0	5.2%	13.0%	39.5%	31.0%	11.3%
Imagery	3.68	.90	1.7%	7.2%	29.9%	43.7%	17.5%
Re-reading	3.56	.59	1.3%	9.2%	35.1%	41.5%	12.9%
Ave. low strategies	3.58	.59					
Strategy – Moderate Effectiveness (*)							
Interleaving	3.20	.92	3.9%	14.4%	47.5%	26.4%	7.9%
Elaborative Interrogation	4.24	.76	0.6%	1.5%	11.6%	46.0%	40.4%
Ave. moderate strategies	3.73	.64					
Strategy – High Effectiveness (*)							
Practice Testing	3.92	.87	1.1%	3.3%	25.2%	43.4%	27.0%
Distributed Practice	3.73	.70	1.1%	4.6%	31.2%	46.0%	17.1%
Ave. high strategies	3.82	.70					
Other Strategies (^)							
Cramming	1.52	.74	59.5%	31.1%	7.4%	1.7%	0.4%
Flashcards	3.33	1.0	5.1%	14.2%	33.8%	36.8%	10.1%
Diagrams	4.09	.82	0.6%	3.3%	15.9%	47.0%	33.3%
Studying w/ Friends	3.69	.90	0.9%	7.9%	31.7%	40.2%	19.5%
Asking Questions in Class	4.36	.69	--	0.2%	11.4%	41.1%	47.3%

Note. (*) = according to Dunlosky; (^) = strategies not classified by Dunlosky.
Strategy effectiveness was measured on a 1–5 scale: 1 = very poor (VP), 2 = poor (PR), 3 = moderate (MOD), 4 = effective (EFF), 5 = very effective (VE). SD = standard deviation.

Relative Effectiveness Ratings of Different Strategies

Participants rated 14 different strategies in terms of their effectiveness. This analysis compares the strategies. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that there were significant mean differences between the study strategies [F(13, 10.68) = 405.77, $p < 0.001$, partial eta squared = 0.44). Table 20 presents the strategies in order of magnitude by the mean rating score. Only the strategy of cramming received a mean score in the 'poor' effectiveness range, with nine strategies in the 'moderately' effective category, and four techniques in the ‘effective’ category. Cramming was rated the poorest strategy (*M* = 1.5), and asking questions in class, was the most effective technique (*M* = 4.4).

In summary, while 14 strategies were presented in this study, only five were rated outside of the moderate category by the faculty in this study. Of the nine Dunlosky strategies, only one (interleaving) was correctly matched with the Dunlosky model. All other Dunlosky strategies did not align with its ranking model, although practice testing (rated moderate in this study) approached the effective rating (3.9), which would coordinate with the Dunlosky model.

Table 20

Instructor Ratings of Learning Strategy Effectiveness

Strategy	Mean	SD
Cramming (^)	1.52	.74
Interleaving (D – M)	3.20	.92
Highlighting (D – L)	3.22	.99
Mnemonics (D – L)	3.30	1.0
Flashcards (^)	3.33	1.0
Re-reading (D – L)	3.56	.59
Imagery (D – L)	3.68	.90
Studying w/ Friends (^)	3.69	.90
Distributed Practice (D – H)	3.73	.70
Practice Testing (D – H)	3.92	.87
Summarizing (D – L)	4.09	.74
Diagrams (^)	4.09	.82
Elaborative Interrogation (D – M)	4.24	.76
Asking Questions in Class (^)	4.36	.69

Note. (D - L) = Dunlosky strategy ranked as low effectiveness; (D - M) = Dunlosky strategy ranked as moderate effectiveness; (D – H) = Dunlosky strategy ranked as high effectiveness; (^) = strategies not classified by Dunlosky. Strategy effectiveness was measured on a 1–5 scale: 1 = very poor (VP), 2 = poor (PR), 3 = moderate (MOD), 4 = effective (EFF), 5 = very effective (VE). SD = standard deviation.

The Relationship of Level of Education to Strategy Ratings

One question of this research addressed the relationship between the level of education completed by members of the faculty and their ratings of various study strategies. Table 21 contains the correlations between the faculty’s level of education and the learning strategies. The faculty's level of education was on a scale of 1 to 4: trade school (1), bachelor's degree (2), master's degree (3) and Ph.D. (4). Overall, six of the 14 strategies were significantly correlated, all negative correlations indicating a pattern for those with lower education.

Starting with ratings for the Dunlosky low effectiveness strategies, two of five were significantly correlated with education in a negative direction, suggesting that the instructors with lower education scored summarizing notes and highlighting as more effective techniques while those with higher education scored them as less effective. The average of the low-effective strategies was also significantly correlated, indicating that those instructors with lower education ranked the Dunlosky low-effective strategies higher. Continuing, the strategy of interleaving and the average of the Dunlosky moderate techniques with the instructor's education was significant, suggesting that faculty with lower education ranked the Dunlosky moderate strategies as more effective. The correlation was a weak one. Concerning the Dunlosky highly effective strategies, the significant correlation of practice testing indicated that those with lower education ranked practice testing more effective. The average of the Dunlosky high-effectiveness strategies (practice testing and distributed practice) was also significant, suggesting that those with lower education ranked the two strategies as more effective. Interestingly, those with higher education ranked cramming as significantly more effective, while those with lower education ranked flashcards as more effective.

In summary, while only six strategies (four from Dunlosky's list and two others) were significantly correlated with the level of education, all were negatively correlated, indicating that effectiveness ratings rose as education declined. The trend noted in the data is that higher education was associated with lower effectiveness ratings for various learning strategies. Correlations tended to be weak, with explanatory power (r squared) in the 1-4% range.

Table 21

Correlations Between Education and Learning Strategies

Strategy	Education
Strategy - Low	
Summarizing Notes	-.01*
Highlighting	-.11*
Mnemonics	-.04
Imagery	-.05
Re-reading	-.00
Average Low Strategies	-.09*
Strategy – Moderate	
Interleaving	-.13**
Asking Qs to self	-.04
Average Moderate Strategies	-.12*
Strategy – High	
Practice Testing	-.13**
Distributed Practice	-.04
Average High Strategies	-.10*
Other Strategies	
Cramming	-.10*
Flashcards	-.20**
Diagrams	-.06
Studying with Friends	-.10
Asking Qs in Class	-.14

Note. * $p < 0.05$ level (2-tailed); ** $p < 0.01$ level (2-tailed)

The Relationship of Degree in Education to Strategy Ratings

One of the questions of this research focused on whether instructors had a specific degree related to education in their training. To compare instructors with education degrees to those without, independent-samples t-tests were conducted. Significant differences were associated with three of the 14 strategies: mnemonics (t = -2.82, p = .005, eta squared = 0.01), imagery (t = -2.11, p = .036, eta squared = 0.01), practice testing (t = -2.28, p = .024, eta squared = 0.01), and average Dunlosky ranked high strategies (t = -2.043, p = .042, eta squared = 0.01).

Both mnemonics and imagery were ranked as low-effectiveness strategies by Dunlosky et al. (2013), yet the instructors with degrees in education (*M* = 3.5, 3.8, *SD* = 0.98, 0.84) rated the techniques as significantly more effective than those without a degree in education (*M* = 3.2, 3.6, *SD* = 1.00, 0.92). Practice testing is considered a highly effective technique by Dunlosky et al. (2013), and those with a degree in education rated the strategy as more effective (*M* = 3.8, *SD* = 0.87) than those that did not (*M* = 3.7, *SD* = 0.82) have a degree in education. Finally, faculty with a degree in education rated the average Dunlosky high strategies (practice testing and distributed practice) as more effective (*M* = 3.9, *SD* = .72) than those without a degree in education (*M* = 3.8, *SD* = .70).

In summary, while those with a degree in education did rank practice testing as significantly more effective than those without such a degree, they also ranked two low Dunlosky strategies as more effective. In overview, with only three of 14 strategies being significantly related to holding an education degree, all with low effect sizes, it could be concluded that a degree in education is not strongly associated with strategy effectiveness rating.

The Relationship of Employment Status to Strategy Ratings

Some of the faculty surveyed worked full-time, while others worked part-time. To compare the faculty's employment status (full-time and part-time), independent-samples t-tests were conducted. Only one significant strategy difference was identified. This was for the Dunlosky technique of highlighting ($t = 2.64$, $p = .008$, eta squared = .01), with part-time instructors (*M* = 3.4, *SD* = .97) ranking the strategy as more effective than full-time instructors (*M* = 3.2, *SD* = .99). The average of the low effective strategies (summarizing notes, highlighting, mnemonics, imagery, and re-reading) was significant at the .05 level exactly (*t* =

1.97, p = .050, eta squared = .001) with part-time instructors (M = 3.7, SD = .62) ranking the strategies more effective than full-time instructors (M = 3.5, SD = .57).

In summary, while Dunlosky et al. (2013) ranked highlighting as a low-effectiveness strategy, both full-time and part-time faculty in this study rated the technique in the mid-moderate range (3.4 and 3.2), and part-time instructors gave this strategy the higher rank. Both full-time and part-time instructors in this study also rated the average of the Dunlosky low effectiveness strategies in the mid to high moderate range (3.7 and 3.5). With only one of 14 individual strategies being significantly related to employment status, it is likely that employment status (full-time or part-time) is not strongly associated with differences in the effectiveness ratings of various learning strategies.

The Relationship of Years of Teaching Experience to Strategy Ratings

Another factor considered predictive of learning strategy ratings was years of teaching experience. Table 22 contains the correlations between years of teaching experience and learning strategy ratings. Only two of 14 strategies (flashcards and studying with friends), both of which were not from Dunlosky's list of techniques, evidenced a significant relationship to instruction years of experience. There was a small negative correlation between the use of flashcards and years of experience (r = -.13, n = 544, p = .002), with higher effectiveness ratings of the strategy being associated with fewer years of experience. There was also a small positive correlation between studying with friends and years of experience (r = .10, n = 542, p = .23), with a higher effectiveness rating of the strategy being associated with higher years of experience.

In summary, with only two of 14 strategies being significantly related to years of experience, one of them positively and the other negatively, it could be concluded that years of teaching experience are not strongly associated with strategy effectiveness ranking.

Table 22

Correlations Between Years of Teaching Experience and Learning Strategies Ratings

Strategy	Teaching Experience
Strategy - Low	
Summarizing Notes	.08
Highlighting	.02
Mnemonics	.02
Imagery	-.05
Re-reading	.08
Average Low Strategies	.05
Strategy – Moderate	
Interleaving	-.11
Asking Qs to self	-.02
Average Moderate Strategies	-.01
Strategy – High	
Practice Testing	-.04
Distributed Practice	-.01
Average High Strategies	-.03
Other Strategies	
Cramming	-.06
Flashcards	-.13*
Diagrams	.04
Studying with Friends	.10*
Asking Qs in Class	.01

Note. * $p < 0.05$ level (2-tailed); ** $p < 0.01$ level (2-tailed)

The Relationship of Institutional Employment to Strategy Ratings

The participants in this research came from both colleges and universities in the Ontario system. To compare college and university faculty on strategy ratings, independent-sample t-tests were conducted, and the results can be found in Table 23. Overall, seven of nine strategies were significant: concerning the Dunlosky et al. (2013) strategies, five of nine strategies were associated with significant differences, as were all three Dunlosky ranking category averages (low, moderate, and high). Regarding the strategies added in this study, two of five (cramming and flashcards) were associated with significant rating differences between college and university faculty.

Among the Dunlosky low-effectiveness strategies, only mnemonics and re-reading the textbook/course material were not associated with significant differences between college and university faculty. Besides summarizing notes, college instructors rated highlighting ($M = 3.3$), imagery ($M = 3.8$), and the average of the low-effectiveness strategies (3.6) significantly more effective than university professors ($M = 3.2, 3.6, 3.5$). Concerning the strategy of summarizing notes, university faculty rated the technique significantly higher ($M = 4.2$) than college instructors ($M = 3.3$).

Amid the Dunlosky moderate strategies, asking questions to oneself yielded no significant differences between institution faculty. For both interleaving ($M = 3.3$) and the average moderate strategies ($M = 3.8$), university instructors rated the technique significantly more effective than college professors ($M = 3.1, 3.7$).

Among the Dunlosky high-effectiveness strategies, the technique of distributed practice had no significant differences between college and university faculty; however, both practice testing (M = 4.0) and the average of the high-effectiveness strategies ($M = 3.9$) saw college professors rate the technique significantly more effective than university faculty ($M = 3.9, 3.8$). Amidst the strategies added in this research, the techniques of diagrams, studying with friends, and asking questions in class noted no significant differences between institutions. Both cramming and flashcards yielded significant differences, with college faculty (*M* = 1.6, 3.5) rating the strategies more effective than university professors (*M* = 1.5, 3.2).

In summary, seven of 14 strategies were significantly related to the institution where the faculty worked, but all effect sizes had very low relationship strength (ranging from 0.1 to 0.3). In addition, all significant and non-significant mean scores for the Dunlosky low-ranked strategies were between 3.3 and 3.8, all moderate to high moderate category ratings in this study, save for summarizing notes, rated at a mean score of 4.2 for university professors. Like Dunlosky's ranking, the faculty in this study rated interleaving in the moderate range (3.1 to 3.3); however, unlike Dunlosky and colleagues (2013), the participants in this study rated elaborate interrogation (asking questions to self) in the effective/highly effective range (4.2 to 4.3), where Dunlosky et al. (2013) ranked the technique in the moderate category. Practice testing was ranked as an effective strategy by Dunlosky et al. (2013). The college instructors rated the technique as effective with a mean score of 4.0, while the university professors rated it just under effective with a mean score of 3.8. In overview, while half of the strategies noted significant interactions, all had effect sizes that were low, indicating the institution from which the faculty participants work is not strongly associated with strategy effectiveness rating.

Table 23

Learning Strategy Ratings—College v. University Instructors

Strategy	P	Effect Size	College	University
Strategy - Low				
Summarizing Notes	006*	.01	3.29	**4.19**
Highlighting	037*	.01	**3.33**	3.15
Mnemonics	.214		3.37	3.26
Imagery	.010*	.01	**3.78**	3.61
Re-reading	.445		3.52	3.58
Average Low Strategies	.024*	.01	**3.64**	3.52
Strategy – Moderate				
Interleaving	.010*	.01	3.08	**3.29**
Asking Qs to self	.799		4.23	4.25
Average Moderate Strategies	046*	.01	3.66	**3.77**
Strategy – High				
Practice Testing	.021*	.01	**4.02**	3.85
Distributed Practice	.261		3.78	3.70
Average High Strategies	.036*	.01	**3.90**	3.77
Other Strategies				
Cramming	.005*	.01	**1.63**	1.45
Flashcards	.000**	.03	**3.54**	3.18
Diagrams	.681		4.08	4.11
Studying with Friends	.362		3.73	3.66
Asking Qs in Class	.364		4.39	4.33

Note. * = $p < 0.05$; ** = $p < 0.001$

The Relationship of Subject Taught to Strategy Ratings

Participants in this research taught different college and university subjects. The survey had eight subject options and an "other" option, including (1) sciences, (2) social sciences, (3) English, (4) business, (5) IT/computers, (6) music, (7) creative arts, and (8) trades. None of the faculty participants in this research gave 'other' as their subject.

A one-way analysis of variance was conducted to explore differences in the subjects faculty taught and their strategy ratings. Overall, only three of the 14 strategies were significant, all Dunlosky techniques (imagery, interleaving, and elaborative interrogation) and the average of the Dunlosky moderate strategies.

Imagery [$F(6, 520) = 3.17$, $p = .005$] significant differences between subjects but had a small effect eta squared size (.04). Post-hoc comparisons using the Tukey HSD test indicated only one significant ($p = .030$) subject difference: faculty teaching the subject of computers ($M = 3.4$. $SD = .98$) ranked imagery as significantly less effective than those teaching in the creative arts ($M = 4.1$, $SD = .80$) instructors. The difference for interleaving was significant [$F(6, 517) = 2.71$, $p = .013$] but weak, with a small effect size (.03). Post-hoc comparisons using the Tukey HSD test indicated that instructors focusing on trades ($p = .028$) rated interleaving as significantly less effective ($M = 2.8$, $SD = .86$) than those teaching in the creative arts ($M = 3.5$, $SD = .86$). Elaborative interrogation [$F(6, 526) = 3.33$, $p = .003$] was also associated with a small effect size (.04). Post-hoc comparisons using the Tukey HSD test indicated that instructors teaching computers rated elaborative interrogation as significantly less effective ($M = 3.8$, $SD = .76$) than faculty teaching social sciences ($M = 4.6$, $SD = .76$, $p = .011$), languages ($M = 4.4$, $SD = .63$, $p = .017$), and business ($M = 4.3$, $SD = .68$, $p = .045$). Finally, average moderate strategies [$F(6, 526) = 3.62$, $p = .002$] also had a low effect size (.04), with the only significant post hoc difference ($p = .011$) being between science and social science instructors with the former ranking the strategies as less effective ($M = 3.6$, $SD = .61$) than the latter ($M = 3.8$, $SD = .67$).

