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Effects of Contemplative Practice Applications on Learning with an Adaptive Training System

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by

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"Effects of Contemplative Practice Applications on Learning with an Adaptive Training System"

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Abstract

Title:
Effects of Contemplative Practice Applications on Learning
with an Adaptive Training System

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This study sought to test the impact of the contemplative practices of guided mindfulness and more traditional mindfulness compared to a standard educational practices control condition, on learning. Guided mindfulness practices are embedded concentrative psychoeducational practices of contingency planning and guided reflection that are systematically sequenced in experiential learning contexts. Traditional mindfulness practices are embodied interoceptive practices such as diaphragmatic breathing, mindfulness meditation, and body scan used in a generalized sense. The control condition standard educational practices include note taking and learning styles. By engaging learners in an embedded psychoeducational practice and embodied interoceptive practices, this study sought to: 1) show how different contemplative practices may facilitate overall learning and higher order learning along the revised hierarchy of educational objectives (Krathwohl, 2002), and 2) test the indirect influence of these practices on learning through the mechanisms of metacognition and cognitive flexibility (Jankowski & Holas, 2014; Spiro et al., 2003).

These relationships were tested using a one-way between subjects repeated measures design in a controlled laboratory setting. Participants in the guided mindfulness and traditional mindfulness groups were administered the respective practices through a mobile application, whereas, participants in the control condition were presented a PowerPoint presentation. Participants were then trained on the real-world task of basic electricity knowledge and skills application via an adaptive training system. Data from 214 participants from a small Southeastern city in the United States were analyzed. Results revealed no significant differences between the groups in overall or higher order learning resulting from either contemplative practice or the control condition. A statistically significant and positive relationship was found between cognitive flexibility and overall learning in both the guided mindfulness and traditional mindfulness conditions. Results of this study reveal a modest effect size for novice meditators engaging in either guided mindfulness or mindfulness practices.

Table of Contents

Keywords

Contemplative practices

Adaptive training systems

Mindfulness

Guided mindfulness

Metacognition

Learning

Cognitive flexibility

Self-regulation

List of Figures

List of Tables

List of Abbreviations

BEETLE: Basic Electricity and Electronics Tutorial Learning Environment

CF: Cognitive Flexibility

GM: Guided Mindfulness

ICAR: International Cognitive Ability Resource

MSLQ: Motivated Strategies for Learning Questionnaire

MSR-R: Metacognitive Self-Regulation – Revised

PANAS: Positive Affect Negative Affect Survey

SHIELD: Strengthening Health and Improving Emotional Defenses

SLP: Self-efficacy for Learning & Performance Subscale

TMT: Trail Making Test

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Dedication

This work is dedicated to my brother James – who didn't always get it right but got back up anyway with a lot of heart and fierce determination. I dearly miss our common-sense truthful conversations and your sarcastic wit. Thank you for reminding me on the last mile of this journey when I wondered if I "lost" my mind undertaking a Ph.D. that I probably found my mind. Indeed, I did and my voice in this last life lesson, too. For that and the encouragement, I will always be grateful to you.

Introduction

The gestalt within which we are currently operating is characterized by complexity and constant change. This environment often outstrips human perceptual abilities, which has resulted in a populace that is under persistent stress and strain. The effect of this can be summed up in a quote with its roots in the Talmud – "We don't see things as they are, we see them as we are. Because it is the 'I' behind the 'eye' that does the seeing." (Nin, 1961). Seeing the world through a clouded lens has long been recognized as resulting in skewed judgments and hampered decision-making (e.g., French, Caplan, & Van Harrison, 1982). The key to success in this area is defining the characteristics needed in the workforce to successfully operate in this environment. An agile workforce resilient to change must be able to pay attention, as well as, think deeply and flexibly to make sense of cues in complex environments to formulate solutions for ill-defined problems. Rigid, traditional teaching paradigms with content presented as unconditional facts are not conducive to learners developing these competencies.

To effectively manage these stressors and enable rapid learning and adaptation, practitioners have pushed a brain culture to encourage workers to adopt a neurocitizen perspective (Pykett & Enright, 2016). Neurocitizens take personal control of their learning, self-mastery, and psychological governance of emotions. Practitioners have developed programs to encourage brain culture and constructs, such as mindfulness, that have received considerable media attention as a result of these efforts (Pykett & Enright, 2016). In alignment with this cultural shift, the marketplace has been flooded with methods and technologies promising to support the activities of neurocitizens. This influx has presented challenges to the consumer to sort through what might work absent a solid evidence base. Organizations' human resource departments are not immune to these challenges, often struggling to establish human capital strategies that incorporate the right methods and tools to support the workforce at the point-of-need. Technology designed to provide cognitive support founded on evidence-based methods holds promise to provide relief. One area particularly well-positioned to reap the benefits of this approach is training and education. Integrating learning opportunities that impart these competencies throughout the training lifecycle in conjunction with traditional knowledge and skill training are more likely to deliver a workforce bearing these desirable characteristics (e.g., Saks & Gruman, 2015).

The training and education community has made considerable investments over the past 25 years in the development of adaptive training systems (e.g., Sottilare & Sinatra, 2014). Adaptive training systems are meant to provide learners with cost-effective learning opportunities with a technological surrogate for one-on-one human tutoring. Adaptive training systems consist of a variety of types of agents designed to adapt to the pedagogical needs of the student with the end goal of increasing learning. Multiagent systems are designed for the acquisition of new knowledge, motor, or cognitive skills (Weiss, 2000). There are many challenges with these types of systems in that they are in a dynamic, open environment and it is difficult to completely specify the system. Current adaptive training systems employ a variety of agents in a decentralized learning system whereby several agents are engaged in the learning process. Each agent in the system may take on a variety of differencing features in the underlying algorithms. Specifically, the degree of decentralization across the agents, how the agents interact between themselves and the learner (i.e., level of interaction, persistence, frequency, pattern, variability), involvement (i.e., relevance, role), goal specific features, learning methods employed, and learning feedback (Weiss, 2000). Numerous combinations of differencing features are possible in any agent based system. The inclusion of a feature necessarily should be driven by concrete learning scenarios the learners will need. Absence of careful design can lead to the credit assignment problem, whereby, it is difficult to assign credit or blame to an agent for contributions to performance changes. Agents should be working in concert with one another to optimize learning goals. The agents perceive the learner's state and calculate necessary actions to achieve the learning objectives. These systems can be highly effective in well-defined domains such as math and science, where rules associated with the content are clear making the design of a multiagent system easier. The key to successful adaptive training system development lies with a solid empirical evidence base to drive development, which is still accumulating, necessitating other considerations.

The Computers As Social Actors (CASA) paradigm posits that as technology becomes more human like in terms of features such as speech, interaction, and appearance, it begins to be treated as a social actor with individuals expecting the technology to comply with social norms, values, rules, and societal expectations (Lee & Nass, 2010). The research community has begun to identify which social rules humans apply to computers and which features, or cues, of the technology cause them to do so. In the seminal series of studies exploring this proposition it was demonstrated that participants interacting with an adaptive training system through tutoring, testing, and evaluation applied politeness norms, treated computer systems as distinct social actors, primitive cues elicited a social response, and that the rules governing the application of praise and criticism elicited similar responses as human dyads (Nass, Steuer, & Tauber, 1994). Further, long standing psychological principles of similarity-attraction, reciprocity, and social stereotyping/categorization were empirically demonstrated between humans and computers (Lee & Nass, 2010).