In summary, while there were a few significant differences in the rated effectiveness of learning strategies associated with the main subject matter taught by individual faculty members, such differences were characterized by weak effect sizes (.03 to 0.4 in range), indicating a lack of strength between the distinctions. Only two of eight subjects agreed with the Dunlosky rankings: the creative arts faculty rated interleaving as a moderately effective strategy with a mean score of 3.5 (in the mid-moderate range), and computer or technology instructors also rated elaborative interrogation or asking questions to self as a moderate strategy with a mean score of 3.6 (also in the mid-moderate range). All other significant findings by subject contrasted with the Dunlosky model: first, the trade teachers rated interleaving as poor, just under the moderate mark, with a mean score of 2.8. Both computer and creative arts teachers rated imagery, a low effectiveness ranking by Dunlosky et al. (2013), as moderate or high, with mean scores of 3.9 and 4.1, approaching effective or just at the effective category rating in this study. While elaborate interrogation or asking questions to self was rated as a moderate technique by Dunlosky et al. (2013), the social science, language, and business faculty all rated the technique as effective in this study with mean scores of 4.6, 4.4, and 4.3. In overview, with only three of 14 strategies being significantly related to the subject in which the faculty teaches, it could be concluded that the subject taught is not strongly associated with strategy effectiveness rating.

The Relationship of Teacher Training Courses/Workshops to Strategy Ratings

It is possible that specific training as a teacher (or its absence) would lead to different views on the effectiveness of learning strategies. Only 51% of the faculty answered the question as to whether they had any teacher training courses outside of a degree in education. While the survey offered six options for the number of training courses or workshops (1-5, 6-10, 11-15, 16-20, 21+), 44.7% indicated no additional teacher training. Due to the lack of input, the data were recoded: those faculty that reported no training formed one category and those with any amount of training/workshop experience another.

There were no significant differences between the two recoded groups with respect to the strategy ratings. However, the difference for the strategy of highlighting approached significance (p = .052), with those reporting some training (M = 3.6, SD = .81) ranking the strategy more effective than those with reported no training (M = 3.2, SD = 1.05).

In overview, with none of the 14 strategies being significantly related to additional teacher training, it could be concluded that training is not strongly associated with strategy effectiveness rating.

The Relationship of Gender to Strategy Ratings

To compare the viewpoints of male and female faculty, independent-samples t-tests were conducted, and significant differences were associated with eight of 14 strategies, all with female instructors ranking the strategy as more effective than male instructors. Of the eight significant strategies, half (mnemonics, imagery, elaborate interrogation or asking questions to yourself, practice testing, and distributed practice) were techniques from Dunlosky's research, while the other half (flashcards, asking questions in class, diagrams, and studying with friends) were added to this research (see Table 24).

In summary, eight strategies had a signification relationship to gender, with female faculty rating the strategies higher than their male counterparts in all instances. All significant interactions had eta squares in the small range. All mean scores for the strategies listed above, regardless of gender, fell within the mid and high moderate range, with the female rating of practice testing falling just below this study's effective range (3.99). Both females and males rated mnemonics and imagery in the mid to high moderately effective range despite Dunlosky et al. (2013) ranking the two strategies as low. Also, both females and males rated practice testing and distributed in the mid to very high moderately effective range despite Dunlosky et al. (2013) ranking the two strategies as highly effective. In overview, while eight of the 14 strategies noted significant interactions with the gender of the faculty, all had low effect sizes (ranging from .01 to .04); therefore, it could be concluded that instructor gender is not strongly associated with strategy effectiveness rating.

Table 24

The Relationship of Gender to Strategy Ratings

Strategy	P	Effect Size	College	University
Strategy - Low				
Summarizing Notes	.779		4.1	4.1
Highlighting	.592		3.2	3.3
Mnemonics	.000**	.04	3.1	**3.5**
Imagery	.000**	.04	3.5	**3.9**
Re-reading	.813		3.6	3.5
Average Low Strategies	.002*	.02	3.5	**3.6**
Strategy – Moderate				
Interleaving	.381		3.2	3.2
Asking Qs to self	.001*	.02	4.1	**4.3**
Average Moderate Strategies	.013*	.01	3.7	**3.8**
Strategy – High				
Practice Testing	.041*	.04	3.8	**4.0**
Distributed Practice	.003*	.02	3.6	**3.8**
Average High Strategies	.002*	.02	3.7	**3.9**
Other Strategies				
Cramming	.631		1.5	1.5
Flashcards	.000**	.02	3.2	**3.5**
Diagrams	.000**	.03	3.9	**4.2**
Studying with Friends	.021*	.02	4.1	**4.3**
Asking Qs in Class	.212			

Note. * = $p < 0.05$; ** = $p < 0.001$

Different Opinions on Why Should Students Test Themselves (Scenario Question #1)

Why should students test themselves? A scenario question was adapted from Morehead et al. (2016), asking faculty to pick the best answer for why students should test themselves. There were three possible answers, two non-evidence-based answers: (1) to figure out how well they learned the information and (2) testing will not benefit students, along with an evidence-based answer that students will (3) learn more than through re-reading. When asked why students should test themselves, 80.3% of instructors in this study picked the non-evidence-based answers (to figure out how well they learned the information; practice testing will not benefit the student) – see Table 25.

Table 25

Scenario Question #1 - Why Should Students Test Themselves

Answer	Percentage
Learn more than re-reading	19.7%
Figure out how well they learned the information	70.0%
I do not think testing students will benefit students	10.3%

To examine the relationship between Scenario Question #1 and the independent variables, no significant differences were associated in seven of the eight independent variables: whether the faculty had a degree in education, employment status (full-time v. part-time), number of years teaching, the affiliated institution (college or university), what subject the faculty taught whether the faculty had any teacher training or gender. The only significant relationship finding was the level of faculty education via a Pearson product-moment correlation coefficient analysis. A significant relationship was associated between the level of education and the reason why students should test themselves ($r = -.092$, $n = 539$, $p = .032$), indicating that instructors with higher education were more likely to choose the evidence-based answer as to why students should test themselves (they will learn more than through re-reading).

In summary, only 19.7% of faculty picked the evidence-based answer as to why students should test themselves, and only one of the eight independent variables was significantly related to the scenario question, albeit with very weak explanatory power (*r* squared). In overview, it could be concluded that the faculty in this study do not know the evidence-based reason as to why students should test themselves.

Different Opinions on Interleaved Practice (Scenario Question #2)

The second scenario, also adapted from Morehead et al. (2016), asked instructors to rate the value of two interleaving strategies. Interleaving involves a learning strategy where the teacher or student moves around from concept to concept. For example, instead of going in chronological order through chapter one and then chapter two of a textbook (called blocking), the teacher or student would move back and forth from various chapters. Evidence-based research (Dunlosky et al., 2013) has proven interleaving superior to blocking for long-term memory.

Faculty participants were presented with a scenario where two students had three chapters to learn. Using the non-evidence-based strategy, Student A would use the blocking technique, studying one chapter at a time. Using the evidence-based strategy of interleaving, Student B would move around from chapter to chapter, studying a little from each at a time. Participants were asked to evaluate the benefits of each strategy, for both students, in three categories: (1) not at all beneficial, (2) somewhat beneficial, and (3) very beneficial.

Table 26 contains the faculty's answers for the two interleaving scenarios. Only 9.1% of the instructors provided a higher rating for "Scenario B" (evidence-based strategy) than "Scenario A" (non-evidence-based strategy).

Table 26

Interleaving Strategy Scenario Results

Scenario	Not Beneficial	Somewhat Beneficial	Very Beneficial
A	0.2%	40.3%	59.5%
B	14.2%	68.6%	17.2%

Faculty participant answers in the interleaving scenario question were compared across other variables in the research, and no significant differences were associated for six of the eight independent variables in this study, including the level of a faculty education, whether the faculty had a degree in education, employment status (full-time v. part-time), the institution where the faculty teaches (college v. university), what subject the faculty teaches, and whether the faculty had any teacher training.

Two significant relationships were noted: the number of years the faculty has taught and the gender of the instructor. For the following analyses, the answers were coded numerically: not beneficial (1), somewhat beneficial (2), and very beneficial (3).   Using a Pearson product-moment correlation coefficient analysis, years of teaching were significantly correlated with the interleaving scenario ($r = .61$, $n = 541$, $p < .001$), indicating that instructors with additional years of teaching experience were more likely to rank "Scenario B" (evidence-based strategy) as more beneficial. An independent-samples t-test yielded that gender was significantly related to the interleaving scenario ($t = 2.78$, $p = .006$, eta squared = .01). Female faculty ($M = 2.1$, $SD = .55$) were more likely to support the use of interleaving ("Scenario B") than male faculty ($M = 1.9$, $SD = .56$); however, both gender averages were at or close to the 'somewhat' beneficial' rating of the interleaving scenario.

In summary, only 9.1% of faculty provided a higher rating for "Scenario B" (evidence-based strategy) than "Scenario A" (non-evidence-based strategy). In addition, only two of the eight independent variables were significantly related to the scenario question. While the explanatory power (*r* squared) for the years of teaching experience was moderate, the effect size for the gender differences was very small. In overview, it could be concluded that the faculty in this study do not know the advantages of interleaved practice while learning.

Summary—Learning Strategies

In summary, the faculty surveyed in this research rated study or learning strategies differently than Dunlosky et al. (2013). As demonstrated in Table 27, almost all (seven of nine) strategies were rated in the moderate category, with only summarizing notes/course material and elaborate interrogation (asking questions to self) getting a mean effective rating. According to participants, there were no low-effectiveness strategies that were ranked by Dunlosky et al. (2013).

For the low effective Dunlosky strategy rankings, highlighting, mnemonics, imagery, and re-reading were given moderate effectiveness ratings by the faculty participants while summarizing was given an effective rating. Concerning the moderately effective Dunlosky strategies, interleaving was rated as moderate by the faculty in this study, but elaborative interrogation was rated effective ($M = 4.2$). For the highly effective Dunlosky strategies, both practice testing ($M = 3.9$) and distributed practice ($M = 3.7$) were given high moderate ratings, almost approaching the effective category.

Interestingly, two of the three highest-rated strategies in this study were two techniques that were not ranked by Dunlosky et al. (2013): diagrams and asking questions in class, both getting effective mean scores (4.1 and 4.3), with the Dunlosky strategy of elaborative interrogation getting a mean score of 4.2. Only summarizing notes ($M = 4.1$), diagrams ($M = 4.1$), elaborative interrogation ($M = 4.2$), and asking questions in class ($M = 4.3$), were rated outside of the moderate effectiveness category, along with cramming ($M = 1.5$). In overview, teachers in the post-high-school system have a view of learning strategy effectiveness that does not agree with the Dunlosky ranking model.

Table 27

Dunlosky Strategy Rankings and Faculty Strategy Ratings Comparison

Strategy (Mean)	Dunlosky Effectiveness Ranking	Rating Category
Summarizing	Low	Effective (4.09)
Highlighting	Low	Moderate (3.22)
Mnemonics	Low	Moderate (3.30)
Imagery	Low	Moderate (3.68)
Re-reading	Low	Moderate (3.56)
Interleaving	Moderate	Moderate (3.20)
Elaborative Interrogation	Moderate	Effective (4.24)
Practice Testing	High	Moderate (3.92)
Distributed Practice	High	Moderate (3.73)

Note. Strategy effectiveness was measured on a 1–5 scale: 1 = very poor (VP), 2 = poor (PR), 3 = moderate (MOD), 4 = effective (EFF), 5 = very effective (VE). SD = standard deviation.

Results—Learning Styles

In this section of the results, faculty were asked a series of questions on learning styles, defined in the survey as 'individuals will learn better when they are taught in a way that matches their preferred or dominant way of learning'. For the first, a 'yes' or 'no' question, instructors were asked whether they believed students had different learning styles. The next question asked faculty participants whether they accommodate learning style differences, also a 'yes' or 'no' question. After querying faculty participants on whether students have different learning styles and whether they accommodate for learning styles, faculty participants were asked how confident they were that students have different learning styles on a scale of zero (not confident) to 10 (very confident). For the 'yes' or 'no' questions, an answer of 'yes' was coded as a one and an answer of 'no', coded as a zero. The three questions listed above will be analyzed individually, citing any significant faculty demographic independent variable differences. Afterwards, a series of learning style questions (henceforth to be abbreviated as 'LSQs') were asked of the faculty participants. These questions were adapted from Dekker et al. (2012) and

Nancekivell et al. (2020) on a 5-point scale: strongly disagree, disagree, neutral, agree, and strongly agree. The LSQs were:

1) Learning styles are determined at birth.

2) Learning styles can change.

3) Those with different learning styles use different brain regions to learn.

4) Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.

5) Learning styles predict the type of career someone will have.

6) Learning styles predict the kinds of teachers from whom they learn best.

The LSQs represent various learning style myths that have been contradicted by evidence-based research. All questions were framed in the same way: agreeing with the statements would contrast evidence-based research. For the six LSQs, the results will be organized by the independent variable. Respondents' education (highest degree obtained) will be addressed first. Followed by whether respondents have a degree in education, the employment status of respondents (full-time or part-time), their teaching experience in years, whether they teach at a Canadian college or university, the subject that they teach, whether they have had any additional teacher training outside of a degree in education, and the gender of the participant. The last question on the survey asked whether faculty participants believed that students use learning strategies that link up with their perceived learning style on a 5-point scale (strongly disagree, disagree, neutral, agree, strongly agree).

Descriptive Statistics—Learning Styles

In a 'yes' or 'no' question, instructors were asked whether they believed students have different learning styles (defined in the survey as 'individuals will learn better when they are taught in a way that matches their preferred or dominant way of learning'), and a large percentage (88.1%) of the faculty answered yes. After asking the faculty participants whether they believed that students have different learning styles, the next question asked them whether they accommodate different learning styles, and 92.5% said they did. Before the series of LSQs, the final inquiry asked faculty to rate their confidence in whether students have different learning styles on a 10-point scale (0 = *not confident*, 10 = *very confident*). Of the 88.1% of faculty that reported that students have different learning styles, the average confidence level, on a 10-point scale, was 8.93.

The next section of the survey asked faculty to state their agreement on six LSQs, adapted from Dekker et al. (2012) and Nancekivell et al. (2020), on a 5-point Likert scale: strongly disagree, disagree, neutral, agree, and strongly agree, and the results can be found in Table 28.

Table 28

Learning Style Questions (In Percentages With Means and Standard Deviations)

	SD	**D**	**N**	**A**	**SA**	**Mean/ SD**
Determined at birth	14.2	31.5	40.7	12.5	1.0	2.4/.04
Can change	0.2	4.4	9.0	67.0	19.4	3.9/.04
Use different brain regions to learn	1.7	2.7	35.1	48.4	12.1	3.4/.04
Hemispheric dominance	2.7	6.3	42.5	40.6	7.9	3.3/.04
Predict career	14.6	29.6	34.9	18.0	2.9	2.5/.05
Predict best teachers	5.8	12.9	23.6	48.2	9.4	3.2/.05

Note. SD = strongly disagree (score of 1), D = disagree (score of 2), N = neutral (score of 3), A = agree (score of 4), SA = strongly agree (score of 5).

For the upcoming faculty demographic independent variable analyses, the scale was coded numerically from strongly disagree (code of one) to strongly agree (code of five). Dekker et al. (2012) and Grospietsch and Mayer (2020) identified various learning style questions that are not backed up by evidence-based research. Therefore, disagreeing with the questions would correlate with evidence-based research. For brevity, see Table 29 for the questions and the abbreviations that will be used in the summaries going forward in the analysis.

Table 29

Learning Style Questions (LSQs) and Abbreviations

Question	Abbreviation
Learning styles are determined at birth.	Birth
Learning styles can change.	Change
Those with different learning styles use different brain regions to learn.	Different brain
Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.	Hemispheric differences
Learning styles predict the type of career someone will have.	Predict career
Learning styles predict the kinds of teachers from whom they learn best.	Predict teacher

As demonstrated in Table 28, four of the six questions had mean scores in the neutral category, including (1) learning styles can change, (2) learning styles use different brain regions to learn, (3) differences in hemispheric dominance explaining differences in learning, and (4) learning styles predict the kinds of teachers from whom students can learn best. The mean scores of two questions that fell into the disagree category include (1) whether learning styles are determined at birth and (2) whether learning styles predict the type of career someone has. Most of the faculty surveyed in this study were neutral (40.7%) concerning whether learning styles are determined at birth, and more instructors disagreed or strongly disagreed (45.7%) than agreed or strongly agreed (13.5%). When asked whether learning styles can change, most of the faculty agreed (67%), and more instructors agreed or strongly agreed (86.4%) than disagreed or strongly disagreed (4.6%).