Counter to these early findings, learners' behaviors can change considerably when interacting with a computerized tutor over a human tutor (Dzikovska et al., 2010). For example, expressions of confusion (i.e., an indicator of metacognitive activity) when interacting with a human tutor versus a computerized tutor differed markedly (Steinhauser et al., 2010). Learners' interactions with human tutors revealed significantly more positively valenced metacognitive statements, which was significantly negatively correlated with learning gain, where learning gain is calculated as *(posttest score – pretest) /(1 – pretest)*; whereas interactions with computerized tutors resulted in both negatively and positively valenced metacognitive statements and negative social statements, which correlated significantly negatively with learning gain. Findings such as these underscore the importance of researching and developing methods and technologies to effectively support self-regulation in adaptive training environments while the science of engineering effective adaptive training systems matures (Sottilare & Sinatra, 2014). Studies in this area have focused almost exclusively on what happens during the tutorial to the exclusion of addressing the learning process end-to-end (i.e., planning for learning; reflection on what was learned). Actively engaged learners are essential to maximize learning and transfer. Putting learners in control of their learning and behaviors is key to success (Spiro, Coulson, Feltovich, & Anderson, 1988). Methods and technologies designed to enhance experiential learning situations spanning from early tutoring to on-the-job learning opportunities via sensemaking activities hold promise to support effective metacognition and cognitive flexibility.

Sensemaking is the process of discovering, assessing, and interpreting cues dynamically (Brown, Colville, & Pye, 2015; Weick, Sutcliffe, & Obstfeld, 2005). This process can be undertaken prior to an event (prospective sensemaking), during an event (dynamic sensemaking), or after an event (retrospective sensemaking).

Embedding design features across the learning environment to promote these activities can assist with learning. For example, written explanations, active comparison, and providing assistance/feedback have been forwarded as supporting development of sensemaking skills (Rau, Aleven, & Rummel, 2017). Prospective sensemaking activities can include understanding one's readiness to undertake the learning experience through careful consideration of knowledge and skills necessary to succeed, the context or situation in which the learning will transpire, and the social situation surrounding the learning event. Retrospective activities include reviewing performance during the learning experience, reviewing progress towards meeting initial goals, and making plans for upcoming learning experiences. Pairing mobile learning applications and adaptive training systems may offer support across the entire sensemaking process. Methods such as mindfulness practice delivered through applications may provide a mechanism for developing metacognitive skill.

Mindfulness and metacognition are conceptually linked under the umbrella of self-regulation. Both concepts hold the same objective of changing an individual's relationship with thoughts and emotions by facilitating detachment (Hussain, 2015). In both concepts, thoughts and emotions are considered as objects in the mind. Beyond these commonalities, each concept operates on different systems. Metacognition addresses knowledge and regulation of cognition. Mindfulness is a state of conscious awareness of thought processes without reacting to them. Additionally, the self serves as an object of observation through detachment. Mindfulness incorporates metacognition in the definition, which has spawned the metacognitive model of mindfulness (Jankowski & Holas, 2014; Norman, 2017; Shute, 2018). This model hypothesizes that metacognitive skill is fundamental to obtaining a mindful state. The model also hypothesizes that there are many levels of mindfulness that are hierarchically structured (Hussain, 2015). Meditation practice is intended to train the mind to achieve a state of mindfulness; however, lower levels of mindfulness transpire absent conscious attention or meditation practice.

The present study assesses contemplative meditation practices at two levels manipulated by manner of practice delivered on a mobile application. First, embodied interoceptive meditation practices will be undertaken. These practices include mindfulness, diaphragmatic breathing, and body scan. Second, guided mindfulness, a set of embedded concentrative psychoeducational practices, will be utilized. These practices include contingency planning and guided reflection.

There is a glut of mindfulness mobile applications on the market promising everything from clarity of thought to a reduction in stress. A few popular mobile applications commercially available include Head Space, Calm, and Mindfulness Coach. Proposed benefits of mindfulness mobile applications for organizations are: lowered cost, scalability, accessibility, and lowered attrition from programs. Despite these proposed benefits, the empirical literature base is limited in the number of studies that have explored the effects and utility of this technology across usage contexts (Fish, Brimson, & Lynch, 2016). Fish et al. (2016) conducted an evidence-based practice review and found support for the use of mindfulness applications in clinical settings. Additionally, they reviewed user reactions to the technology and practices and found that participants appreciated multimedia applications and practice sessions that were 30-minutes or less. Despite findings such as this, considerably more research is necessary to determine effectiveness of different applications across contexts in order to derive principles and guidelines appropriate for the use of this technology (Fish et al., 2016).

Recently, four longitudinal studies were published to determine the effectiveness of mindfulness applications (Cavanagh et al., 2018; Economides, Martman, Bell, & Sanderson, 2018; Kök & Singer, 2017; van Emmerik, Berings, & Lancee, 2018). Results of these studies were generally positive, showing enhanced positive affect, energy, present focus, as well as improved psychological, social, and environmental quality of life. Additionally, these mindfulness applications reduced attention to distractions, perseverative thinking, stress, and irritability. Of relevance to this study is an increase in metacognitive awareness and less distraction attached to participation in observational thought meditation practice (Kök & Singer, 2017). Additionally, mindfulness psychoeducational applications were also found to be effective for increasing mindfulness (Cavanagh et al., 2018).

While these results are supportive of mindfulness applications' ability to induce mindfulness states and reap long-term benefits, the effects of these applications on learning outcomes remains unexplored. Mindfulness practices delivered over mobile applications offer potential to empower and enable learners to make sense of complex content. It may be that mindfulness facilitates self-regulation such that the use of feedback loops is maximized. Research findings are generally supportive of the use of mindfulness practices for supporting learning. However, assuming that these findings will carry forward yielding the same results when technology is the delivery mechanism is tenuous. The proposed study seeks to begin to address this gap in the literature.

The present study seeks to test the relationship between mindfulness, as a sensemaking intervention and learning in a controlled laboratory setting. Propositions following the metacognitive model of mindfulness will be addressed through the test of the effect of mindfulness practices versus an active control condition on learning. In brief, the theory posits that mindfulness states result in a reduction in temporal and translational dissociations resulting from an increase in available working memory. It is further posited that mindfulness states also foster inhibition of cognitive interference from both internal and external sources enabling switching attention to achieve flexibility of thought. The proposed study seeks to test these propositions. More specifically, the mediating mechanisms of metacognition and cognitive flexibility will be tested as depicted in Figure 1. The relationship between mindfulness and cognitive flexibility will be tested with a set and task shift exercise as opposed to just a set shift exercise as has been done in recent empirical studies; it is hoped that the added complexity will reveal significant results in alignment with proposed theory (Shapiro, Carlson, Astin, & Freedman, 2006). Further, these mechanisms will be tested in the neurotypical adult population as opposed to children or neurodiverse adults. Human development principles dictate that these constructs function differently across these populations. These relationships will be tested using a real-world task of basic electricity training knowledge and skills application as opposed to the formation of novel words or educational lecture content. This training will be delivered via an adaptive training system, which is also novel where tests of the effects of mindfulness practice and learning are concerned. Additionally, adaptive training systems may have an effect on metacognition that mindfulness practices might ameliorate ultimately enhancing learning outcomes. Finally, the utility of mindfulness practices delivered through a mobile application for enhancing learning has not been tested as of the writing of this proposal, nor, has the specific practice of guided mindfulness. Prior to unpacking each of the proposed interventions, mediating constructs, and the associated relationships theoretically and empirically, the foundational literature for learning will be summarized.

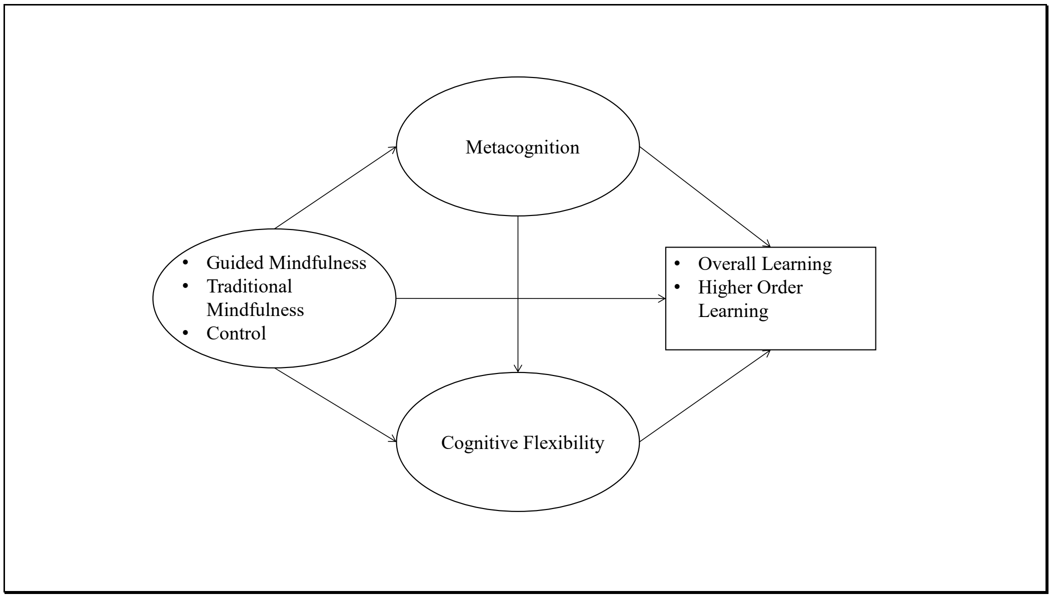

Figure 1. Contemplative practice effect on learning mediated by metacognition and cognitive flexibility.

Chapter 1

Literature Review

Learning

Bloom's original taxonomy of educational objectives is designed as a tool for educators to systematically classify education goals, objectives, and test items (Bloom, 1956). Through the classification exercise, it can be determined if the learning objectives and associated pedagogical artifacts are structured to support student achievement of mastery of content at an appropriate level (Krathwohl, 2002). The original taxonomy is a unidimensional framework consisting of six categories derived from the domain of cognitive processes (i.e., Bloom, 1956). The cognitive domain was defined as comprising knowledge to be recalled and recognized, as well as, the development of intellectual skills (Bloom, 1956). The challenge with this definition and the resulting categories (i.e., knowledge, comprehension, application, analysis, synthesis, evaluation) is that, as structured, the lowest level of knowledge has applicability across all higher levels of the hierarchy. Specifically, as defined in the original taxonomy knowledge covers knowledge content or type and the cognitive processes that the learner should exhibit to master this level (Krathwohl, 2002). Knowledge content is an important aspect of all levels of the framework, which spurred a revision to the model (Anderson et al., 2001).

The revised taxonomy of educational objectives is comprised of the two dimensions of knowledge and cognitive process (Krathwohl, 2002). In alignment with the original taxonomy, the categories underpinning each dimension are hierarchically structured from lower order to higher order thinking skills, such that mastery of a lower level category is a prerequisite to the next highest level.

The knowledge dimension of the revised taxonomy is comprised of four categories. The first three categories are native to the original framework and are factual, conceptual, and procedural knowledge. Cognitive science evolved since the original taxonomy was forwarded as has educational practice necessitating the inclusion of a fourth knowledge category of metacognitive knowledge. Metacognitive knowledge is the knowledge of an individual's cognitions concerning strategy, tasks, and self.

The cognitive process categories were refined from the original model. As previously mentioned, knowledge needed revision to better meet the taxonomic criteria of mutual exclusivity. Based upon content that is now exclusively reflective of cognitive processes, the category was renamed *remember*. Further renaming of the categories was undertaken to facilitate use of the taxonomy by education practitioners by replacing scientific jargon with verbs commonly used by educators to develop learning objectives (Krathwohl, 2002). The revised framework maintains six categories with 19 specific cognitive processes. The lower order thinking skills categories are *remember* and *understand*, formerly titled knowledge and comprehension, respectively. The higher order thinking skills categories are *apply*, *analyze*, *evaluate*, and *create*, formerly titled application, analysis, evaluation, and synthesis. In the revision, the synthesis (create) and evaluation (evaluate) levels swapped places with synthesis, now labeled create, being the highest level of the taxonomy. As defined under the new category labels, evaluation involves making judgements through check or critiques, whereas, creating involves creating novel products through the cognitive processes of generating, planning, and producing. The placement swap was warranted as creation of novel products is a more abstract set of cognitive processes that are more difficult to master than evaluating what others have produced.

The dimensions of the revised taxonomy be formed into a table with knowledge placed on the vertical axis and the cognitive process dimension on the horizontal axis to map learning objectives or test items in the applicable cells (Krathwohl, 2002). From a practical perspective, this allows for an objective analysis of whether the existing content meets the necessary mastery goals. Further, the mapping can be used to assess whether planned course media and interventions will adequately support instruction. Along these lines, the scientific community can use this framework to gain a nuanced understanding of how emerging instructional interventions, such as contemplative practices, operate with respect to lower and higher order learning and thinking skills, such as what is proposed in this study.

Recently, mindfulness practice activities have begun to be tested with respect to understanding the effect on adult learning with positive results (e.g., Bonamo, Legerski, & Thomas, 2015; Calma-Birling & Gurung, 2017). However, discussion of cognitive process levels, let alone knowledge levels, is absent in the reporting of these studies leaving the reader to determine what cognitive process is under test. Empirical evidence concerning the relationship between mindfulness and learning will be discussed later in the body of the literature review. First gaining an understanding of the nature of contemplative practices is required.