The faculty were also asked whether students use different brain regions to learn, a neuromyth identified by Grospietsch and Mayer (2020). The term “neuromyth” refers to explanations for a behavior related to brain functioning which are generally accepted but wrong. Most teachers agreed (48.4%) that those with different learning styles use different brain regions to learn; however, a strong proportion was neutral (35.1%) on the statement. Another neuromyth identified by Grospietsch and Mayer (2020) concerned whether differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners. As demonstrated in Table 27, there was a close split between neutral (42.5%) and agree (40.6%) on whether hemispheric dominance explains a learner’s individual differences. Next, faculty were asked whether learning styles can predict the type of career someone will have: most of the faculty surveyed in this study were neutral (34.9%); however, an even bigger portion strongly disagreed or disagreed (44.2%). Most instructors (48.2%) agreed that learning styles predict the kinds of teachers from whom they (students) learn best, with 23.6% stating neutral. As noted, agreeing with the statements would contrast with evidence-based evidence (Dekker et al., 2012; Nancekivell et al., 2020). All six LSQ questions had an average of 47.9% agreement (either agree or strongly agree), 31.0% neutral, and 21.1% disagreement (either disagree or strongly disagree).

The last question in the survey involved asking faculty whether they believe their students use learning strategies that link up with their perceived learning style (see Table 29). As noted in Table 30, most agreed (52.6%), with only 10.2% either disagreeing or strongly disagreeing. There were no significant associations with faculty opinion on whether students use learning strategies that link up with their perceived learning styles and any of the instructor demographic independent variables.

Table 30

Instructor Responses—Do Students Use Learning Strategies That Link Up With Their Perceived Learning Style?

	Percentage
Strongly Disagree	3.1
Disagree	7.1
Neutral	22.8
Agree	52.6
Strongly Agree	14.4

Due to the large percentage (88.1%) reporting a belief in learning styles, the remaining analyses will only examine those faculty that stated a belief in learning styles. The analysis will begin by examining whether there are any significant faculty demographic independent variable differences with the first three questions of the survey: whether students have different learning styles, whether instructors accommodate learning styles, and the faculty's confidence in whether students have different learning styles. Afterwards, the LSQ questions in Table 27 will be examined by independent variable. Respondents' education (highest degree obtained) will be addressed first. Followed by whether respondents have a degree in education, the employment status of respondents (full-time or part-time), their teaching experience in years, whether they teach at a Canadian college or university, the subject that they teach, whether they have had any additional teacher training outside of a degree in education, and the gender of the participant.

Faculty Participant Belief in Learning Styles

One question of this research addressed whether faculty participants believed that students have different learning styles. With 88.1% of the faculty in this study reporting a belief in learning styles, significant differences were associated with three of eight independent variables: the faculty's level of education, the institution where the teacher taught, and the subject the instructor teaches.

The faculty's level of education was on a scale of 1 to 4: trade school (1), bachelor's degree (2), master's degree (3) and Ph.D. (4). A small negative correlation was noted between the faculty's level of education and whether they believed in learning styles ($r = -.14$, $n = 544$, $p = .001$), indicating that the lower the teacher education, the more likely the instructor would be to state a belief in learning styles.

To compare a belief in learning styles and whether the faculty participants worked at a college or university, an independent-samples t-test was conducted, and significant differences were noted ($t = 29.79$, $p = .009$, eta squared = 0.01). Post-hoc comparisons using the Tukey HSD test indicated that college faculty ($M = .92$, $SD = .26$) were more likely to agree that learning styles existed than university professors ($M = .85$, $SD = .36$).

A one-way analysis of variance was conducted to explore differences in the subjects taught and whether faculty stated a belief in learning styles. Significant subject differences were noted involving business and social science teachers [$F(6, 526) = 2.86$, $p = .01$] with a small effect size (.01). Post-hoc comparisons using the Tukey HSD test indicated that instructors from business ($p = .007$) were more likely ($M = .96$, $SD = .19$) to state a belief in learning styles than social science faculty ($M = .81$, $SD = .39$).

In summary, while the faculty's level of education was significantly associated with a belief in learning styles, the correlation was weak. While the institution where the faculty taught and the subject the instructor teaches also were also related to belief, both had very small effect sizes (.01), and the mean score belief still ranged very high (81% to 96%). In overview, it could be concluded that faculty demographics are not strongly associated with a belief in learning styles, which was expressed by most participants.

Faculty Participant Opinions—Do You Accommodate Learning Styles?

After asking whether they believed their students had different learning styles, faculty participants were questioned whether they accommodated the learning styles in their classrooms. Five of the eight demographic independent variables were significantly associated with whether faculty accommodated learning styles in their classroom, including the faculty's level of education, whether the instructor had a degree in education, years of teaching experience, the institution where the faculty worked, and the gender of the teacher.

The faculty's level of education was on a scale of 1 to 4: trade school (1), bachelor's degree (2), master's degree (3) and Ph.D. (4). A small negative correlation was associated with the faculty's level of education and whether they accommodated student learning styles in their classroom ($r = -.12$, $n = 475$, $p = .007$), indicating that the lower the teacher's education, the more likely the instructor would be to alter their teaching methods for the learning styles in their classrooms.

To compare if faculty accommodates learning styles in the classroom and whether the instructor had a degree in education, an independent-samples t-test was conducted, and significant differences were yielded ($t = -2.92$, $p = .004$, eta squared = 0.02). Post-hoc comparisons using the Tukey HSD test indicated that faculty with degrees in education were more likely to accommodate learning styles ($M = .98$, $SD = .14$) than those without ($M = .93$, $SD = .26$).

To evaluate whether faculty participants' accommodation of learning styles was related to years of teaching experience, a Pearson correlation was conducted, and a small negative correlation was noted ($r = -.141$, $n = 479$, $p = .002$), indicating that as the years of teaching experience increased, the faculty members were less likely to accommodate a student's learning style.

The participants in this research came from both colleges and universities in the Ontario system. To compare whether the instructors worked at a college or university and whether they accommodated learning styles, an independent-samples t-test was conducted, and significant differences were noted (t = -4.64, p < .001, eta squared = 0.04). Post-hoc comparisons using the Tukey HSD test indicated that college instructors (M = 9.9, SD = .98) were significantly more likely to accommodate than university faculty (M = .90, SD = .30).

To compare the viewpoints of male and female faculty, an independent-samples t-test was conducted, and significant differences were yielded (t = 3.18, p = .022, eta squared = 0.02). Post-hoc comparisons using the Tukey HSD test indicated that female faculty (M = .97, SD = .17) were more likely to accommodate than male instructors (M = .90, SD = .30).

In summary, significant differences in attitudes were present, but they were all associated with weak correlations and small effect sizes. While a degree in education was significantly associated with accommodating learning styles, both groups (with or without a degree in education) reported accommodating learning styles at very high rates (98% and 93%). A similar pattern emerged for the institution differences, with 99% of college and 90% of university faculty stating they accommodate for learning style differences in their classroom. Concerning gender differences, another similar pattern with 97% of females and 90% of males indicating that they accommodate learning styles in their classroom. In overview, regardless of demographics, faculty accommodate learning styles at very high rates.

Faculty Participant Confidence - Belief in Learning Styles

After asking faculty whether they believed learning styles are an advantage for student learning and whether they accommodated learning styles, a question was asked about their confidence in whether students have different learning styles. Four significant faculty demographic independent variables were generated: the faculty's level of education, employment status, the institution at which the instructor worked, and the subject they teach. The faculty's level of education was on a scale of 1 to 4: trade school (1), bachelor's degree (2), master's degree (3) and Ph.D. (4). When faculty were asked about their confidence in learning style existence, a small negative correlation was noted, indicating that those with lower education ($r = -.22$, $n = 475$, $p < .001$) reported higher confidence in the existence of learning styles than those with higher education.

Some of the faculty surveyed worked full-time, while others worked part-time. An independent-samples t-test was conducted to compare employment status, and significant differences were generated ($t = 3.05$, $p = .002$, eta squared = 0.02). Post-hoc comparisons using the Tukey HSD test indicated that part-time instructors ($M = 9.2$, $SD = 1.4$) were significantly more confident than full-time faculty ($M = 8.8$, $SD = 1.5$).

To compare whether the faculty worked at a college or university to their opinion, an independent-samples t-test was conducted, and significant differences were associated with the institution ($t = -3.42$, $p = .001$, eta squared = 0.02). Post-hoc comparisons using the Tukey HSD test indicated that college teachers ($M = 9.2$, $SD = 1.2$) were significantly more confident than university instructors ($M = 8.8$, $SD = 1.6$) of the existence of learning styles as an advantage for learning.

Participants in this research taught different college and university subjects. A one-way analysis of variance was conducted to explore differences in the subjects taught and faculty confidence in whether students have different learning styles. Significant differences were evident [$F(6, 464) = 3.23$, $p = .004$] with a small effect size (.04). Post-hoc comparisons using the Tukey HSD test indicated that instructors from trades ($p = .013$) rated their confidence in learning styles higher ($M = 9.8$, $SD = .52$) than social science faculty ($M = 8.7$, $SD = 1.51$).

In summary, while significant relationships were noted between confidence in learning style existence and faculty demographics, all had weak correlations or small effect sizes. Also, all groups, despite significant differences, had very high confidence in the existence of learning styles (low of 87% confidence to a high of 98%). Therefore, faculty demographics might have a major impact on instructor confidence in whether students have different learning styles.

The next section will address the Learning Style Questions (LSQs) from Table 27. All the questions in the LSQ were framed in a way that agreeing with the statement contrasts evidence-based research.

The Relationship of Level of Education to Learning Style Belief

One question of this research addressed the relationship between the level of education completed by members of the faculty and their belief in learning styles. The faculty's level of education was on a scale of 1 to 4: trade school (1), bachelor's degree (2), master's degree (3) and Ph.D. (4). Overall, opinions for two of the six LSQs were significantly correlated with level of education: all were negative correlations indicating a pattern where those with lower education expressed greater belief in the LSQ (which was technically wrong).

Two questions on learning styles and the brain were asked, and both were noted to have significant differences related to the faculty's level of education. Concerning whether differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners, a small negative correlation was noted, indicating that those faculty with lower education (r = -.17, n = 474, p < .001) were more likely to agree on hemispheric differences. On whether students with different learning styles use different brain regions to learn, a small negative correlation was noted, indicating that faculty with lower education (r = -.16, n = 475, p = <.001) were more likely to agree that learning styles use different brain regions.

In summary, two of the six LSQs in this study were significantly correlated with the faculty's level of education: students use different brain and hemispheric sections of the brain to learn. Of interest, all significant findings were negative correlations, indicating a pattern that those with lower education tend to agree more with the questions on different brain regions and hemispheric dominance. While two of the six LSQs questions were significantly associated with the faculty's level of education, the correlations tended to be weak, with explanatory power (r squared).

The Relationship of a Degree in Education to Learning Style Belief

One of the questions of this research focused on whether instructors had a specific degree related to education in their training. To compare the learning style questions with those with degrees in education, independent-samples t-tests were conducted. Significant differences were associated with only one of the six LSQs: whether differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners (t = -2.52, p = .012, eta squared = 0.01). Post-hoc comparisons using the Tukey HSD test indicated that the faculty with degrees in education were more likely to agree that hemispheric dominance (M = 3.6, SD = .79) helps explain individual differences amongst learners than those without (M = .93, SD = .26; M = 3.4, SD = .84).

In summary, only one of the six LSQs in this study was significantly related to whether a faculty had a degree in education. For the hemispheric dominance question, it is important to note that faculty with or without a degree in education were in the mid-neutral range ($M = 3.6$ and $M = 3.4$) with only a 0.2 difference between them. In overview, the lack of significant interactions in the LSQs could indicate a lack of relationship between whether faculty had a degree in education and the LSQs in this study.

The Relationship of Employment Status to Learning Style Belief

Some of the faculty surveyed worked full-time, while others worked part-time. To compare the learning style questions with employment status (full-time vs. part-time faculty), independent-samples t-tests were conducted. Three of the six LSQs were significantly different across groups, including whether learning styles can change ($t = 2.07$, $p = .04$, eta squared = 0.01), specific brain regions ($t = 2.60$, $p = .01$, eta squared = 0.01), and hemispheric differences ($t = 3.02$, $p = .003$, eta squared = 0.02).

When faculty were asked about whether learning styles can change, post-hoc comparisons using the Tukey HSD test indicated that part-time teachers ($M = 4.1$, $SD = .76$) were significantly more likely to agree than full-time instructors ($M = 4.0$, $SD = .65$). Next, faculty were asked whether different learning styles use different brain regions to learn and part-time faculty ($M = 3.8$, $SD = .78$) were more likely to agree than full-time faculty ($M = 3.6$, $SD = .79$). Lastly, part-time faculty ($M = 3.6$, $SD = .83$) were more likely to agree that differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners than full-time instructors ($M = 3.4$, $SD = .83$).

In summary, three of the six LSQs in this study were significantly related to faculty employment status, and a clear pattern emerged. Part-time faculty were more likely to agree on questions concerning learning style change, different brain regions, and hemisphere dominance than full-time faculty. The mean scores, regardless of employment status, were both in the mid to high 'neural' category for the brain and hemisphere questions and just in the 'agree' category for whether learning styles can change, which contracts evidence-based research. In overview, half of the LSQ questions generating significant interactions, and the low effect sizes for the significant interactions, could indicate a lack of relationship between faculty employment status and the LSQs in this study.

The Relationship of Years of Teaching Experience to Learning Style Belief

Another factor considered predictive of learning strategy ratings was years of teaching experience. None of the six LSQs were significantly related to teaching experience. Therefore, the lack of significant findings could indicate a possible lack of relationship between the faculty's years of teaching experience and the LSQs in this study.

The Relationship Institution Employment to Learning Style Belief

The participants in this research came from both colleges and universities in the Ontario system. To compare the LSQs to whether the faculty worked at a college or university, independent-samples t-tests were conducted, and significant differences were associated in three of the six LSQs: whether learning styles being present at birth (t = -2.92, p = .004, eta squared = 0.02), specific brain regions (t = -2.94, p = .003, eta squared = 0.02), and hemispheric differences (t = -3.43, p = .001, eta squared = 0.02).

When asked about whether learning styles are present at birth, post-hoc comparisons using the Tukey HSD test indicated that college faculty (M = 2.7, SD = .93) were significantly more likely to agree than university teachers (M = 2.4, SD = .90). Next, faculty were asked if different learning styles use different brain regions to learn and college teachers (M = 3.8, SD =

.75) were more likely to agree than university faculty (*M* = 3.6, *SD* = .81). Lastly, faculty were asked whether hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners and college faculty (*M* = 3.6, *SD* = .78) were more likely to agree than university instructors (*M* = 3.3, *SD* = .86).

In summary, three of the six LSQs in this study were significantly related to the institution where the faculty worked, and a clear pattern emerged. In three of the six LSQs, college faculty were more likely to agree more with the statements on learning styles being present at birth, different brain regions, and hemispheric dominance than university teachers. Concerning whether faculty believed learning styles were present at birth, while there were significant mean differences between institutions, they were small (mean difference of only 0.3), with both college and university teacher means in the mid to high 'disagree' range. Both the brain and hemisphere questions had very little mean score differences, and both college and university faculty stated a mid to high 'neutral' agreement with the statements. In overview, while half of the LSQs noted significant interactions, all effect sizes were low, indicating the institution from which the faculty participants work is not strongly associated with the LSQs.

The Relationship of Subject to Learning Style Belief

Participants in this research taught different college and university subjects. The survey had eight subject options and an "other" option, including (1) sciences, (2) social sciences, (3) English, (4) business, (5) IT/computers, (6) music, (7) creative arts, and (8) trades. None of the faculty participants in this research gave 'other' as their subject.

A one-way analysis of variance was conducted to explore differences in the subjects taught and their opinions on the LSQs. Overall, three of the six LSQs generated significant relationships: questions on birth, predicting career and predicting the best teacher.

When asked whether learning styles were present at birth, significant differences in the faculty's subject were noted [$F(6, 464) = 2.76$, $p = .012$], with a small effect size (.03). Post-hoc comparisons using the Tukey HSD test indicated that instructors from the computer field ($p = .012$) rated their agreement higher (*M* = 3.0, *SD* = .84) than social science faculty (*M* = 2.4, *SD* = 1.0).

An inquiry was made as to whether faculty agreed that learning styles could predict the type of career someone will have, and significant differences were noted in the faculty's subject [$F(6, 464) = 2.63$, $p = .016$] with a small effect size (.03). Post-hoc comparisons using the Tukey HSD test indicated that instructors from the trades field (p = .03) rated their agreement higher (*M* = 3.2, *SD* = 1.0) than social science faculty (*M* = 2.5, *SD* = 1.0) and language instructors (*M* = 2.4, *SD* = .92).

Faculty were asked whether they agree that learning styles can predict the kinds of teachers from whom they learn best, and significant differences in the faculty's subject were noted [$F(6, 464) = 5.21$, $p < .001$], with a small effect size (.06). Post-hoc comparisons using the Tukey HSD test noted three significant differences: first, faculty from the sciences agreed significantly higher (*M* = 3.7, *SD* = .82) than teachers from the social sciences (*M* = 3.2, *SD* = 1.0, $p = .001$) and instructors from the languages (*M* = 2.9, *SD* = 1.1, $p < .001$). Second, faculty from business agreed significantly higher (*M* = 3.6, *SD* = 1.0, $p = .009$) than instructors from the language fields (*M* = 2.9, *SD* = 1.1).