Contemplative Practices

Secularized contemplative practices are systematic activities, independent of any ideology, designed with the express purpose of inquiring into the nature of things while putting aside preconceptions in order to more fully account for present moment reality via direct observation (Christian, 2018). Contemplative practices all share three characteristics to achieve insight. First, attention is self-regulated to reduce automaticity of thought. Second, a non-judgmental orientation is taken toward thoughts or experiences during the activity with the intention of building a comprehensive mental model absent the influence of attitudes or emotions (i.e., attitudes or emotions are viewed as objects to consider in the mental model rather than exerting influence in the moment). Third, working memory is freed up through a combination of the first two characteristics and present-moment focus. Through engagement in contemplative practice activities, individuals gain enhanced awareness and understanding of self and reality with which to self-regulate task performance (Dorjee, 2016).

The development of self-regulatory capacity arising from contemplative practices is theorized to result from the mechanisms of adaptive goal-directed metacognition and attention regulation, emotion regulation, and conceptual processing with the end goal of developing existential awareness or, more colloquially, better *understanding* of self and reality and adapting thoughts and behaviors accordingly (Dorjee, 2016). While the mechanisms work in tandem with one another to influence understanding, the development of metacognitive self-regulatory capacity exerts the greatest influence on understanding based upon the nature of metacognition. Metacognition is conscious, purposeful thought to achieve a specific goal. Regarding specific goals, the intention and context of the different practices may influence the operation and development of each of the mechanisms. Additionally, the autonomous nervous system may influence emotional regulation and conceptual processing, exclusively, with no direct influence on metacognition, which is likely a result of the nature of the practice. While the spectrum of contemplative practice activities is virtually limitless, they can be crudely dichotomized as embodied practices and embedded concentrative psychoeducational practices.

Embedded concentrative psychoeducational practices are focused on metacognitive skills and awareness of thoughts through self-inquiry of strengths and weaknesses (Singer, 2018). These practice activities are situated within a context in which individuals are embedded. The purpose of these practices is to foster creativity and/or generate positive perspectives or behaviors. Example practice activities in this category include journaling, visualization, and meditation (Barbazat & Bush, 2014). Ideally, the result of embedded practice is the development of a mental scaffold to facilitate cue-pattern recognition to enhance future behavioral response.

Embodied practices are interoceptive in nature in that these activities focus attention at the general level on one's physiological state. Interoception is the subjective physiological state derived from multimodal integration of sensations arising from visceral and somatic tissue, emotions, learned associations, and memories (Ceunen, Vlaeyen, & Van Diest, 2016). The purpose of these activities is to gain generalized attention, presence in the moment, and internal body awareness (Ceunen et al., 2016). Example practices in this category include both sitting activities, such as breath awareness or body scan, and whole-body movement activities such as quadrato motor training or walking meditation.

The present study tests contemplative practice activities that fit under the umbrella of mindfulness within the embedded practice category (i.e., guided mindfulness preparation and reflection) and embodied practice category (i.e., mindfulness, diaphragmatic breathing, body scan).

Mindfulness

Contemplative training interventions, especially mindfulness, have been lauded by many workplace practitioners as making improvements to workplace performance ranging from increased productivity to enhanced decision-making (Hess, 2017). While some of these results are backed by empirical evidence, the scientific community lags in comprehensively validating these claims (Van Dam et al., 2018a). Despite these techniques' ancient origins in religious practices (i.e., Buddhism) and use in clinical psychology settings, this is an emergent field of scientific inquiry in a nascent state (Dane, 2011; Harrington & Dunne, 2015; Van Dam et al., 2018b). This has resulted in calls from the science community to establish a comprehensive research agenda across disciplines of psychology to address the need to underpin practical prescriptions with empirically derived principles and guidelines (Davidson & Dahl, 2017; Davidson & Kaszniak, 2015; Hyland, Lee, & Mills, 2015; Van Dam et al., 2018a).

Some criticisms of the existing body of empirical research are that there is: (1) no single operational definition for mindfulness, (2) an over reliance on subjective recall measures, leaving common method bias as a concern, (3) an ill-defined nomological network, (4) a failure to control for confounds, and (5) an inability to replicate results found (Bishop et al., 2004; Dane, 2011; Rupprecht, Koole, Chaskalson, Tamdjidi, & West, 2019; Van Dam et al., 2018a). Certainly, this points to the need to understand the boundary conditions of mindfulness concepts more fully. Acknowledgement of these challenges provides opportunities to employ rigorous methods driven by theory to arrive at an informed, evidence-based practice. Further, these types of studies will assist practitioners with answering what the return-on-investment is for interventions such as mindfulness practice.

Mindfulness Definition

Globally, what is meant by the term mindfulness is largely dependent upon which theoretical perspective of mindfulness is being utilized. This fact has led to an incohesive literature base, which is further compounded by interest in the topic across disciplines. While cross-disciplinary interest provides some exciting prospects, it also presents challenges when crosstalk across disciplines is stilted. Theoretical perspectives underpinning work in mindfulness can be crudely dichotomized into those that nest neatly within eastern philosophy and those that have been adapted to fit within western philosophy.

To address the need for a cohesive definition of mindfulness, Nilsson and Kazemi (2016) conducted a thematic analysis of mindfulness definitions found in the literature base. Thirty-three different definitions were identified. Analysis of these definitions revealed four major themes: (1) awareness and attention, (2) present centeredness, (3) external events, and (4) cultivation. To bridge Eastern and Western philosophy, the authors added a fifth category: (5) ethical mindedness. Awareness and attention, while distinct concepts, are mutually dependent upon one another and as such were grouped. Awareness addresses awareness of what is taking place within the self (i.e., thoughts, emotions, sensations). Whereas, attention addresses how one pays attention in a receptive, focused, and de-automatized pattern of cognitive thought activity. Present centeredness involves present moment awareness. External events deal with the stimuli occurring outside of the body such as events or objects that effect mind-body function. Cultivation addresses the development of individual character through mindfulness. Ethical mindedness positions the concept of mindfulness as being a fundamentally social concept whereby one is responsible for making positive contributions to the world. The authors provide the following definition of mindfulness: "a particular type of social practice that leads the practitioner to an ethically minded awareness, intentionally situated in the here and now" (p. 190). The first three definitional components address what one does and how they do it during mindfulness practice. The last two definitional components address the why behind engaging in mindfulness activities. However, the why behind engaging in mindfulness is dependent upon the intention of the individual or sponsoring organization engaging in the mindfulness activity. For example, in the context of the present study the intention behind engaging in mindfulness practices is to foster better learning of course materials, in this case, cultivation of character is a nice to have and the ethics attached to electrical circuitry knowledge and skills is likely irrelevant. Further, while this definition does contain the five elements forwarded, it puts mindfulness only as a practice overlooking other important conceptualizations. Good et al. (2016) conducted a review of the mindfulness literature to understand the effects in the workplace. Results of this review revealed that the term "mindfulness" has been used to refer to trait mindfulness, state mindfulness, mindfulness practices, and mindfulness interventions. Leyland, Rowse, and Emerson (2019) add a fifth concept of mindfulness induction to this list. While all of these uses are valid, the use of the umbrella term "mindfulness" is not recommended for facilitating a coherent scientific and technical base to advance understanding. Rather, specificity of which conceptualizations are under consideration in any given study is imperative. In alignment with this recommendation, Table 1 depicts the current conceptualization to facilitate ease of selection of terminology.

Table 1. *Mindfulness conceptualizations.*

Mindfulness Concept	Definition	Citation
Trait mindfulness	- Individual predisposition to engage in receptive attention to and awareness of present events and experiences or the average/baseline level of a person's mindfulness absent a mindfulness practice or intervention	Brown, Ryan, & Creswell (2007)
State mindfulness	- State of experiential processing focused on attention to internal and/or external stimulus to register the facts observed in the present moment	Good et al. (2016)

Mindfulness Concept	Definition	Citation
Mindfulness practice	- Actively practicing contemplative meditation activities such as focused attention or monitoring of sensory stimuli to achieve a state of mindfulness	Good et al. (2016)
Mindfulness induction	- A one time practice that is novel to a participant, that may be a part of a mindfulness intervention	Leyland et al. (2019)
Mindfulness intervention	- An organizational intervention such as a lecture, discussion, or policy/procedure designed with a specific organizational outcome (e.g., wellness, enhanced decision making)	Good et al. (2016)

Addressing Methodological Shortfalls in Testing Mindfulness Concepts

Systematic reviews of the methodological quality of the clinical and work psychology mindfulness literature base identify some significant shortfalls with only modest improvements over the last 17 years (Goldberg, Tucker, Greene, Simpson, Kearney, & Davidson, 2017; Jamieson & Tuckey, 2017). Needed methodological improvements noted are: (1) active control conditions, (2) larger sample sizes, (3) longitudinal studies, (4) treatment fidelity assessment, and (5) reporting of instructors/instruction certification/validation, and (6) a failure to conduct manipulation checks. Indeed, these shortfalls may be further amplified by an overreliance on cross-sectional methods leaving common method bias a concern and causation in the existing nomological network unanswered (Good et al., 2016). Further, a failure to replicate results has been noted. This could be a factor of testing mindfulness concepts with heterogeneous populations inclusive of neurotypical and neurodiverse participants, which may result in differential presentation of the constructs in alignment with the nuances of each population (Leyland et al., 2019). All told, these shortcomings present opportunities for growth and the many methodological deficiencies noted are easily remedied (e.g., conducting a power analysis can assist with identifying the right sample size to adequately test a concept in any given study).

Recently, there have been efforts across both the clinical and work psychology disciplines to provide frameworks to organize existing research and define points of departure for future research (Good et al., 2016; Van Dam et al., 2018a). These frameworks were integrated in Table 2 where there was convergence, with the addition of a category where one should naturally exist (i.e., attitudes). Additionally, Table 2 includes existing measures that were culled from tests of mindfulness concepts in the literature demonstrating that researchers are spanning beyond the surveys used in cross-sectional studies. Two superordinate categories of human functioning and human performance arise. The human functioning category includes: cognitive, emotional, behavioral, and physiological lines of inquiry. The human performance category includes: social/interpersonal relationships, task performance, well-being, attitudes, and attention.

The categories are in no way mutually exclusive and thus fail to meet the criteria for a true taxonomy. Rather it is intended to serve as an organizing framework around which to collaborate across disciplines to address mindfulness concepts. The proposed list of associated measures is not exhaustive. However, the measures are a point of departure to design studies to test antecedents, correlates, and proximal/distal outcomes. In this vein, such an organizing framework lends itself to development of testable theories of mindfulness, where few exist. Further, through rigorous methodologies, and understanding of mechanisms that may have substantial pay off one could engage in experimental design to rapidly define a research agenda.

Table 2. *Mindfulness categories and potential measures.*

Categories of Mindfulness Inquiry	Potential Measures	Citations
Human Functioning		
Cognitive	- Cognitive capacity - Cognitive flexibility	Good et al. (2016); Van Dam et al. (2018a)
Emotional	- Reactivity - Valence	Good et al. (2016); Van Dam et al. (2018a)
Behavioral	- Self-regulation - Reduced automaticity	Good et al. (2016); Van Dam et al. (2018a)
Physiological	- Neural plasticity - Cortisol levels - Brain response - Heart rate - Respiration	Good et al., (2016); Van Dam et al. (2018a)
Human Performance		
Social/interpersonal relationships	- 360 Degree feedback reports - Communications - Quality of interactions - Conflict management - Empathy/compassion - Leadership - Team performance	Good et al. (2016); Van Dam et al. (2018a)
Task performance	- Productivity - Job/task - Safety	Good et al. (2016); Van Dam et al. (2018a)
Well-being	- Psychological	Good et al. (2016); Van Dam et al. (2018a)
Attitudes	- Job satisfaction - Organizational citizenship behaviors - Deviance	Walwanis & Bryan (2018)
Attention	- Stability - Control - Efficiency	Good et al. (2016); Van Dam et al. (2018a)

Theoretical Mechanisms of Mindfulness

Four primary mechanisms of mindfulness are captured across seven theories, models, and frameworks of mindfulness (see Table 3). First and foremost, mindfulness is a form of metacognition whereby one controls the manner in which information is perceived (Bishop et al., 2004; Jankowski & Holas, 2014; Langer, 2014; Shapiro et al., 2006). Mechanisms underlying metacognition include de-automatization of information processing and inhibition of extraneous information processing. Second, metacognitive skill enables the mechanism of attention (Bishop et al., 2004; Dane, 2011; Good et al., 2016). Mindfulness attention is characterized as non-judgmentally sustaining wide attentional breadth, both, internally and externally to the self. Third, mindfulness metacognitive skill and attention enables enhanced self-regulatory response (Bishop et al., 2004; Glomb, Duffy, Bono, & Yang, 2011; Shapiro et al., 2006; Jankowski & Holas, 2014). Intentional attention enables enhanced self-regulatory response of affect, physiology, and behavior. Fourth, the mechanisms of metacognition, attention, and self-regulation enable the mechanism of cognitive flexibility (Bishop et al., 2004; Glomb et al., 2011; Shapiro et al., 2006; Langer, 2014; Jankowski & Holas, 2014). Cognitive flexibility enables the generation of novel categories of information, reperceiving existing categories, and flexible cognitive, behavioral, and emotional response. Jankowski and Holas' (2014) metacognitive model of mindfulness addresses these mechanisms drawing upon empirical evidence to support the propositions forwarded.