In summary, three of the six LSQs in this study were significantly related to the faculty's subject. It is important to note that all effect sizes were small. The lack of many possible subject interactions and the small effect sizes, could indicate that the subject taught by the faculty in this study is not strongly associated with the LSQs.

The Relationship Teacher Training to Learning Style Belief

It is possible that specific training as a teacher (or its absence) would lead to different views on the effectiveness of learning strategies. Due to the lack of response in the survey, this analysis will only compare faculty that indicated any number of teacher training to those that indicated no training, outside of a degree in education.

To compare training, independent-samples t-tests were conducted, and significant differences were noted in two of the six LSQs: learning styles present at birth (t = -2.30, p = .022, eta squared = 0.02) and whether those with different learning styles use different brain regions to learn (t = -2.43, p = .016, eta squared = 0.03). Post-hoc comparisons using the Tukey HSD test indicated that faculty that reported no additional training (M = 2.6, SD = .90) were more likely to agree that learning styles are present at birth than those teachers who reported that they had some training (M = 2.1, SD = .87). Faculty were also asked whether they agree that those with different learning styles use different brain regions to learn, and those that stated they had teacher training (M = 4.1, SD = .80) were more likely to agree than the instructors with no reported training (M = 3.6, SD = .84).

In summary, only two of the six LSQs were significantly related, both with very small effect sizes (0.02 and 0.03), indicating a possible lack of relationship between teacher training and the LSQs in this study.

The Relationship of Gender to Learning Style Belief

To compare the viewpoints of male and female faculty, independent-samples t-tests were conducted, and significant differences were associated with only one of the six LSQs: whether differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners (t = 2.10, p = .04, eta squared = 0.01). Post-hoc comparisons using the Tukey HSD test indicated that female instructors (*M* = 3.5, *SD* = .87) were more likely to agree than male teachers (*M* = 3.4, *SD* = .80).

In summary, only one of the six LSQs, with a small effect size (0.01), was significantly related to gender. On the question of hemispheric differences, while there was a significant mean score difference, the variance was only 0.1, and both genders' mean scores fell in the mid 'neutral' range, going against evidence-based research. These factors could indicate a possible lack of relationship between the gender of the faculty and the LSQs in this research.

Summary—Learning Styles

In summary, a large proportion of the faculty participants surveyed in this study believed in learning styles (88.1%), declared that they accommodated learning styles in their classrooms (92.5%), and were very confident in their belief that learning styles exist as an advantage for student learning (89.3%). When asked whether students use strategies that link up with their perceived learning styles, most faculty participants (52.6%) agreed, 22.8% were neutral, and only 10.2% disagreed or strongly disagreed.

Concerning the six LSQs, only two of the six questions (learning styles are determined at birth and predict career) yielded mean scores in the disagree category, correlating with evidence-based research. Three of the six LSQs (brain regions, hemispheric dominance, and predict best teacher) were in the low to mid-moderate category, while one question (learning styles can change) approached the agreed category, contrasting with evidence-based research. Therefore, in four of the six LSQs, the faculty participants' answers did not correlate with evidence-based research.

In overview, due to the lack of powerful differences in opinion associated with faculty demographics, and the weak correlation strengths/low effect sizes, the demographics of the faculty in this study do not seem to alter beliefs in the existence of learning styles as an advantage for student learning.

Chapter 6: Discussion

The research in this dissertation examined opinions held by college and university teachers in Ontario, Canada, with respect to learning strategies and learning styles. These opinions were compared to the current recognized learning strategy standards (Dunlosky et al., 2013) and to the best evidence concerning learning styles (Massa & Mayer, 2006; Pashler et al., 2008) as an advantage for learning. The results led to two major conclusions. First, current teachers' opinions did not match the accepted standards (Dunlosky model), nor were they in line with the best evidence. Second, demographic differences among groups of teachers, which were occasionally related to some of their opinions, were not meaningful predictors of them. Significant effects involving demographic variables were rare, and effect sizes were low. For example, concerning the learning strategy results, only 26.9% yielded significant differences with effect sizes ranging from .01 to .04. This discussion section addresses both the learning strategy and learning style conclusions in detail. As teachers' opinions were not in line with recognized standards or best evidence, one might be tempted to conclude that either the standards or the teachers' opinions were incorrect. This may not be the case because learning is a complicated situation, and different conclusions might validly apply to different situations. This discussion will also treat issues in applying the conclusions of the research.

The first part of the discussion will be divided into two sections: study strategies and learning styles. Following the sections on study strategies and learning styles, theories will be considered to explain why instructors may not be able to identify evidence-based study strategies or why they might not realize that learning styles offer no learning advantages according to peer-reviewed research. The final section of the discussion will list study limitations, suggestions for future research, and recommendations for the education system on study strategies and learning styles.

Discussion—Study Strategies

This section of the research aimed to explore faculty opinions on learning or study strategies by asking instructors to rate the effectiveness of 14 techniques and their opinions on two scenarios involving specific strategies: testing (why students would practice test themselves) and interleaved practice. One of the main goals of this project was to examine different opinions between Canadian college and university faculty concerning learning strategy effectiveness, with a total of eight demographic independent variables also investigated. While there are three studies (McCabe, 2018; Morehead et al., 2016; Piza et al., 2019) that examined faculty perceptions of study strategies, to the knowledge of this researcher, there are no papers that investigate the reasons why instructors rate, rank, or recommended strategies. No research papers also discuss why teachers have mixed results in identifying which techniques are more effective according to evidence-based data. This branch of the discussion section will examine the results as they relate to previous peer-reviewed academic research on learning strategy effectiveness and, where applicable, provide hypotheses addressing any demographic faculty differences.

The faculty were asked to rate the effectiveness of 14 study strategies, nine from Dunlosky et al. (2013) and five that were added for this research. As reported in Table 31, in a number of cases where demographic variables were associated with significant differences in the rating of strategies despite this study having eight demographic independent variables and 14 strategies, only 28 of 104 (26.9%) comparisons resulted in significant differences: all of these were associated with a low correlational strength and effect size.   This study had a total of six independent variables that were analyzed for group comparisons, including whether respondents had a degree in education, the employment status of respondents (full-time or part-time), whether they taught at a Canadian college or university, the subject that they instructed, whether they had any additional teacher training outside of a degree in education and the gender of the participant. There were 84 possible tests (X variables by Y strategies), with only 22 of 84 (26.2%) generating significant differences. Of the 22 significant associations, only seven (31.8%) had learning strategy effectiveness category differences. Therefore, an overarching conclusion could be that faculty demographics may not be a strong factor in predicting the rated effectiveness of study strategies.

Table 31

Learning Strategy Rating—Significant Group Differences for Various Strategies

Strategy	# of Significant Differences	Range of Effect Sizes (r or eta squared)	Faculty Demographic Associations
Summarizing	2/8	*r*: -.01; eta = .01	Level of Education, Institution
Highlighting	3/8	*r*: -.01; eta = .01	Level of Education, Employment Status, Institution
Mnemonics	2/8	eta = .01 and .04	Degree in Education, Gender
Imagery	4/8	eta: .01 to .04	Degree in Education, Institution, Subject, Gender
Re-Reading	0/8		
Interleaving	3/8	*r*: -.13; eta: .01 to .03	Level of Education, Institution, Subject
Elaborate Int.	2/8	eta = .03 and .02	Subject, Gender
Practice Testing	3/8	*r*: -.03; eta: .01 to .04	Level of Education, Institution, Gender
Distributed Practice	1/8	eta = .02	Gender
Cramming	2/8	*r*: -.10; eta = .01	Level of Education, Institution,
Flashcards	4/8	*r:* -.10 and -.13 eta: .02 to .03	Level of Education, Years of Teaching Experience, Institution, Gender
Studying w/ Friends	2/8	*r*: .10; eta = .02	Years of Teaching Experience, Gender
Asking Questions	0/8		

One of the most interesting findings in this study was the lack of low-effectiveness learning strategy ratings by the faculty participants. Outside of cramming the night before the assessment, none of the strategies in this research were rated in the very poor or poor category, in contrast to previous academic research on study strategies (Dunlosky et al., 2013). In Dunlosky et al. (2013), five strategies were ranked as having low effectiveness, including summarizing notes, highlighting, mnemonics, imagery and re-reading the textbook/course materials. This research resulted in all but two Dunlosky strategies (summarizing notes and elaborative interrogation) falling above the moderate category. While the faculty participants in this study gave elaborative interrogation a high effectiveness rating, it was ranked as moderately effective by the Dunlosky model. Summarizing notes was also given a high effectiveness rating in this study but was ranked as a low effectiveness strategy by the Dunlosky model. Only the interleaving strategy was correctly correlated with the Dunlosky as moderately effective. Thus, only one of the nine strategies (interleaved practice) was correctly rated in the exact same category rankings as those of the Dunlosky model. These results bring into question the faculty's awareness of learning strategy effectiveness when compared to the Dunlosky model. Of further interest, eight of the 14 strategies (57%) were rated in the moderate effectiveness category, indicating that the faculty participants in this study view many of the strategies as neither extremely effective nor ineffective.

While Morehead et al. (2016) and Piza et al. (2019) asked students and faculty which strategies they recommend/use, the two papers did not ask participants to rank or rate the techniques. McCabe (2018) did ask heads of academic support centres, or those individuals that assist students and faculty with academic training, to rate various study or learning strategies. There are two differences between the strategy rating system in this study and the McCabe

(2018) research. First, while this study used 14 strategies, McCabe (2018) had participants rate 36 strategies. In total, nine of the 14 strategies in this study overlapped with the McCabe research. Second, while both this study and McCabe (2018) used a similar scale for the rating system, they were not identical. Both studies used a 5-point Likert scale, with moderate in the middle (value of three) but had some wording differences (see Table 32).

Table 32

Scale Differences for Strategy Ratings—This Study and McCabe (2018)

Scale Value	Wording – This Study	Wording – McCabe (2018)
1	Very poor (effectiveness)	Not Effective
2	Poor (effectiveness)	Slightly Effective
3	Moderate (effectiveness)	Moderately Effective
4	Effective	Very Effective
5	Very Effective	Extremely Effective

While subtle wording/rating differences exist, a strategy rating comparison can be found in Table 33. As noted in Table 33, the learning strategy ratings from the academic support heads are very similar to those in this study. Studying with friends and practice testing yielded an effectiveness category difference between the two studies, with the two techniques getting a moderate effectiveness rating in this study and a high effectiveness rating in the McCabe (2018) paper. All other strategies were very similar in their ratings, with interleaving, highlighting, mnemonics, flashcards and re-reading course material getting moderate ratings from both studies; all study techniques except interleaving contrasting with the Dunlosky model. To compare the results of this study to McCabe (2018), Pearson correlations and paired samples t-tests were conducted, and the results demonstrated strong positive correlations ($r = .75$, $p = .02$) and no significant mean differences between the two studies ($t = 1.66$, $p = .136$). Thus, there appears to be consistency in strategy rating between this study and McCabe (2018), with both results contrasting the Dunlosky model.

Table 33

Instructor Ratings of Learning Strategy Effectiveness

Strategy	Mean (This Study)	Mean (McCabe, 2018)
Cramming (^)	1.52	
Interleaving (D – M)	3.20	3.55
Highlighting (D – L)	3.22	3.14
Mnemonics (D – L)	3.30	3.73
Flashcards (^)	3.33	3.60
Re-reading (D – L)	3.56	3.18
Imagery (D – L)	3.68	
Studying w/ Friends (^)	3.69	4.00
Distributed Practice (D – H)	3.73	
Practice Testing (D – H)	3.92	4.47
Summarizing (D – L)	4.09	4.21
Diagrams (^)	4.09	4.00
Elaborative Interrogation (D – M)	4.24	
Asking Questions in Class (^)	4.36	

Note. (D - L) = Dunlosky strategy ranked as low effectiveness; (D - M) = Dunlosky strategy ranked as moderate effectiveness; (D – H) = Dunlosky strategy ranked as high effectiveness; (^) = strategies not classified by Dunlosky; Strategy effectiveness was measured on a 1–5 scale (this study/McCabe (2018): 1 = very poor (VP)/not effective, 2 = poor (PR)/slightly, 3 = moderate (MOD)/moderately, 4 = effective (EFF)/very effective, 5 = very effective (VE)/extremely effective.

In this study, outside of cramming, the faculty rated two of the four non-Dunlosky strategies as moderate (flashcards, studying with friends) and two high effectiveness (diagrams and asking questions in class). Both added strategies that were rated highly effective (diagrams, asking questions in class) have limitations/barriers and limited evidence of effectiveness, as previously discussed in the literature review. For example, diagrams have generalizability challenges (Acevedo et al. 2009), which the Dunlosky model reports as a barrier to getting a high effectiveness score. Concerning asking questions in class, academic research not only notes that students rarely ask questions in class (Dillon, 1988; Dunn, 1996; Graesser & Person, 1994;

Pearson & West, 1991), but also the grading advantage for students who ask questions is mixed (Handelsman et al., 2005; O'Connor et al., 2017). The Dunlosky model states that frequency of use was a precursor for the strategy picks; thus, research on the frequency of student questions may explain why Dunlosky et al. (2013) did not choose/rank the technique and calls into question whether the strategy should be rated as highly effective. Studying in groups, ranked as moderately effective in this research, also has many challenges (see Basden et al., 1997; Clark et al., 2000; Finlay et al., 2000). Such studying may demand training, a requirement that the Dunlosky model rejects as a basis for strategy picks. In summary, while diagrams/asking questions in class and studying with friends were rated moderately and highly effective in this study, the academic research is mixed regarding backing up this rating. One final note on flashcards: by definition, flashcards are a type of practice test, but were rated lower (M = 3.3) than practice testing (M = 3.9). The lower rating could be due to faculty believing that flashcards only work for simple, or surface-level assessments or learning, compared to practice testing, which could encompass deeper-level assessments or learning.

Concerning the faculty demographic independent variables in this research, of the 14 study strategies in this study, only two (re-reading class materials and asking questions in class) had no significant group differences associated with any of the eight independent variables. Re-reading is a very popular (Carrier, 2003; Karpicke et al., 2009) student learning strategy and is a technique recommended by 41% of faculty in the Morehead et al. (2016) paper. In Piza et al. (2019), there were two wordings for the reading technique: "read course material" was "often recommended' and rated 'very effective' by heads of academic support centres. The wording of 're-read course material for review' was 'moderately' recommended with an effectiveness rating in the 'moderate' category. While no literature exists that explains why students and even teachers recommend/rate re-reading as a strategy, some theories can be suggested. Students are often a product of their environment: students who were taught that re-reading was an effective strategy then become teachers, and the cycle of recommending non-evidence-based study strategies continues. It is also feasible to suggest that before the age of the internet, or even the age of easier access to the internet (for example, logging onto learning management systems via a mobile phone), students would only have had access to a textbook or course material for studying.

Teachers and students before the internet age would not have had access to a modern learning management system (LMS), a resource that allows faculty to upload various resources for students to use outside of the classroom. One of the main features of modern LMS systems is the ability to upload practice multiple-choice tests (a high-effectiveness strategy according to the Dunlosky model), either created by the faculty or using test banks offered by textbook publishers. Many textbook publishers offer test banks coded for modern LSM systems that can be uploaded to a practice test using little time or training. Modern LSM systems, textbook companies, and various internet websites provide students with easy access to practice tests. Before the internet age, a student's only real resource was their textbook; therefore, teachers and students might have been limited in the availability of take-home study strategies such as practice testing. We can conclude that, in some cases, due to a lack of technology, the limited learning strategy recommendations are passed on to the next generation, causing students to recommend the strategy as teachers. It would be very interesting to see if the strategy rating of re-reading might decrease over the next decade due to an increased number of teachers having instant access to practice test banks via their LMS or a publisher's LMS, thus allowing for the benefits of becoming more apparent early in their teaching careers. A similar argument could be made for asking questions in class, another strategy with no demographic differences. Asking questions in class might have been the only way to communicate with faculty before the Internet was available. In the internet age, students can access their instructor using email, a method that was not commonplace until the late 90s. In 2023, students also have access to their instructor via Zoom, an internet video meeting application, that can be used even via a mobile device. In the modern internet era, students can log onto Zoom, get questions answered outside the classroom, and even converse with their instructor from any location. A limitation of this study could be the wording on 'asking questions or verbally participating in class', which could be worded differently to include simply asking the instructor questions. When examining the independent variables more closely, there are findings that contrast the Dunlosky model and further strengthen the overarching theme of low correlational strength and effect sizes in demographic associations.

First, regarding the relationship of level of education to the strategy ratings, the results demonstrated that only six of the 14 strategies were significantly related to participants' education. The trend noted in the data was that higher education was associated with lower effectiveness ratings for various learning strategies, including summarizing notes, highlighting, interleaving, practice testing, cramming and flashcards. Unfortunately, the strategy ratings in this research represent a mix of low (summarizing notes, highlighting), moderate (interleaving) and highly effective (practice testing), according to the Dunlosky model. Thus, the rating of summarizing notes and highlighting as low effectiveness correlated with the Dunlosky model, but rating the practice testing lower did not. In summary, with mixed results on the ratings, low correlational strength, a lack of correlation with academic research on the strategy's effectiveness, and a lack of significant strategy associations, the faculty's level of education might not be a compelling factor in the rating of strategy effectiveness. To the knowledge of this researcher, there is no research that might explain the reasons behind the level of faculty education and rating the effectiveness of study strategies. A limitation to examining the strategy effectiveness differences with the level of education is that the education itself might not be in the field of teaching. Only 23% of the faculty participants had a degree in education, which could include curriculum on study strategies. Education in fields outside of education might not have any curriculum on teaching strategies or specific study strategies.

To further the discussion on education, this study asked faculty whether they had a degree in education. The degree in education variable was included in this research as the program involves the study of teaching, which may include study strategies. Only three of the 14 strategies were significantly associated with whether the faculty had a degree in education, but both groups (with or without a degree in education), regardless of significant mean rating differences, rated the three strategies as moderately effective, in contrast to the Dunlosky model. In this study, the education degree participants rated mnemonics as moderately effective and imagery in the high-moderate category, almost in the effective category. Dunlosky et al. (2013) ranked both strategies as low effectiveness, and those with a degree in education in this study came very close to rating imagery as 'effective'. With low effect sizes and a lack of significant strategy associations/correlations with the Dunlosky model, questions about how study strategies are taught in education programs need to be asked. To the knowledge of this researcher, there is no research that might explain the reasons behind rating the effectiveness of study strategies and having a degree in education. If the Dunlosky model is correct concerning which study strategies are effective and ineffective, perhaps a closer look at the curriculum, specifically the content on study or learning strategies, in an education program is required.

Only the highlighting strategy significantly interacted with the faculty participants' employment status. When examining the significant interaction of employment and highlighting, part-time instructors rated the technique significantly higher than full-time faculty; however, both groups rated the technique in the moderate effectiveness range, in contrast to the Dunlosky model. Once again, the lack of significant strategy associations could indicate that employment status might not be a compelling factor in rating strategy effectiveness.

When inquiring about the relationship between years of teaching and strategy effectiveness ratings, only two of 14 techniques (flashcards and studying with friends) had significant associations, both non-Dunlosky strategies. Therefore, all the Dunlosky strategies had no significant relationship to years of teaching, although it should be noted that just over half (51.3%) of the faculty respondents reported under 10 years of teaching experience. It is reasonable to assert that the results could be different if additional faculty were surveyed with 20 years of teaching. The lack of significant strategy interaction indicates that experience had no impact on how faculty rate technique effectiveness, despite academic research indicating effectiveness differences. To this researcher's knowledge, no studies have been done on years of teaching and rating or ranking of study strategies. A variety of research (for example, Podolsky et al., 2019) concludes that, as teaching experiences increase, so does student achievement. Unfortunately, studies like Podolsky et al. (2019) do not investigate whether the implementation of tactics like study strategies explains student achievement increases.

In contrast to many of the previous demographic variables, the institution where the faculty works had many significant differences associated with place of employment. There were seven in total, five from the Dunlosky model and two techniques added in this study. Summarizing notes was given a moderate mean score by college faculty, while university faculty gave the technique an effective mean score. Both groups contrasted the Dunlosky model that ranked the strategy as low effectiveness. To this researcher's knowledge, no studies have been done on Canadian faculty institution differences and effectiveness ratings of study strategies. It is reasonable to suggest that universities can be viewed as the more intense workload of the two institutions concerning theory or reading; thus, the university faculty could view the effectiveness of summarizing notes as higher than college instructors. Practice testing, ranked as a high-effectiveness strategy by the Dunlosky model, was given a high effectiveness rating by the college faculty (4.0) and a high-moderate rating by the university instructors (3.9), although the mean score difference is only 0.1, making significant differences between the two institutions minor at best. All other significant strategy differences failed to have effectiveness category differences between institutions. Therefore, with mixed correlations to the Dunlosky model and low effect sizes, there is a question as to whether the institution where a faculty works is a significant factor in rating learning strategy effectiveness.

Despite 14 study strategies and seven subject areas, only three strategies (imagery, interleaving, and elaborative interrogation) were significantly related to the subject area in which a faculty taught. Within the significant strategies, imagery and interleaving had single-subject associations, while elaborative interrogation had three; all associations had interesting results. First, concerning imagery, a rare effectiveness category difference occurred in this study: computer faculty rated the strategy as moderately effective, while the creative arts faculty rated the technique in the high effectiveness category. It is feasible that a subject like creative arts, where faculty teach in areas such as visual arts, might require a stronger connection to using imagery as a strategy. Unfortunately, the Dunlosky model ranked imagery as a low-effectiveness strategy, which contrasts the ratings of both computer and creative arts faculty. Next, subject differences were also generated for interleaving, with the trades rating the strategy significantly lower, in the poor effectiveness category than those faculty teaching creative arts rating the technique in the mid-moderate effectiveness category. Therefore, only the faculty from creative arts that rated interleaving in the moderate category correlated with the Dunlosky model. It is plausible to theorize that trade teachers require their students to focus on one task (or technical machine) at a time, thus explaining the diminished rating for interleaving. Creative arts might require students to explore many different mediums at the same time, allowing for additional interleaved practice. Lastly, the strategy of elaborate interrogation (asking yourself questions) yielded a significant interaction between faculty that taught computers and social sciences or language. The faculty that taught computers rated elaborate interrogation as less effective (in the moderately effective category) than those instructors that teach social sciences or languages, with the latter two subjects rating the technique as effective. While the computer faculty's rating of elaborative interrogation correlates with the Dunlosky ranking of moderate effectiveness, it is reasonable to conclude that social sciences and language faculty might require increased internal questioning from their students. For example, social science programs may demand increased thought about a variety of complex social variables that contribute to inequality, poverty, racism, and more. Further, social science programs may also have prerequisites surrounding self-reflection, a skill that requires asking questions of oneself, which might explain the higher ratings for elaborative interrogation. The study of languages might also require internal questioning: for example, when learning a new language, the student might have to ask themselves questions about words or phrases, comparing their first language to the new one. While discussion and analysis on the significant program or subject differences may be valuable, the lack of findings concerning the subject taught may imply that the program or subject taught does not significantly impact faculty strategy effectiveness ratings.

While no significant differences were found with additional teacher training outside of a degree in education, it is important to note that only 51% of the participants answered the survey question on training. While the survey question on training had options for the participants to pick from, due to the limited number of responses, a data recode was implemented (some training or no training). The results demonstrated that none of the strategies were significantly associated with faculty training. Therefore, additional research needs to be examined in the future concerning the effect teacher training has on strategy effectiveness training.

The gender of the faculty had the most significant learning strategy associations (eight of 14), all with female faculty rating the strategies as higher than their male counterparts. Unfortunately, all significant associations had very low to low effect sizes and, of the eight significant differences, only two had effectiveness category changes (practice testing and diagrams). While both genders rated mnemonics and imagery in the moderate category (not aligning with the Dunlosky model's low-effectiveness ranking), the female faculty rated the two strategies as higher than their male counterparts, going in the opposite direction of the Dunlosky model. In contrast, the Dunlosky model ranked practice testing and distributed practice as highly effective techniques, with the female faculty in this research rating the two strategies in the direction correlating with the Dunlosky model. Regardless of gender, the other three strategies (mnemonics, imagery, and distributed practice) were rated in the moderate effectiveness category while the Dunlosky model ranked the strategies as low effectiveness (mnemonics and imagery) or high effectiveness (distributed practice). A search of the literature did not reveal any studies related to faculty gender and rating study strategies. Research on gender differences comes with many limitations, including “diversity within the categories of males or females” (Sabbe & Aelterman, 2007, p. 525), a lack of insight into why the differences may occur (Sabbe & Aelterman, 2007), with gender difference researchers tending to conclude that differences between males and females are small (Lott, 1997) or socially insignificant (Epstein, 1999). Therefore, future research to explain why female faculty in this study rated certain strategies higher than their male counterparts might be difficult. To theorize, several studies (Barber 2002; Dey, 1995; Kalaian & Freeman, 1994;) conclude that female instructors tend to be more student-oriented than male faculty. Perhaps, the female instructors in this study view many of the strategies as more effective as they might support their students’ preferred study strategies at higher rates than male faculty. Nevertheless, with low effect sizes and very few effectiveness category changes between male and female faculty and mixed results that correlate with the Dunlosky model, the gender of the instructor might not be a significant factor for learning strategy ratings.

This research used two scenarios adapted from Morehead et al. (2016) on practice testing and interleaving strategies. In the first scenario on practice testing, faculty were asked why students should test themselves, and only 19.7% of the faculty participants identified the evidence-based answer that students would learn more than through re-reading. The findings in this research are almost identical to Morehead et al. (2016), where 19% identified the evidence-based answer. In Piza et al. (2019), faculty stated the evidence-based answer at a much higher rate of 36% than both Morehead et al. (2016) and this study. Of further interest to this scenario, only one of the independent variables (level of faculty education) was significantly related to identifying the evidence-based answer, with instructors of higher education more likely to choose that students would learn more than through re-reading. Therefore, in accordance with the conclusions of Morehead et al. (2016) and Piza et al. (2019), while faculty might recommend and endorse practice testing, they do not seem to know the advantages of testing with respect to increased learning. To this researcher's knowledge, no studies have been done on why faculty do not identify the advantages of practice testing. In the appropriately titled paper, the "Ten benefits of testing and their applications to educational practice" (Roediger et al., 2011), the authors describe the various advantages of testing. The authors note that "testing in school is usually done for purposes of assessment, to assign students grades (from tests in classrooms) or rank them in terms of abilities" (p. 1). The authors also refer to testing and other forms of assessment as "necessary evils" (Roediger et al., 2011) for teachers. From these quotes, a theory can be made, as testing is one of the oldest and most frequent forms of assessment for students and teachers, perhaps teachers view testing as a necessity and its benefits are limited to determining knowledge of the concepts within the test itself. Perhaps the faculty in this study cannot identify that testing is more efficient for learning than re-reading as they may be aware of the direct advantages of teaching, but not the indirect ones, leading to a lack of motivation to investigate testing research. The authors suggested that "besides these direct effects of testing, there are also indirect effects that are quite positive" (Roediger et al., 2011, p. 2). In the Roediger et al. (2011) paper, the authors discussed a distinction between the direct and indirect effects that tests have on a student. Indirect advantages include that testing can identify gaps in knowledge, produce better organization of knowledge, prevent interference from prior old or prior material when learning new material, and encourage students to increase their effort to study (Roediger et al., 2011). If the indirect advantages of testing are not commonplace in education, perhaps faculty may perceive the direct advantages as satisfactory and not see the need to research further. This lack of inquiry could lead faculty to neglect the indirect advantages of testing and the effectiveness of practice testing versus other study strategies.

In the second scenario on interleaving, faculty participants stated their opinions on the strategy's benefits via two scenarios: one that had a student use a block studying technique and one that had a student use an interleaving studying technique. The evidence-based answer would require faculty to rate the interleaving scenario as more beneficial than the blocking technique. Only 9.1% of the faculty participants rated the interleaving scenario as more beneficial, thus putting into question their awareness of the strategy's benefits. The results of this scenario correlate with the Morehead et al. (2016) results, where 16% of students and 13% of teachers provided a higher rating for the evidence-based scenario. Piza et al. (2019) also used the scenario in this research, with 37% of students and 39% of faculty providing higher ratings for the evidence-based scenario. To this researcher's knowledge, no studies have been done to explain the lack of faculty knowledge surrounding the benefits of interleaving. The advantages of interleaving might be a concept foreign to many teachers as it was rated the second lowest in this study. Only cramming the night before a test got a lower mean effectiveness rating score. The opposite of interleaved practice would be blocked practice, and empirical evidence (Grospietsch & Mayer, 2019) suggests that interleaving is superior for learning. A study by Grospietsch and Mayer (2019) asked pre-service biology teachers if blocked learning is better than interleaved and 52% agreed. Interleaving can be confusing as it is not necessarily a familiar study technique, as perhaps summarizing notes, highlighting or re-reading a textbook. Interleaving can be used with a large variety of study strategies, both ineffective and effective. Using the example of interleaving with re-reading, a low-effectiveness strategy according to the Dunlosky model: a student can re-read 10 pages from chapter one, then the first 10 pages of chapter two, moving back and forth. If a student used interleaving with re-reading, the learning might not be as effective as practice testing by moving back and forth between concepts in different chapters. Therefore, additional research must be explored on why faculty do not recommend interleaving.

In summary, faculty participants were asked their opinions on learning strategy effectiveness, why students should test themselves, and the advantages of interleaved practice. The results demonstrated a lack of agreement with evidence-based research (for example, the Dunlosky model) and a lack of faculty demographic interaction. When significant faculty demographic associations were found, all had low correlational strength, low effect sizes and very few strategy effectiveness category changes. These results bring into question whether faculty demographics are a factor in the effectiveness ratings of study strategies, a conclusion that continues in the next section of the discussion on learning styles.

Learning Styles

This study defined learning styles as embodying the opinion that 'individuals will learn better when they are taught in a way that matches their preferred or dominant way of learning'. Most of the faculty participants in this research agreed with the statement (88.1%) and, of those that agreed with the definition, the average confidence level was 89.3%. The high agreement that learning styles exist as an advantage for students corresponds with many previous studies that surveyed instructors (Dekker et al., 2012; Howard-Jones, 2014; Morehead et al., 2016), heads of academic support centres (McCabe, 2018), and ERIC/PubMed research articles (Newton, 2015). When asked whether they accommodated learning styles in their classrooms, 92.5% reported yes, which correlates with previous research (Morehead et al., 2016; Piza et al., 2019). Clearly, the myth of learning styles, as an advantage for learning, is thriving within Canadian academic institutions.

Concerning the LSQs, if peer-reviewed research (for example, Pashler et al., 2008) concludes that learning styles do not give a learning advantage to students, what other related myths might be prevalent within education? Grospietsch and Mayer (2020) identified nine neuromyths concerning learning and memory, with four used in this research, along with two questions on whether learning styles predict a student's future career and the best teacher, adapted from Nancekivell et al. (2020). The four neuromyths that were used in this research include whether learning styles are (1) determined at birth and (2) can change, (3) whether those with different learning styles use different brain regions to learn, and (4) if differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners. According to Grospietsch and Mayer (2020) and MacDonald et al. (2017), neuromyths come from overgeneralizations of research on the brain. All questions were framed in a way that agreeing with the questions would contrast evidence-based research. Unfortunately, the results are mixed: while there was 47.9% agreement overall: only one of the neuromyth questions (learning styles are determined at birth) and one learning style question (predicts the best teacher) had a mean score rated as disagreement. All other neuromyth questions (learning styles can change, different brain regions, and hemispheric differences) and the other learning style question (predicts best teacher) had mean scores in the neutral category.

Before summarizing the results of this study and previous research on the LSQs, the demographic differences between the studies need to be addressed (see Table 34).

Table 34

Comparison of LSQ Demographic Research Papers

Research	Demographics
This Study	Canadian post-secondary faculty
Nancekivell et al. (2020)	General public (6.5%) stating they worked in academia
Mayer (2019)	Pre-service science teachers
Dekker et al. (2012)	Primary and secondary school teachers
Grosprietsch and Mayer (2019)	Pre-service science teachers specializing in biology

The LSQs results in this study have some similarities with previous research (see Table 35).

Table 35

Comparison of Results on the LSQs

Research	This Study	Nancekivell et al. (2020)	Mayer (2019)	Dekker et al. (2012)	Grosprietsch and Mayer (2019)
Birth	Disagree	Somewhat disagree			
Change	Neutral	Somewhat disagree			
Hemispheres	Neutral			86-91% agreed	82% agreed
Brain	Neutral	Somewhat agree	82% agreed		85% agreed
Career	Disagree	Somewhat agree			
Teacher	Neutral	Somewhat agree			

As noted in Table 34, both the faculty in this study and the general public in Nancekivell et al. (2020) disagreed that learning styles are determined at birth, correlating with peer-reviewed research. On whether learning styles can change, faculty in this study were neutral on the question, compared to the Nancekivell et al. (2020) study, where the general public somewhat disagreed, the latter study correlating with evidence-based research. Similar to many of the LSQs in this study, faculty were neutral on whether those with different learning styles use different brain regions to learn, compared to the general public ‘somewhat agreeing’ (Nancekivell et al., 2020) and pre-service science teachers in Mayer (2019) also agreeing at a high rate (82%). All three studies either agreed or were neutral on whether those with different learning styles use different brain regions to learn, contrasting with peer-reviewed research. On whether differences in hemispheric dominance (left brain, right brain) can help explain individual differences among learners, faculty in this study were neutral, while primary and secondary school teachers (Dekker et al., 2012) and pre-service science teachers specializing in biology (Grosprietsch & Mayer, 2019) both agreed in strong percentages (82%-91%). All three studies either agreed at high percentages or were neutral, contrasting evidence-based research. On whether learning styles predict the type of career someone will have, faculty in this study disagreed, while the general public in Nancekivell et al. (2020) somewhat agreed, the latter contrasting with peer-reviewed research. Lastly, on whether learning styles predict the kinds of teachers from whom they learn best, faculty in this study were neutral, while the general public in the Nancekivell et al. (2020) somewhat agreed, both studies contrasting evidence-based research.