Table 3. *Mechanisms of mindfulness captured across frameworks, models, and theories.*

Theorized Mindfulness Mechanisms	**Citation**
Self-regulation of attention – Sustaining attention – Switching-flexibility of attention – Experiencing events directly – Monitoring and inhibiting secondary elaborative processing through metacognitive skills *Orientation to experience* – Curiosity – Acceptance of present experience – Investigation of thoughts and feelings	Bishop et al. (2004)
Attentional breadth – Wide external attentional breadth (e.g., stimuli, data, materials) – Wide internal attentional breadth (e.g., thoughts, beliefs, emotions)	Dane (2011)
Core Processes – Decoupling of self from experiences, events, and mental processes – Decreasing use of automatic mental processes – Increasing awareness of physiological regulation *Secondary Processes* – Responding flexibly – Decreasing rumination – Increasing Empathy – Regulating affect – Increasing self-determination and persistence – Increasing working memory – Processing affect accurately	Glomb et al. (2011)
Primary Function – Increasing stability, control, and efficiency of attention *Secondary Functions* – Focusing cognition – Controlling emotions – Controlling behaviors – Controlling physiological responses	Good et al. (2016)

Theorized Mindfulness Mechanisms	Citation
Meta-mechanism – Reperceiving – meta-perspective shift to non-judgmental observation of objects *Sub-mechanisms* – Self-regulating – intentional attention connecting an individual to an experience enhancing self-regulatory response – Clarifying values – identification of what is meaningful and valued enabling reflective choice – Flexibly adapting cognitive, emotional, and behavioral responses – Exposing – experiencing emotions objectively with less reactivity	Shapiro et al. (2006)
– Creating new categories – recategorizing, labeling, and relabeling objects after paying careful attention to the situation and context to arrive at precise distinctions – Welcoming new information – actively attending to changing signals in the environment for a broader, more differentiated information base – Taking more than one point of view – openness to different points of view or perspective on an object, actor, or situation enlarging possible behavioral responses and enabling change – Controlling context – reappraisal of contextual factors – Engaging in process before outcome – orientation and awareness of the process of engaging in making choices – De-automatizing – old categories broken down and rigid distinctions relinquished	Langer (2014)
– Monitoring attention – Accepting momentary experiences non-reactively	Lindsay & Creswell, 2017
Metacognition – Monitoring explicitly – Experiencing a decentered attitude of acceptance – Metacognitive knowledge of mindfulness – Utilizing metacognitive skills to maintain alertness, attention, and inhibit cognitive interference	Jankowski & Holas (2014); Shute, 2018

Metacognitive Model of Mindfulness

Jankowski and Holas (2014) forwarded the metacognitive model of mindfulness based upon current cognitive theory and empirical findings arising from neurocognitive science concerning the operation of mindfulness. The premise of the model is that mindfulness is a dynamic, self-regulatory, metacognitive process, that utilizes mindfulness knowledge and skills to drive how objects or qualia are observed, be these perceptions of internal thoughts or emotions, or activities taking place in the external environment. This model posits that a mindfulness state is the product of metacognitive processes. The model contains three tiers: the meta-meta level, which contains mindfulness awareness, knowledge, and skill; the meta-level which encompasses metacognitive experiences, knowledge, and skills; and the object level, which contains cues. Shute (2018) parenthetically noted the purpose of each level as mindfulness, metacognition, and basic experiences to ease understanding in a refined model. To ease understanding, the levels are referred to by the purpose for which they were designed throughout this section (e.g., the meta-meta level is referred to as the mindfulness level).

Shute (2018) refined the model with the intention of studying mindfulness as it relates to child and adolescent development. The changes have applicability to the study of mindfulness in adults. Shute's changes capture properties of developmental, dynamic systems, and mind theories. These theories forward the propositions that cognition and perception are enactive, or dependent upon the activity of the individual (embodiment) and the individual's interactions with the environment (embedded). Shute proposed that embodiment is a property almost exclusively at the object level with some influence at the metacognitive, and tangentially at the mindfulness level through observation of embodied aspects of the mind.

The model represented here, departs from this position on embodiment, drawing upon Lyddy and Good's (2017) inductive model of mindfulness. This model posits that workers transition between a state of mindfulness (a state of being or disentanglement) and state of unmindfulness (a state of doing or entanglement). These transitions were reported as resulting from situation (embedded) and individual (embodied) factors providing evidence for mindfulness being embodied in an adult population. While Shute's position points toward an ideal state of mindfulness, this meta-metacognitive process takes place within an open system-of-systems with permeable boundaries subject to the influence of cognition as resident in the brain and the body and, as such, is influenced by both. See Figure 2 for a graphic representation of the model (Jankowski & Holas, 2014; Shute, 2018). The resulting model is a multi-tiered model of metacognition with the highest level being represented as mindfulness, which is both influenced by and influences the lower levels of metacognition and object ultimately affecting behavioral interactions within an environmental context.

The model begins with a feed in of stimuli into the object level (Shute, 2018). Stimuli can arise from either sources internal to the individual or external from the embedded context within which the individual is enactive. Behavior is a direct source of stimuli and interacts with the social and non-social world. The social world represents the human created context in which the cognizer is operating, whereas, the non-social world represents the physical environment. Both the social and non-social world serve as stimuli.

The object level contains perceptions or qualia of which one is aware. These include perceptions, sensations, emotions, thoughts, and images. Cues from the objective level are implicitly or explicitly monitored at the metacognitive level where they are a feed into metacognitive experiences. Object cues are also explicitly monitored by the mindfulness level. Cues at this level are a feed into meta-awareness or experience.

The meta-level includes the three primary components of metacognitive knowledge, metacognitive experience, and metacognitive skills. Within the metacognitive level, metacognitive experiences are interpreted through metacognitive knowledge which triggers the use of metacognitive skills. Alternatively, a metacognitive experience can directly trigger the use of metacognitive skills (e.g., alertness, attention, inhibition). Metacognitive skill then exerts control over objects. Metacognitive experiences are explicitly monitored by the mindfulness level and feed into meta-awareness and experience at this level.

Within the mindfulness level meta-awareness encompasses mindfulness intentions, decentering, and acceptance, which fits with the agreed upon concepts in other mindfulness models. Much like the function of the meta-level, this either triggers meta-cognitive knowledge, which in this case is exclusive to knowledge that promotes mindfulness, or metacognitive skills. Mindfulness knowledge refers to beliefs about the relationships between subject and object. This knowledge can be used to trigger metacognitive skills. Metacognitive skills can be used to inhibit activity at the metacognitive level below (e.g., stop automatic processing) and/or enhance attentional focus and recognition at the object level (e.g., open more working memory up to observe larger number of internal or external cues). Results of this three-tiered process drive individual behavior. Based upon this model, Jankowski and Holas (2014) forward a series of hypotheses elaborating on how the model is believed to function.