In summary, when comparing research on the prevalence of learning style myths and neuromyths, both seem commonplace. However, participants in the various studies outlined in Table 34 endorsed the myths to different degrees, and the faculty participants in this study were more skeptical of learning style myths than the participants in Nancekivell et al. (2020).

The LSQ results represent a mix of essentialism and non-essentialism views on learning style myths. Essentialism is a “belief that certain categories (such as dogs, girls, or auditory learners) have an underlying reality or true nature that one cannot observe directly but that is biologically based and highly predictive of many other features” (Nancekivell et al., 2020, p. 222). Examples of essentialism include that learning styles are determined at birth and cannot change. Non-essentialism suggests that learning styles are not necessarily determined at birth and can change. Between essentialism and non-essentialism would be a hybrid version, where individuals have mixed beliefs (Nancekivell et al., 2020). The results of this study are mixed and could be interpreted as a hybrid between essentialism and non-essentialism. Most (four of the six LSQs) of the faculty answers were neutral, meaning that the faculty participants neither agreed nor disagreed with the questions. For two questions (birth and career), the faculty had a non-essentialist position, meaning that they did not agree that learning styles are pre-assigned from birth or that one's learning style can predict the career type. While the mean scores for the LSQs tended to be neutral, there are significant challenges in the agreement proportions. For whether learning styles can change, 86.4% of faculty agreed/strongly agreed, despite the neutral mean score of 3.9, which is approaching agreement. Since a very high percentage of faculty reported a belief in learning styles at a high rate (92.5%) and disagreed that learning styles are determined at birth, it is logical that they agreed that learning styles could change. For the question of whether those with different learning styles use different parts of the brain, 60.5% of the faculty agreed. Almost half agreed/strongly agreed when asked whether hemisphere differences help explain individual differences among learners (48.5%). For the two questions on the brain, even pre-service biology teachers, a field that could specialize in the brain, agreed/strongly agreed at rates above 80% (Grosprietsch & Mayer, 2019), so the agreement is not surprising considering many of the faculty in this study might not have any specialization in the brain. It is possible that faculty participants have heard the function of various parts of the brain and the left/right brain comparisons in simplistic descriptions throughout academia, the media, and their social lives, thus lending to misinterpretations.

The more interesting results came in the final two questions, where faculty participants disagreed that learning styles predict the type of career someone will have but were neutral on predicting the best teacher. There are important differences when looking at the agreement rates (agree or strongly agree) between the two prediction questions. For the question on career, only 20.9% either agreed or strongly agreed, while more than double (57.6%) either agreed or strongly agreed on the teacher question. This difference in agreement category and the percentage of agreement or strong agreement contradicts the Nancekivell et al. (2020) paper, where the general public participants ‘somewhat agreed’ with both questions. Further research is needed on why faculty would disagree with learning styles predicting a career but be neutral, with over half agreeing/strongly agreeing on learning styles predicting the best teacher for a student. In the literature review of this paper, many reasons for the prevalence of the learning style belief were discussed, including kernels of truth, perceived uniqueness of the students, confirmation bias, and false interpretations. When a student has trouble or fails a course, it may be easier to point to a specific learning style as the possible issue, not the multitude of external reasons that can become complicated to interpret. It is possible that teachers lean on learning styles as a reason why students fail their course, thus allowing for over half (57.6%) of the faculty participants in this study to agree/strongly agree at much higher percentages than the question on predicting careers.

The final question in the survey asked faculty participants if students use learning strategies that link up with their perceived learning style. Various research (for example, Husmann & O'Loughlin, 2019) concluded that student study strategies do not align with their reported learning style. In this research, only 10.2% of faculty participants disagreed that students use learning strategies that link up with their perceived learning style, while over half

(71%) of instructors agreed or strongly agreed. Husmann & O'Loughlin (2019) also stated that 40% of the students scored strongly across all four VARK categories (visual, auditory, reading/writing, and kinesthetic), implying that many students did not even fit into one learning style category. Studies like Husmann & O'Loughlin (2019) further question the existence of learning styles as an advantage for student learning as learning styles, by definition, tend to imply a single style, whether it is (for example) visual, auditory, or touch. In addition, none of the independent variables in this study generated significant interaction with the question of whether students use study strategies that align with their reported learning style. These results suggest that there is much work to be done to reduce the learning style myth in academia.

This study also identified a lack of other significant associations with the faculty demographic independent variables, and all the LSQs. For example, concerning the six LSQ questions, there were 36 possible group comparisons but only 13 (36%) generated significant group differences. Of the 13 significant group comparisons with the LSQs, only four generated agreement category differences, three from one independent variable: the subject that the faculty teaches. Therefore, faculty demographics may not be a strong factor in learning style belief. The next part of the discussion will address the lack of strong correlations, effect sizes, and agreement category changes by the independent variable, starting with faculty level of education. To the knowledge of this researcher, no studies examine the reasons for learning style belief associated with the demographic independent variables in this study. Therefore, when applicable, theories will be given for any significant demographic differences.

Starting with whether faculty participants believed that students have different learning styles, only three of eight demographic variables were significantly associated, all with small correlation strengths (the faculty's level of education) or weak effect sizes (institution and subject). While significant differences were generated between faculty belief in learning styles and the institution where the faculty worked, regardless of institution, 92% of the college and 85% of university instructors strongly agreed that students have different learning styles that give an advantage in learning. With eight possible subject categories, only one yielded significance: business faculty in this study were more likely to agree (96%) that learning styles exist as an advantage for learning than social science faculty (81%). While it is feasible to suggest that social science professors, coming from a subject area that could teach more about learning and the brain, might identify the myth of learning styles over a subject like business, the social science teachers still agreed that learning styles give an advantage for learning at a large proportion (81%).

Faculty were also asked whether they accommodate learning styles and, while five of the eight instructor demographic variables were associated, all had weak correlational strength (level of education and years of teaching experience) and small effect sizes (degree in education, institution, and gender of the faculty). Whether faculty believed that students have different learning styles, faculty with or without a degree in education stated they accommodated learning styles at high rates: 98% and 93%. Regardless of the institution, faculty from both colleges and universities stated they accommodated learning styles at very high rates: 97% and 90%. Regardless of gender, both male and female faculty stated they accommodated learning styles at very high rates: 97% and 90%. While visual, auditory, reading/writing, and kinesthetic might be the most frequently discussed, Coffield et al. (2004) examined 71 learning style models and identified over 28 specific learning styles. The authors also noted that no studies had been performed comparing the various learning styles and if they overlap. Therefore, even if faculty ignore the research that learning styles do not offer an advantage for learning, they would have to accommodate a possible 28 learning styles in their classrooms. Questions must be asked: do faculty accommodate 28-plus possible learning styles? Is it possible to accommodate 28-plus learning styles? To the knowledge of this researcher, no studies have been done to examine how many learning styles a faculty accommodates in their classroom, traditional or virtual.

Faculty were asked about their confidence, and four significant faculty demographic variables were generated. As with the previous questions, the trend of weak correlations (level of education) and small effect sizes (employment status, institution and subject taught) continued. Despite a significant difference in employment status, full-time (88%) and part-time faculty (92%) reported high confidence that students have different learning styles that give them an advantage in learning. Despite significant differences in the type of institution the faculty worked, both college (92%) and university (88%) had high confidence that students have different learning styles that give them an advantage in learning. Lastly, despite this study's wide range of subject types, only one significant difference was generated between trades and social sciences faculty: the former rated their confidence at 98% compared to the latter at 87%; again, both stated very high confidence. It is clear from the previous three results that faculty participants believe that learning styles exist as an advantage for learners, accommodate learning styles at high rates, and are very confident in the existence of learning styles regardless of faculty demographics.

Concerning the LSQs, there were 36 possible significant associations, but only 13 were significant. Of those significant associations, only four had agreement category changes across two faculty demographic independent variables, three of the four coming from the subject in which the faculty teaches. All significant associations had either weak correlational strength or low effect size. Therefore, the various neuromyths and the learning style questions may have no strong relationship with the faculty demographics. The subject in which the faculty teaches may contain one of the more interesting results in this study. While there were significant associations between the LSQs and the faculty demographics, only four had group agreement category differences. Of the four agreement category differences, three came from one independent variable: the subject taught by the faculty. There was also a pattern within the significant subject associations and agreement category changes: in all significant differences, the social science faculty were involved and disagreed with the questions.

The faculty from social sciences disagreed that learning styles are present at birth (compared to computer faculty), predicted the best career (compared to trade faculty), and predicted the best teacher (compared to the science faculty). It is feasible that social science faculty might have unique perspectives about the brain or variables relating to education and career paths.

In summary, faculty participants were asked their opinions on learning styles as an advantage for learning, whether they accommodated learning styles, and their confidence that learning styles exist. The instructor participants were also asked a series of questions that surveyed their opinions on various myths about learning styles. The results demonstrated a lack of agreement with evidence-based research with few faculty demographic associations. When significant associations were found, all had low correlational strength, low effect sizes and very few strategy effectiveness category changes. These results bring into question whether faculty demographics are a factor in opinions on learning styles as an advantage for learners.

Theories: Lack of Faculty Alignment with Evidence-Based Research

While there are studies (McCabe, 2018; Morehead et al., 2016; Piza et al., 2019) that examined faculty perceptions of study strategies, to the knowledge of this researcher, there are no papers that investigate the reasons why instructors rate or rank the techniques the way they do or why teachers have mixed results concerning identifying which techniques are more effective according to evidence-based data. Similarly, with study strategies, to the knowledge of this researcher, no studies exist that ask faculty why they believe in learning styles as an advantage for learners or their belief in neuromyths. The literature review of this dissertation addressed various theories on why the learning style myth persists (Newton, 2015; Pasher et al., 2009; Riener & Willingham, 2010; Woolfork, 2017); therefore, this section of the discussion will mostly focus on theories surrounding study strategies.

Faculty Believe Students Already Have Study Strategies

It is reasonable to consider that post-secondary teachers believe their students already have study strategies that work for them. Thus, the faculty might not see the benefits of researching and teaching the research on evidence-based study strategies.

Time Constraints

It is feasible that teachers are faced with an increased workload and do not have the class time to research or teach evidence-based research on study strategies. For example, in the Ontario college system, semesters have decreased from 15 weeks to 14 weeks in the fall semester of 2020 to accommodate a fall reading week. The decreased semester time and the possible workload increase could demotivate college faculty from addressing learning strategy research. Further, many post-secondary institutions have moved to accelerated programs; for example, three years to two years. This reduction in teaching time could also reduce the opportunity to research and teach evidence-based study strategies. New faculty will also be significantly affected by workload, having to prepare new courses and, due to not having time in their initial years of teaching, creating a pattern that focuses solely on the course material.

Complex Job

Teaching the content is not the only requirement of faculty. Teachers need to know their content, keep up to date on their field, find methods to deliver it, may have multiple delivery types (traditional, online, hybrid), need to learn how to use various technologies (the institution's LMS, classroom technology), ensure a positive environment (classroom management), be a motivator, and collaborate with their academic and institutional teams. It is possible that the teacher must deal with their job requirements as well as external factors, which could decrease any time or motivation to teach study strategies.

Question of Teacher Training

Post-secondary teachers come from a large variety of careers and educational backgrounds, but only those with a degree in education might have formal training in how to teach. Therefore, faculty without formal education in teaching must get their training from other sources. The question becomes, where do faculty get their training? Is it from required first-year training when they accept a teaching position? If so, does the training address evidence-based research on learning strategy effectiveness or the myth of learning styles as an advantage for learning? Does the professional development that the faculty take, either internal or external of their institution, address research on learning strategy effectiveness or learning styles? Recall that the study from McCabe (2018) concluded 'mixed' results concerning heads of academic institutions recommending evidence-based study strategies to their faculty and students. Outside of training and education, the other source of teacher training could come from their peers. Instructors could be speaking to their faculty peers but, as noted in this study as well as others (Morehead et al., 2016; Piza et al., 2019), teachers might not be able to identify evidence-based research on learning strategy effectiveness or that learning styles offer no learning advantages for students.

The Cycle Continues

If research such as this study and others (McCabe, 2018; Morehead et al., 2016; Piza et al., 2019) conclude that teachers may not know which strategies are ineffective or effective according to academic research, then there is a challenge of repeated history. If faculty and students are using and recommending study strategies that may not be evidence-based, and those students become teachers, they might suggest the strategies their teachers recommended them as students, and the cycle continues to the next generation of teachers and students.

Lack of Technology

Pre-internet teachers might only have had a textbook as a resource for students to study outside the classroom. While teachers may have done practice testing in their classrooms pre-internet, they would not have been able to send students home with the ability to log onto a learning management system containing practice tests. Modern learning management systems have integrated practice tests into their systems, allowing faculty to upload custom and publisher test banks. In addition, technology now allows faculty to create video practice tests that range in technical difficulty from full video editing software to recording from a mobile phone in one take. It is possible that faculty pre-internet did not have the advantage of engaging students with practice testing in or outside the classroom. This inability could force teachers to recommend re-reading the textbook as their main strategy, and those students suggest the technique to others and possibly future students as teachers.

Emphasis on Individual Differences in the Modern Educational System

The modern educational system places an emphasis on individual learning styles via the concept of universal design. Universal design for learning (UDL) is a "philosophy, framework, and set of principles for designing and delivering flexible approaches to teaching and learning that address student diversity within the classroom context" (Capp, 2017, p. 791). The idea behind UDL is to create an educational curriculum that addresses the increasingly diverse students in modern education. The seven principles behind UDL include equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size/space for approach and use in the learning environment (Gargiulo & Metcalf, 2017). While much research and promotion suggest that UDL is focused on K-12 learners and those students with disabilities, it is also endorsed for all ages, including post-secondary education, and students with or without disabilities (Council for Exceptional Children, 2005). Therefore, UDL places a significant emphasis on individual learning that may impact both study strategies and learning styles. For example, concerning study strategies, if a student suggests that a particular low-effectiveness technique works for them, the faculty might not mention research-driven alternatives due to an emphasis on individual learners.

While an examination of multiple textbooks on UDL is beyond the scope of this paper, an inquiry into one textbook on UDL was completed using Gargiulo and Metcalf's 2017 textbook, "Teaching in today's inclusive classrooms: A universal design for learning approach (3rd Edition)," published in 2017. The textbook is published by Pearson Publishers, a popular educational publisher for Canadian colleges and universities, and is currently in its 4th edition as of 2023. In the third edition, the textbook mentions the learning strategies approach as "an instructional approach that emphasizes both the attainment of observable skills and behaviors as well as cognitive strategies that go beyond specific content areas" (Gargiulo & Metcalf, 2017, p. 259).

However, within the section on learning strategies, only mnemonics are mentioned, and the authors describe the technique as effective, without mentioning any limitations to the technique. The textbook mentions modeling, shaping, chunking and other techniques, but no study strategies used in this study or the Dunlosky model are cited. Future research could investigate whether additional study strategies and research surrounding their effectiveness compared to other techniques are mentioned in other textbooks on UDL.

Concerning learning styles, by definition, the concept involves individuality and is mentioned in the Gargiulo and Metcalf textbook; however, in a contrasting presentation. Early in the textbook, the authors describe the advantages of UDL as reaching a variety of students to support unique learning styles, while not defining the concept. Also, early in the textbook (p. 42), the authors present the concept of learning preferences as "students typically have different strengths in the visual, auditory, tactile, and kinesthetic areas" (p. 42) but mention that "few documented studies on the effectiveness of teaching to learning preferences exist, although most researchers believe they can be helpful in an informal way" (p. 42). While the authors do note the lack of research on learning styles as an advantage for learners, they contradict themselves later by suggesting teachers use learning style inventories: "to maximize learning for your students, it is important to build on their strengths by matching your instruction to their learning styles" (p. 227). The authors also reference Dunn, one of the creators of the Dunn and Dunn learning styles model, and state "when students are taught with approaches that match their learning preferences, they demonstrate higher achievement scores" (p. 227). Recall, from the literature review, that the Dunn and Dunn learning style model has failed to produce internal consistency, test-retest reliability, construct validity, and predictive validity (Coffield et al., 2004). While a general conclusion cannot be made about promoting learning styles from a single UDL textbook, with the high prevalence of learning styles in academia, it is reasonable that learning strategy effectiveness and literature discussing the myth of learning styles as an advantage for learning might be diminished in UDL textbooks.