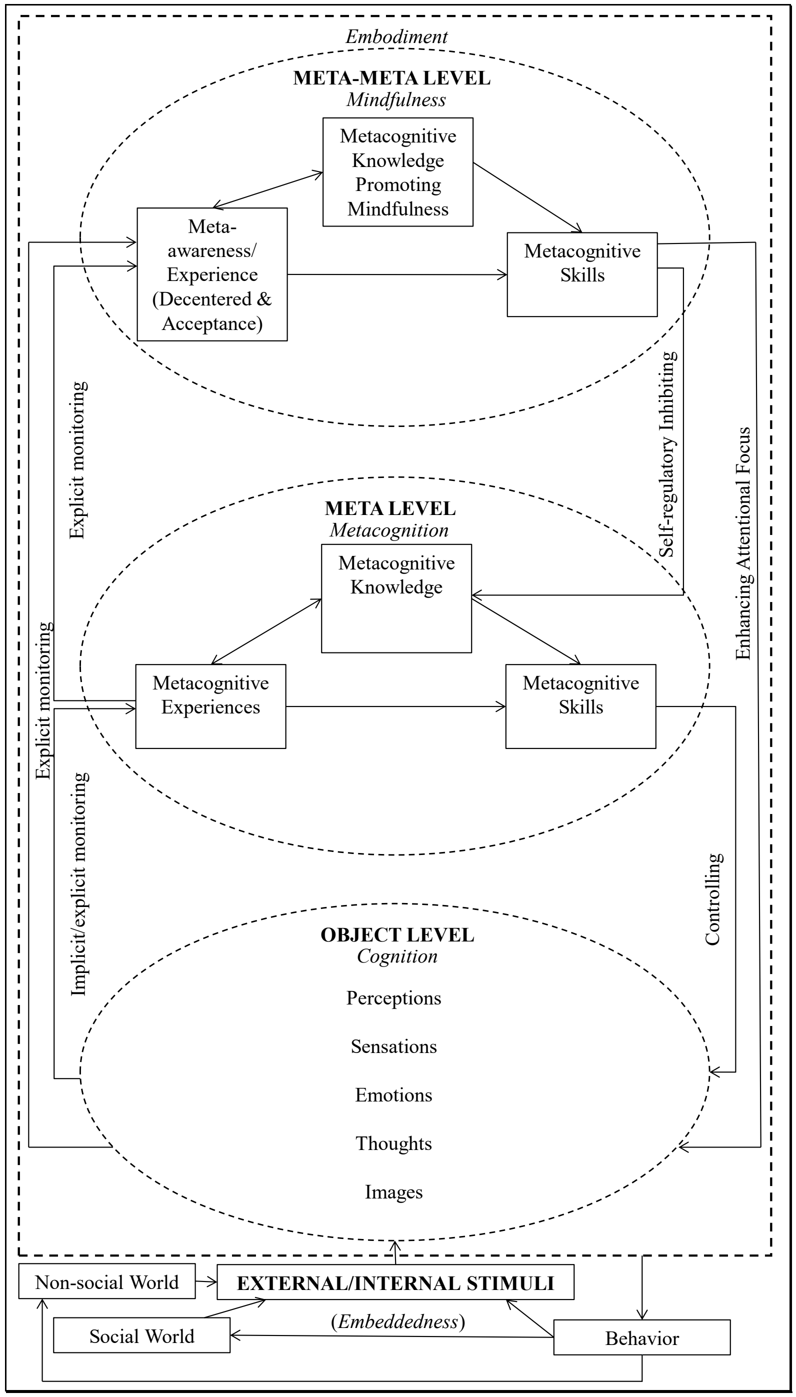

Figure 2. The metacognitive model of mindfulness adapted from Jankowski and Holas (2014) and Shute (2018).

The first hypothesis states that "Metacognitive, multilevel processing of information is inherent to a mindfulness state" (p. 68). Essentially, all levels of the model are active concurrently. The lower levels of the model become objects for the mindfulness level. That is, metacognition and object levels are monitored by the mindfulness level and thus, the mindfulness level exercises control of these levels. They forward an example where the mindfulness level is exercising control over functioning on the metacognitive level as a metacognitive process unfolds that is particularly relevant to the Guided Mindfulness framework discussed later (i.e., self-evaluations conducted under this concept are complemented by mindfulness knowledge and skills) (Griffith, Steelman, Moon, al-Qallawi, & Quraishi, 2018). Specifically, self-evaluation is cited as a metacognitive process that takes place at the metacognitive level. In this process, an individual can determine that there is a discrepancy in ability to complete a task or acquire a new skill. In this case, and individual could engage in strategizing how to make up the gap in ability or engage in maladaptive accusatory thought patterns stemming from anxiety. In a mindful state, the mindfulness level would operate on the metacognitive level to inhibit maladaptive ruminatory thought patterns to free up working memory and engage the central executive brain functions to complete the task.

The second hypothesis of the model is that the three components of the mindfulness level work dynamically with one another to maintain state mindfulness. Specifically, metacognitive knowledge promoting mindfulness, metacognitive experience, and metacognitive skill all work in cooperation with one another. Metacognitive knowledge consists of the part of long-term memory that contains information, models, and scripts specific to mindfulness. Additionally, goals and intentions of mindfulness exist in metacognitive knowledge and are hypothesized to follow generic if-then aims such as maintaining contact with the experience, staying decentered, and accepting the experience. Metacognitive experience consists of feelings and emotions related to mindfulness. From these experiences arise metacognitive insight, which is perceiving thoughts as thoughts with no emotion behind it (i.e., emotions become objects). Emotions are contextualized to a generalized self-attitude resembling self-esteem. Meta-experiences may be viewed with novelty in a state of mindfulness. Metacognitive skills related to mindfulness state are activated based upon a combination of metacognitive experience and metacognitive knowledge. Metacognitive experience is the motivational force driving which skill is necessary, whereas metacognitive knowledge serves as the executive function. Metacognitive skills include intensity, selectivity, and sustainment of attention. Additionally, metacognitive skills of inhibition and task switching are hypothesized to support cognitive flexibility. The combination of these mechanisms increases the available working memory through reduction in mind wandering, emotion, and directed attention.

The third hypothesis states that mindfulness is exclusively conscious by nature, whereas, lower level metacognition can be both implicit and explicit in nature. Research on automaticity has shown that control processes can run unconsciously underpinning this assertion. Similarly, goal activation has been shown to unconsciously driving individual behaviors in accordance with goals that were not consciously set. The implications of mindfulness as a conscious state is that an individual gains insight, or awareness, to underlying thought processes that may ultimately enhance the quality of self-regulated behaviors. Mindfulness conscious states may have the effect of enabling integration of concepts, autonomy of choice, inhibition of irrelevant or suboptimal automatic responses yielding enhanced function and greater cognitive flexibility.

For their fourth hypothesis, Jankowski and Holas (2014) hypothesize that mindfulness states reduce dissociations between the metacognitive and object levels. There are two types of dissociations that a mindfulness state may assist with: temporal and translational. First, temporal dissociation occurs when there is a lack of awareness of ongoing experiences. This is due to limited shared information processing resources operating at the object and metacognitive level. Mindfulness state exerts top down regulation of these resources, which is intended to result in better presence and present moment focus and less cognitive drift. Mindfulness state is always conscious by definition – it is a state of being aware of one's awareness and adopting a non-judgmental attitude toward ongoing experiences and mental processes. Through mindfulness states, temporal dissociations should be reduced, which results in greater internal clarity, more focused attention, and greater observation of external or internal stimuli.