UDL's main objective surrounds access to learning, specifically increasing the options and access to learning. The challenge is that access to knowledge or a variety of presentation methods, does not necessarily mean access to learning. For example, in the aptly titled paper, "Universal design for learning: the more, the better?", the authors examined the number of materials and concluded that the "study could not detect significant advantages of the extensive UDL learning environment" (Roski et al., 2021, p. 13). The authors cite a key criticism of UDL: complexity; as UDL, by definition, demands an incredible quantity of resources to fit the diverse student population. Therefore, Roski et al. (2021) suggest that quantity might not be as important as quality. Further, a study by Capp (2017) investigated the effectiveness of UDL in the literature between 2013 and 2016 ($N = 18$ papers). The author concluded that the advantages of UDL demonstrated in the literature cannot be fully confirmed due to a lack of pre-and post-test methodology. In summary, this author is not devaluing the advantages of being aware of diversity in the classroom and using diverse teaching methods, but an increased presence of academic research into learning strategy effectiveness and addressing the myth of learning styles as an advantage for learning is needed in academia.

Lack of Learning Strategy Knowledge

In both this study, Morehead et al. (2016) and Piza et al. (2019), the researchers either asked questions about specific learning strategies or listed techniques to be rated; therefore, conclusions cannot be made about the number of study strategies faculty could list. In McCabe (2018), the researcher did ask heads of academic institutions to state their three top learning strategies recommendation but, afterwards, provided a list of 36 techniques to rate (on effectiveness and frequency of recommendation). The authors stated that "by far the most common response was related to time management skills" and "studying in groups with peers" (McCabe, 2018, p. 145). Thus, to the knowledge of this researcher, no studies have been done on faculty knowledge of study strategies. If asked, how many strategies could the faculty list? It is feasible that the faculty might not know various study strategies or the strengths and challenges of each technique. In Grospietsch and Mayer (2019), when specifically asked whether blocked learning is better than interleaving, 52% agreed, going against evidence-based research. This study rated interleaving as the second-lowest learning strategy concerning effectiveness. Also, in this study, when presented with an interleaving scenario, only 9.1% of the faculty participants rated the interleaving scenario as more beneficial than the blocking. A similar pattern was found in other studies with the Morehead et al. (2016) results, where 16% of students and 13% of teachers provided a higher rating for the evidence-based scenario than the scenario that was not evidence-based. Piza et al. (2019) also used the scenario in this research, with 37% of students and 39% of faculty providing higher ratings for the evidence-based scenario. These results question whether faculty know the advantages of an interleaving study session. In addition, a similar pattern emerged with the practice testing scenario in this study. When asked why students should test themselves, only 19.7% of the faculty participants identified the evidence-based answer that students would learn more than through re-reading. The findings in this research are almost identical to Morehead et al. (2016), where only 19% identified the evidence-based answer and Piza et al. (2019), where faculty stated the evidence-based answer at 36%. Therefore, while faculty might recommend and endorse practice testing, they do not seem to know the reasons why testing increases learning. Thus, there is a question as to whether faculty know a variety of study strategies or their strengths and limitations according to evidence-based research.

Biased Observations

It is plausible that many faculty view memorizations as a negative concept, thus allowing for increased effectiveness ratings of several strategies that could be viewed as achieving deeper learning, such as summarizing notes, diagrams, elaborative interrogation, and asking questions in class. Memorizing is a very subjective concept and can be misunderstood due to biased observations: for example, a faculty sees a certain portion of their students struggling on tests and thinks the learners are simply memorizing the content and not learning it. How do faculty define memorization? Do faculty think that memorizing a new address or phone number would be negative, or does this only apply to academic work? When a student memorizes a concept and can prove they understand it via an assessment, would the student not have learned it? The disconnect between what is perceived as valuable information to memorize (for example, a new postal code after moving to a new apartment or home) and what is not valuable (for example, academic course material) makes the advantages and disadvantages of memorizing challenging. Further, do faculty look at memorizing as a strategy or a component of a technique? For example, do instructors define memorization as re-reading the material until the concepts are memorized? Do they define memorization as re-writing notes until it is memorized? Academic material can be memorized using a variety of study strategies; thus, further confusing the definition of memorization as a learning strategy.

Limitations

Individual Strategies May Not Apply to All Types of Learning Experiences

As stated by Dunlosky et al. (2013), there are many limitations to ranking or rating study strategies. First, student differences are vast and multifaceted; thus, the benefit extent might be difficult to quantify. Second, Dunlosky et al. (2013) mention that the study strategies' learning durability is “largely unknown” (p. 45) as most studies use single sessions as the teaching and testing conditions. Lastly, educational contexts are a limitation, as few studies have examined research in real-life academic settings.

Individual student differences must also be taken into consideration: while research can conclude that certain academic study strategies are more effective than others, faculty cannot dismiss that evidence-based low-effectiveness strategies might help students in certain conditions. For example, the demographics of this study: while this study had over 500 respondents from a variety of institutions and subject areas, they all represented post-secondary institutions. Faculty learning strategy effectiveness ratings may differ in grade school or high school, but the effectiveness of the various techniques could diverge with students in different academic institutions, students with various disabilities, and physical or mental health challenges.

Teaching and learning are very complex concepts, and study strategies may not apply to all learning experiences. Teachers have a very complex job as students may come into the classroom with a variety of experiences that influence whether they have learned the course material. While a full overview of the factors that influence learning is beyond the scope of this paper, some examples can be provided. Students can come into the classroom from a variety of social economic conditions, which could affect the resources required to learn. Students can enter an academic institution with a variety of prior knowledge levels, ranging from significant to insignificant, that affect their learning. Every institution, program, and teacher has various ranges of difficulty, number of assessments, and communication skills that could affect student learning. Some students could enter a classroom very motivated and give maximum effort, while others are satisfied to get by with minimal motivation or effort. Study strategies could also depend on whether the student is motivated to use them, puts in the effort, and uses metacognition to reflect and evaluate whether the technique(s) is working for them. All of the factors discussed can impact learning strategy effectiveness for an individual student, thus limiting the universal strength of any model of learning techniques.

Another challenge surrounds the North American model of grading. A central theme in most studies that investigate learning strategy effectiveness research is the role of grading students. The Dunlosky model, for example, might be limited in academic situations where students are not assessed using a formal grading system. Students are graded in North America, and many parts of the world, usually on a letter system from A to F. Grades tend to be used "to measure learning, sort students, motivate learning behaviors, and provide feedback (Cain et al., 2022, p. 908). The letter system reflects the student's competence but comes with several challenges. In Cain et al. (2022), the authors identified several challenges to grading: first, what the authors call "the most basic assumption" (p. 909), questions whether grading accurately measures what the student learned. For the challenge of accuracy, the researchers are questioning whether assessments given out by instructors are checked for reliability and validity. The next challenge of a grading system is the variety of grading schemes used by faculty. For example, in the same course, one faculty could have five assessments (three tests and two assignments), while another instructor could have 10 assessments (three tests, four small quizzes, and three assignments). The varying assessment weights could affect the grading system, which puts into question the interpretation of a student's final grade and the reliability/validity of the system itself. The next challenge involves testing: when using a test-based system, the number of questions on the test not only varies by instructor, but the number of questions also could affect grade standing perception. For example, on a test with 100 questions, the difference between 75% and 81% is negligible (only six question difference), but the letter grade could place the two students in two different interpretations (a B letter grade v. an A letter grade) by the institution, student, and even the faculty (Cain et al., 2022). The fourth challenge is the faculty themselves, as every instructor has a different rigor and leniency (Donaldson & Gray, 2012) concerning assessment. The final challenge to the grading system is similar to the varying assessment weights: differing assessment types. Faculty teach in different programs (or subjects), which affects the assessment type, but may use the same grading system. For example, a student in a welding program that must demonstrate competence in welding is a different assessment type than a student writing an essay in a social service program. The assessment types could vary even if faculty teach in the same program. For example, two faculty teaching in the same social service program might have different assessment types for students to demonstrate competence in reflection skills. One teacher could require students to write a reflection paper, while another faculty could ask the students to reflect verbally via a video or an in-person interview. Thus, due to the varying assessment types, the reliability and validity of a grading system, and its interpretation, are problematic (Cain et al., 2022). The author of the previously mentioned study summarizes the challenges with grading systems: "Taking all these assumptions together, while grades may reflect aspects of learning, they may not be a particularly accurate measure. Interpretations of grades within and across systems are clouded by numerous issues related to instructor variability, which brings into question the validity and usefulness of grades for sorting students by their learning outcomes" (Cain et al., 2022, p. 910). In summary, individual strategies may not apply to all types of learning experiences due to the complexity of learning.

Respondents

While this study had 544 responses, 7,015 emails were sent out to faculty from various institutions with a response rate of 7.8%. The rate of respondents might not be representative of the post-secondary educational system. As with most surveys, those faculty that responded could be more interested in the topic or more knowledgeable and bias the results.

Self-Reporting

The responses in this study were self-reported and may not represent a complete representation of a faculty's educational practice. The faculty in this study are observers of the student's learning experience, not the learners themselves; therefore, bias or misinterpretation of study strategies and learning styles could affect any conclusions. Further, rating scales have several limitations. Questions such as 'yes or 'no' can be interpreted as restrictive and numerical scales could result in participants giving extreme or middle responses to all questions. Finally, all self-reporting surveys have limitations such as participant honesty, level of introspection, and interpretation of the questions, all of which can limit the analysis of the study.

Lack of Meta-Cognition Questions

This study only asked faculty to rate study strategies and answer questions on learning styles, without any opportunities to explain the reasons behind the answers. A possible research project could include a mix of quantitative and qualitative methodologies to acquire insight into the faculty's beliefs. Concerning the quantitative methodology, rating scales could be created to obtain faculty opinions on why instructor effectiveness ratings of study strategies do not align with evidence-based research. For example, ask faculty the degree to which they agree that current teachers recommend study strategies due to their instructors suggesting them. Concerning the qualitative methodology, various questions could be asked, including ‘why do you think faculty opinions on learning strategy effectiveness do not align with evidence-based research’? Another question could be framed around learning styles after displaying evidence-based research demonstrating that learning styles have no advantage for learning: “Why do you think the learning style myth persists in academia?” Using grounded theory, insights into the reasons behind why there is a disconnect between faculty belief in learning strategy effectiveness and learning styles may be obtained.

Perceptions of the Learning Strategy Effectiveness

When faculty are asked about the effectiveness of various study strategies, this study cannot determine how the instructors perceive the strategies. For example, with the wording of “practice testing,” the instructors might only perceive the effectiveness of the strategy when used in what they view as a traditional testing scenario, for example, multiple final exams. Other faculty might not view their curriculum as having practice tests: for example, an English teacher that assigns only written assignments and no traditional tests might not view practice testing as effective as faculty that teaches first-year anatomy, where testing might be the main assessment type. Re-wording “practice testing” to “practicing” might change the effectiveness ratings in the English teacher scenario.

Defining Academic Success

When faculty are asked about the effectiveness of various study strategies, there is a lack of feedback about how they perceive the goal of the strategies in general. Many faculty might perceive the effectiveness of study strategies in many ways, such as passing a single test, passing an assignment, passing a course, or graduating. There is much debate in academic research as to what constitutes academic success. A paper by York et al. (2015) described the definition of academic success as “amorphous” (p. 1) or without a clear definition. The authors Kuh et al. (2006) defined academic success as “academic achievement, engagement in educationally purposeful activities, satisfaction, acquisition of desired knowledge, skills and competencies, persistence, attainment of educational outcomes, and post-college performance” (p. 5). This study did not define a study or learning strategy for the participants, so it is possible that the faculty participants have different opinions on the goal of study strategies. In Canadian institutions, academic achievement is most likely measured by grades or grade-point average (GPA), along with passing courses and graduating from the program. While grades and graduation rates could be the main indicators of academic success, there are others, such as student satisfaction, the acquirement of skills, persistence, attainment of learning goals, and career success (York, 2015).

The Pandemic

Early in the 2020 COVID-19 pandemic, faculty were forced to go fully online, perhaps for the first time in their career. This transition to online learning could have affected the results of this study as some faculty might have had different ideas about learning pre- and post-pandemic.

Faculty Learning Style Preexisting Definition(s)

Participants could view learning styles as simply someone who is more efficient when working with a specific learning style. Although this research did provide a specific definition of learning styles that addresses an advantage for learning, before answering the questions, it is possible that preexisting definitions could have affected the results.

Type I Error

This research involved the testing of multiple hypotheses, thus increasing the chances of experiment-wise Type I error. For example, in the learning strategy comparisons with faculty demographics, there was a total of 104 tests (with 28 having significant differences). Concerning the Learning Style Questions comparisons with the demographics, a total of 48 tests occurred (with 16 having significant differences). To reduce the chances of a Type I error, Tukey's Honest Significant Difference (HSD) post-host test was used when employing Analysis of Variance (ANOVA). To highlight the marginality of significant differences and the potential danger of experiment-wise error, the p-value for individual tests was reduced to $< .001$. A total of five tests, out of 152, evidenced a significant difference associated with faculty demographics after this correction. The lack of significant demographic differences at $p < .001$, with both learning strategy ratings and learning style questions, is in agreement with reported weak correlational strengths and effect sizes. Such group differences, as are reported and discussed, are not strong ones.

Future Research

This section of the discussion will address future research related to study strategies and learning styles in academia. Please note, the research suggestions are not in any order of importance.

Surface vs. Deep Learning

One of the challenges to the Dunlosky model surrounds the frequent use of surface learning in the research that the authors used to create the ranking system. An investigation into the proportion of surface and deep learning in post-secondary education could assist in knowing when to use the Dunlosky model. To the knowledge of this researcher, no studies exist that quantify the proportion of surface and deep learning tasks in post-secondary education. If the proportion of surface learning is significantly higher than deep learning, then the Dunlosky model would be a very good fit for students. If faculty can identify the areas where surface learning is taught, then instructing students on learning strategy effectiveness could be beneficial. When deep learning is being evaluated, a reduction of technique effectiveness might be warranted.

Impact of Learning Strategy Research Training

There appears to be a lack of significant research on whether training students in learning strategy research would change behavior. Pan and Rivers (2023) suggested that "task experience alone can be insufficient for learners to correct inaccurate beliefs about learning techniques," but "various forms of support, however, have been shown to promote knowledge updating for other effective learning strategies" (p. 6). Therefore, the research suggests that, for example, demonstrating that practice testing can improve a student's GPA might not be enough to change study behavior patterns. Multiple approaches, including teaching learning strategy research, demonstrating and identifying the improved results, and supporting students via metacognition reinforcement, might be required to change learning strategy behavior.

Age

If faculty see the benefit of teaching learning strategy effectiveness, there is a question as to what age to begin the instruction. Perhaps, future research can look into what age or grade faculty could start implementing learning strategy research training.

Training and Re-Training Students on Learning Strategy Effectiveness

After age is researched, the next step could be determining how often students need to be reminded of learning strategy effectiveness research. When during the semester would the optimal time be for student retraining? Would students change their study techniques if trained in learning strategy effectiveness research? If so, how long would the behavior change last? Would behavior change be a result of the degree of grade improvement? For example, if students used evidence-based study strategies instead of their usual low-effectiveness techniques, would they change behaviors if the grade increase was small (for example, a 5% increase) or would the increase have to be significantly higher (for example, a letter grade increase)?

Asking Why

This study and others (McCabe, 2018; Morehead et al., 2016; Piza et al., 2019) asked faculty about learning strategy effectiveness, but none asked for the reasons behind the rankings, ratings, or recommendations to students. Future research could investigate not only the reasons behind the ratings but also the reasons why faculty rate or recommend the strategies.

Faculty "Learning Styles"

As most instructors seem to agree that learning styles exist as an advantage for learning, it is feasible that faculty in this study tailor their teaching style to their own learning style. Future studies could inquire about the teacher's perceived learning style and determine if they promote or use their own learning style as the primary mode of delivery in the classroom.

Recommendations for Academia

Education on Evidence-Based Study Strategies

The results of this study indicate a need to develop a curriculum that addresses evidence-based research on learning strategy effectiveness and the lack of evidence that learning styles provide an advantage for learners. This new curriculum could be introduced not only in education programs but also in post-secondary teacher training.

Education on Learning Style Myths

Like the above recommendation, a curriculum that addresses the research on learning styles needs to be developed. First, noting the research that learning styles offer no empirical advantage for learning. Second, addressing the lack of reliability and validity with the commercial and non-commercial learning style inventories. In addition, education also needs to focus on the consequences of boxing a student into a specific learning style. Lastly, additional education can be created to address the various neuromyths, so that the myth of learning styles as an advantage for learning can be diminished. In Brown (2023), the author recommended three strategies to combat the myth of learning styles: first, eliminating "less relevant" (p. 8) topics in neuroscience courses to increase class time to incorporate neuromyth education. Second, include the 32-item true/false questionnaire on neuromyths, developed by Dekker et al. (2012), in various psychology and neuroscience courses. As the questionnaire is short, little class time is needed to address the challenges surrounding neuromyths. The last proposal from Brown (2023) suggests recommending that students focus on peer-reviewed journals on neuromyths over "educational and popular science magazines, as the latter may appear to support the meshing hypothesis and other neuromyths" (p. 8), although it should be noted that Newton (2015) examined research papers (ERIC and PubMed databases; 2013-2015) and concluded that 89% of the articles endorsed the use of learning styles.

Reframing Learning Styles

In Piza et al. (2019), the authors suggested less emphasis on the concept of learning styles, being a single method of learning, and increased emphasis on dual coding as "a more evidenced-based approach for educators” (p. 1415). Lastly, addressing the pivot from learning styles to learning preferences as both concepts imply the same idea: that only one method of delivery can benefit a student. This author is not suggesting that faculty ignore that a student has a preferred method of learning, but rather diminishing the conclusion that only a single method enhances or gives an advantage for learning.

A Personal Note from the Author

Question Everything: this thesis was entitled “Question Everything” for the reasons identified in the literature review and results. The literature and the results of this study identified that faculty, students, and heads of academic support centres have mixed results when asked to identify evidence-based study strategies. The faculty, students, and heads of academic support centres also have difficulty identifying evidence-based reasons why students should test themselves and the advantages of interleaving compared to block learning. Additionally, the literature also states a lack of evidence that learning styles give an advantage to learning, but previous research and the results of this study note that the learning style myth is thriving in academic institutions.

When I first became a teacher, I thought learning styles created an advantage for learners. It was only because I “questioned” the concept that I realized it was a myth, via reading peer-reviewed research. My teachers recommended that I re-read my textbook, and I thought it was a great learning strategy, which I then brought to my students when I first became a teacher. I “questioned” what study strategies were more effective based on evidence-based research and changed my beliefs, which from student feedback, has enhanced my teaching ability and student success.

Independent of study strategies and learning styles, faculty must question and reflect on their teaching methods as much as possible. To the teachers reading this paper, ask yourself, ‘why do I use strategy X? When you are in a meeting or training session, and someone brings up a teaching strategy, always question it and investigate evidence-based research. Look at the paper’s methodology and question whether there are any methodological problems or variables that may not have been considered. The questioning, monitoring, and evaluating of your teaching methods might improve student success.

I will leave you with another popular myth in education to reflect upon. Why do you use four lures (answers) in multiple-choice tests? For example, “a,” “b,” “c” and “d?” What if I told you that there is research that demonstrates you only need three lures? Over the years, the majority of multiple-choice tests I have seen have four answers (a, b, c and d), but I have seen some tests that go up to “H” or even “I” (that is nine answers). What if we reduced the number of answers to three? Many would say that it increases the chances of guessing the correct answer, but is this conclusion true? Let’s start with a study by Baghaei & Amrahi (2011), who had students complete three different multiple-choice tests: five answers, four answers or three answers. The study found no significant differences in many areas, including grades, question difficulty, and test reliability over time. Landrum et al. (1993) also confirmed that the three-answer method was no different from the four-answer method.

The misinformation effect is another reason to reduce the number from four to three. The misinformation effect suggests that seeing wrong answers increases the possibility that a student will later believe it to be true. For example, in crime and accident scene studies: when presented with a wrong or false option, it has negative consequences for later memory. Multiple choice tests have this disadvantage because, in a typical “A-B-C-D” format, three (or 75%) of the answers are incorrect. Let us have a look at some key studies starting with Toppino and Brochin (1989), who used a 7-point scale (very true to very false) and, on the second test, false statements that had appeared on the first test were rated "more true". Thus, the lures or incorrect answers were interpreted as "more true" on the re-test. Brown et al. (1999) also found that exposing subjects to misinformation after an initial test influenced subjects on the final cued-recall and multiple-choice tests. This outcome occurred even when wrong information was identified during the between experiment task. Roediger and Marsh (2005) found similar results: taking a multiple-choice test caused subjects to answer later cued-recall tests with incorrect information, despite the subjects being warned against guessing. Jacoby and Hollingshead (1990) even found that reading correctly and incorrectly spelled words influenced later spelling accuracy for those same words.

Why does the misinformation effect occur? First, the memory of correct information is degraded by experiencing related, incorrect information. Second, retrieval interference: both the correct and incorrect memory exist, making it harder to pull the correct one. Lastly, recency bias: if the student read (or focused on) the last item, and it was incorrect, it increases the likelihood that the incorrect item will be pulled from memory first. The study by Roediger and Marsh (2005) found that increasing the number of false answers (or lures) produced an increase in the probability that students answered cued-recall questions with lures from the prior multiple-choice test. In sum, the more lures, or false answers your test has, the more false beliefs a student may create in their mind after the test.

When I first read about three lures being statistically no different than four (or more), I was shocked as every single multiple-choice test I have done has a minimum of four answers. Without questioning multiple choice testing, I would still be using four lures and not be giving my students the advantages mentioned. This is why questioning everything is so important, as we need to question every teaching technique, even those that seem universal, like learning strategy effectiveness or learning styles as an advantage for learning.

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Appendices

Appendix A: Survey—Learning Strategies

You are being invited to take part in a research project. The research will only take approximately 5-10 minutes of your time. Before you decide whether you want to take part, it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully.

Project Title: Instructor Study Strategy Investigation
Principal Researcher: Derek Newman
Researcher contact details: derek.newman@cambriancollege.ca

1. What is the purpose of the project?
The purpose of this project is to investigate what study strategies instructors use and suggest to their students.

2. What will I have to do?
You will be asked to complete a questionnaire comprised of questions in the following areas:

- Demographic questions about yourself
- Questions to investigate study strategies and learning styles

It is up to you to decide whether to take part as participation is entirely voluntary.

3. Will there be any negative effects of taking part in the study?
No risks are anticipated in taking part in this study.

4. What benefits will the study have for the participants?
Benefits of taking part in this study include aiding research into what study strategies instructors use and suggest to their students.

5. How will confidentiality be assured?
You will not be asked to give your name or any identification on any of the materials used during this study, so all the information you give will be anonymous and confidential.

6. Who will have access to the information that I provide?
Only the researcher will have access to the data, which will be stored by the researcher in accordance with Cambrian College's policy on data security.

7. Has this project received appropriate ethical clearance?
Yes.

8. How can I withdraw from the project?
It will not be possible for participants to withdraw once their completed questionnaire has been returned to the researcher due to the difficulty identifying anonymous data. However, participants are free to withdraw at any time during completion of the questionnaire prior to submitting their answers.

Section 2 - Descriptive Questions

By completing the questionnaire, you are consenting to participate in this research. The survey will take approximately 5-10 minutes. Thank you for your input.

1. What is the highest degree or level of education you have completed?
- Ph.D. or higher
- Master's Degree
- Bachelor's Degree
- Trade School

2. Do you have a degree in education?
- Yes
- No

3. Current status
- Full-time
- Part-time

4. Number of years teaching in current employment status.
- 0-5 years
- 6-10 years
- 11-15 years
- 16-20 years
- 21+ years

5. What is the highest level you teach?
- College
- University faculty: undergraduate
- University faculty: graduate
- Both undergraduate and graduate
- Other

6. What subject area do you primarily teach?
- Sciences
- Social sciences
- English
- Business
- IT/Computers
- Music
- Creative arts
- Trades
- Other

7. Approximately how many teacher-training certificates have you accumulated in your career outside of your degree? For example, training within the college or external training.
- None
- 1-5
- 6-10
- 11-15
- 16-20
- 21+

8. Gender
- Male
- Female
- Prefer not to say

Section 3 - Study Strategies

1. Do you recommend study strategies to your students?
- Yes
- No

2. On average, how often do you discuss study strategies?
- A few times a class
- About once a class
- Usually only before tests/major assignments
- I don't recommend study strategies

3. Do you think students use your recommended strategies?
- Yes, I think they use them in all their classes.
- Yes, I think they use them only in my class.
- No
- I don't recommend study strategies

Section 4 – Ranking and Scenario Questions – Study Strategies

1. Please rank the following study strategies: very poor, poor, moderate, effective, very effective

1. Cramming lots of information the night before the test
2. Summarizing material into notes
3. Interleaved practice (moving around from concept/chapter to chapter)
4. Practice testing
5. Using flashcards
6. Distributed practice (increasing time to practice before test)
7. Highlighting
8. Keyword mnemonic
9. Imagery
10. Re-reading textbook, articles, notes
11. Elaborative interrogation (asking questions about course material)
12. Making diagrams, charts or pictures
13. Studying with friends
14. Asking questions or verbally participate during class

2. If you think students should quiz themselves (either using a quiz at the end of a chapter, a practice quiz, flashcards or something else), why should they do so?

- They will learn more that way than through re-reading
- To figure out how well they have learned the information they're studying
- I do not think quizzing will necessarily benefit students

3. Students have three chapters of material to learn. Student A studies one chapter at a time. Student B moves around, studying a little chapter one, then a little from chapter two, and a little from chapter three. Both students study the same amount of time. Please rate the value of the strategy.

	Not at all beneficial	Somewhat beneficial	Very beneficial
Student A			
Student B			

Section 5 - Learning Styles

The following questions will be about learning styles, which means that individuals will learn better when they are taught in a way that matches their preferred or dominant way of learning

1. Do you believe students have different learning styles (e.g., visual vs. auditory learners)?
- Yes
- No

2. Do you teach to accommodate those differences?
- Yes
- No
- I don't believe in learning styles

3. How confident are you that students have different learning styles?
- 0 to 10

4. Please rank the following statements – strongly disagree, disagree, neutral, agree, strongly agree:

1. Learning styles are determined at birth.
2. Learning styles can change.
3. Those with different learning styles use different brain regions to learn.
4. Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.
5. Learning styles predict the type of career someone will have.
6. Learning styles predict the kinds of teachers from whom they learn best.

5. Students use learning strategies that link up with their perceived learning style.
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Contact Information: If you wish to learn the results of the research study, see below.

Please place your email address in the field, and the researcher will contact you with the results. Thank you.

Appendix B: Research Ethics Board Approval Letters

APPROVAL FOR CONDUCTING RESEARCH INVOLVING HUMAN SUBJECTS
Research Ethics Board – Laurentian University

This letter confirms that the research project identified below has successfully passed the ethics review by the Laurentian University Research Ethics Board (REB). Your ethics approval date, other milestone dates, and any special conditions for your project are indicated below.

TYPE OF APPROVAL / New X / Modifications to project / Time extension

Name of Principal Investigator and school/department	Derek Newman, Graduate Student (Human Studies), Dr. Cynthia Whissell (supervisor)
Title of Project	Instructor Study Strategy Investigation
REB file number	6021296
Date of original approval of project	Nov 15, 2022
Date of approval of project modifications or extension *(if applicable)*	
Final/Interim report due on: *(You may request an extension)*	Nov 15, 2023
Conditions placed on project	

During the course of your research, no deviations from, or changes to, the protocol, recruitment or consent forms may be initiated without prior written approval from the REB. If you wish to modify your research project, please refer to the Research Ethics website to complete the appropriate REB form.

All projects must submit a report to REB at least once per year. If involvement with human participants continues for longer than one year (e.g. you have not completed the objectives of the study and have not yet terminated contact with the participants, except for feedback of final results to participants), you must request an extension using the appropriate LU REB form. In all cases, please ensure that your research complies with Tri-Council Policy Statement (TCPS). Also please quote your REB file number on all future correspondence with the REB office.

Congratulations and best wishes in conducting your research.

Sandra Hoy, PHD, Chair, *Laurentian University Research Ethics Board*

Western Research

Western University
Room 5150 Support Services Building, 1393 Western Road
London, Ontario, Canada, N6G 1G9
Tel: 519-661-2161
ethics@uwo.ca

Date: June 8, 2021
To: Derek Newman, Cambrian College
Study Title: Instructor Study Strategy Investigation
Review Type: Administrative Review

Dear Mr. Newman,

The Office of Human Research Ethics, on behalf of Western University's Research Ethics Boards, has conducted an administrative review of the Cambrian College approved study documents, and has determined that this research can be conducted at Western University as outlined in the following documents:

- REB_newman
- survey_newman
- email_newman
- Expert Panel Letter (MC2021-04-006)
- Letter of Approval; D Newman
- Email thread with Katelyn Harris dated February 12-June 8, 2021

Please note that Western University's REBs are not approving this research, as a local Principal Investigator is not directly involved in this research. As such there is no local oversight on the conduct of this research. Cambrian College and its REB remain responsible for overseeing the conduct of this study. Nonetheless, Western's REBs acknowledge that this research is taking place and that there are no major objections to the manner in which it will be conducted as described in the study documents listed above.

Please note that there should be no references to Western University's REBs in your communications with participants (including, but not limited to, the consent form) as the REBs do not provide oversight for this project.

If, during the course of this study, there are changes to the project or new information comes to light, which would affect the determination stipulated above, these should be brought to the immediate attention of the Office of Human Research Ethics for re-assessment.

If Western's Office of Human Research Ethics is contacted to confirm Western's REBs' position on this external study, we will confirm that it has been reviewed and acknowledged.

Best wishes for the successful completion of your project.

Sincerely,

The Office of Human Research Ethics, on behalf of Western University's Research Ethics Boards

HUMBER
Research Ethics Board

June 9, 2021

Derek Newman
Cambrian College

Dear Derek,

Your application, *Instructor Study Strategy Investigation,* has been approved by the Humber Research Ethics Board for one year, until June 9, 2022. Your protocol number is *REB-0219.*

If you amend your research methodology in any way, or if you would like to extend your approval, please visit the Humber Research Ethics Board website (www.humber.ca/research/REB) to locate the appropriate form.

Upon completion of your project, please submit a Project Completion Form, which can also be found on the Humber Research Ethics Board website.

Best wishes as you pursue your research interests.

Sincerely,

Lydia Boyko

Dr. Lydia Boyko
APR, FLMI, BJ, MEd, PhD
Chair, Humber Research Ethics Board

Note on Institutional Approval: All internal and external researchers planning to conduct research involving the collection of data from Humber staff, faculty, students, or access to institutional data/resources, must obtain institutional approval in addition to Humber Research Ethics Board (HREB). HREB approval does not automatically constitute Institutional Approval, and vice versa. Institutional Approval is granted by the Office of the Senior Vice-President, Academic. To request Institutional Approval, please visit the REB website (https://www.humber.ca/research/reb/#hero_banner) to download the form or contact research@humber.ca.

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May 20, 2021

Derek Newman
Cambrian College
1400 Barrydowne Rd
Sudbury (ON) P3A3V8

Dear Mr. Newman,

RE: Instructor Study Strategy Investigation

Ethics Approval	Original Approval Date: May 20, 2021 Expiry Date: May 20, 2022

I am pleased to inform you that the Cambrian College Research Ethics Committee has granted approval to the above-named research study, for a period of one year, under the REC's delegated review process.

Please note that approval is based on the following:

a) The REC must be informed of any protocol modifications if they arise.
b) Any unanticipated problems that increase risk to the participants must be reported to the REC immediately.
c) The study is approved for one year. If needed, please apply for an extension before the expiry date.
d) A copy of the final report must be submitted to the REC upon completion of the project.

Best wishes for the successful completion of your project.

Sincerely,

SMcCall

Sherrill McCall
Dean, Planning and Research
Cambrian College

Fanshawe College Research Ethics Board Review

Approval Notification of Proposed Research
Involving Human Participants at Fanshawe College

Protocol Number:	21-05-17-2
Principal Researcher(s):	Derek Newman
Research Protocol Title:	Instructor Study Strategy Investigation
Research Project Start Date:	June 1, 2021
Expected date of termination:	December 31, 2021
Documents Reviewed:	Protocol; Email to Faculty; Survey Questions

Based solely on the ethical considerations raised by the research proposed in the application, the Research Ethics Board has completed its delegated review of the above research proposal and
Approved the project on May 28, 2021.

Comments and Conditions:

Please note that the REB requires that you adhere to the protocol reviewed and approved by the REB. The REB must approve any modifications to the protocol before they can be implemented.

Researchers must report to the Fanshawe REB:
a) any changes which increase the risk to the participants;
b) any changes which significantly affect the conduct of the study;
c) all adverse and/or unexpected experiences in the course of carrying out the study;
d) any new information which may adversely affect the safety of the participants or the conduct of the study.

Ethics approval of this protocol is for a period of one (1) year from the approval date above.
· Researchers must submit an REB Amendment/Extension form if research continues beyond this period.
· Upon completion, researchers must submit an REB Annual Review/Status Update form.

ETHICS APPROVAL DOES NOT CONSTITUTE PERMISSION TO CONDUCT THE RESEARCH; OTHER INSTITUTIONAL APPROVALS MAY BE REQUIRED TO CONDUCT THE RESEARCH PROJECT.

Members of the FCREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the FCREB.

S. Veenvliet

Scott Veenvliet, PhD
Vice-Chair, Research Ethics Board
Fanshawe College

May 28, 2021
Date