Second, translational dissociations occur when noise, or extraneous information distractions from the object or metacognitive level interferes with awareness resulting in encoding information incorrectly or not at all. The reduction of dissociations arising from mindfulness practice and the resulting mindfulness state should enhance learning outcomes due to a reduction in distortions in information culled from the object level and inhibition of the metacognitive level. Mindfulness skills of inhibition and switching attention should also work in conjunction with one another to enable cognitive flexibility. These skills are utilized to reduce mind wandering thereby increasing available working memory for the task at hand. That is, automatic processing is inhibited, and mental resources are directed toward making sense of current events, which should facilitate learning.

The fifth hypothesis in the metacognitive model of mindfulness states that components of mindfulness cognition develop and change as practice progresses (Jankowski & Holas, 2016). The basis of this hypothesis is that meditation practices should follow a building block approach such that novices necessarily need to develop basic knowledge and skills early that will support advanced practice later. For example, concentration practices enable stability of attentional focus, which can reduce entanglement or falling out of a mindfulness state during later practices such as open monitoring. Further, they note that the practices of concentration and open monitoring work on different aspects of executive function. Supportive of this supposition is the longitudinal study conducted by Singer (2018).

Singer's (2018) longitudinal study explored the effects of different mindfulness practices on attitudes, physiological response, and changes to the brain over the course of a year with participants practicing for 30 minutes per day. Mindfulness practices included presence, affect, attention, and perspective taking. Each group was administered a test battery for attention, compassion, and theory of mind. Results revealed that specific practices had a significant effect on specific outcomes. For example, presence practices such as breathe awareness and body scans significantly effected attention, whereas, affect and perspective taking did not significantly effect attention but did have an effect on attitudinal measures of compassion and theory of mind, respectively. Next, physiological responses were aligned with specific practices. In the presence group, there was greater heart beat perceptions and in the affect and perspective taking groups, there was a reduction in cortisol levels. Finally, each group showed a significant thickening of grey matter in specific regions of the brain attached to each practice. Presence practices showed thickening in the pre-frontal region, perspective taking in the parietal junction, and affect in the supramarginal gyrus and insular regions. These results point to the need to carefully consider aligning practices to the intended learning outcome of education and training activities.

Mindfulness and Learning

Overall, the studies that have looked at the relationship between mindfulness and learning outcomes are positive. The studies consisted of laboratory, case, longitudinal quasi-experiments, and a meta-analysis. The studies utilized a variety of mindfulness practices (e.g., body scan, focused attention on breathing). Table 4 contains key findings from each study reviewed. Mindfulness practices of 20 minutes or less seem to be effective. Enhanced performance outcomes included better performance on memory tasks and graded quizzes. Performance appears to be significantly better in the short term with long term performance showing no significant difference between experimental and control groups in classroom settings (Calma-Birling & Gurung, 2017; Lin & Mai, 2018). The nomological network surrounding the mindfulness and learning relationship includes cognitive performance, resilience, and stress. Zenner, Herrnleben-Kurz, and Walach (2014) addressed the use of mindfulness practices in elementary, middle, and high school students. Generally, they found that mindfulness enhanced cognitive performance. However, taking conclusions from this population and applying it to an adult population should be done with caution. Development of the brain across the life span necessitates that children and adults utilize different cognitive strategies to complete tasks. This is evidenced by variations in the activation patterns across the structures of the brain when performing tasks (e.g., Dajani & Uddin, 2015).

Table 4. *Mindfulness and learning.*

Article	Study Type	Sample	Key Findings
Bonamo, Legerski, & Thomas (2015)	Laboratory	- *N* = 136 - Adults - Females	- Participants that engaged in a 20-minute mindfulness body scan intervention recalled significantly more words than participants in a 45-minute body scan or the control condition
Calma-Birling & Gurung (2017)	Longitudinal quasi-experiment	- *N* = 67 - Adults - Females and males	- Participants that engaged in a 5-minute mindfulness practice prior to a lecture obtained higher quiz scores on the lecture content
Czajkowski & Greasley (2015)	Case study	- *N* = 8 - Adults - Females and males	- Participants that engaged in an eight-week mindfulness class and 10-minute daily mindfulness practice were distinguishable from those that did not, based upon behavior and performance change

Article	Study Type	Sample	Key Findings
Lin & Mai, 2018	Longitudinal quasi-experiment	- *N* unreported - First year undergraduates	- Participants in the high-level meditation group had better short-term academic performance (formative assessment) than participants in the low-level meditation group - There was no difference between experimental and control groups for long term academic performance (summative assessment)
Zenner, Herrnleben-Kurz, & Walach (2014)	Meta-analysis	- $K = 24$ - $N = 1,348$ - Females and males - Grades 1-12	- Mindfulness practice has a significant effect on cognitive performance ($g = 0.80$), resilience ($g = 0.36$), & stress ($g = 0.39$)

Guided Mindfulness

The guided mindfulness (GM) framework is proposed as a series of intentional sensemaking activities meant to enhance learning in experiential learning environments (Griffith, Steelman, Wildman, LeNoble, & Zhou, 2017). GM is a series of self-analysis or self-inquiry sensemaking activities to scaffold learners at key points during a learning episode to facilitate encoding information (Griffith et al., 2018). These activities are posited to enhance self-regulation through learner social, self, and situation awareness, and mental rehearsal of responses to expected events. As a targeted approach, the GM framework allows for content specific to the event to be inserted into each sensemaking activity. That is, unlike generic mindfulness interventions, such as meditation to enhance attention and manage emotions through influencing physiological systems function (e.g., brain, breathe awareness, heart rate), GM is positioned to influence the function of the cognitive systems with focus on specific skills or competencies in relation to a planned experiential learning event. Like traditional mindfulness practices, the intent is to aid in unbiased reflection through awareness and attention absent judgement (Griffith et al., 2017; Griffith et al., 2018). Further, it is meant to reduce automaticity in cognitive processing because the learner knows what cues to attend to, avoiding extraneous cognitive processing (Griffith et al., 2017).

The GM framework allows for a series of four scaffolded intervention points in a learning episode: (1) event-based probing questions prior to an event, (2) mental rehearsal during event preparation, (3) guided reflection during an event, and (4) post-event reflection and decomposition (see Figure 3 for a graphic depiction). These activities are underpinned by both prospective and retrospective sensemaking processes with the intent to increase learners' cognitive flexibility and self-regulation. Each activity is meant to guide the learner to be self, situationally, and socially aware with the intent of improving self-regulation to free up cognitive bandwidth and avoid cognitive tunneling. Unlike global mindfulness practices meant to open up cognition to perception of cues absent judgement, GM is focused on building up a mental framework prior to an event or activity to free cognitive resources to focus on the task (Griffith et al., 2017).

Initial assessment activities involve engaging the learner in a series of probing questions related to the event and the individual's skills and competencies. The questions are aimed at aiding the learner in understanding the level of their skill or competency in relation to the event (i.e., self-awareness), the social environment in which the event will take place, and situational awareness. The intent is to allow the learner to understand readiness for the event, seek resources to bridge the gaps in skills necessary to perform to the extent practicable, and set performance goals. This prospective sensemaking activity should lead to a learner forming or revising a mental representation, consequently freeing up cognitive resources during an event to enable mindful observation and enhance performance.

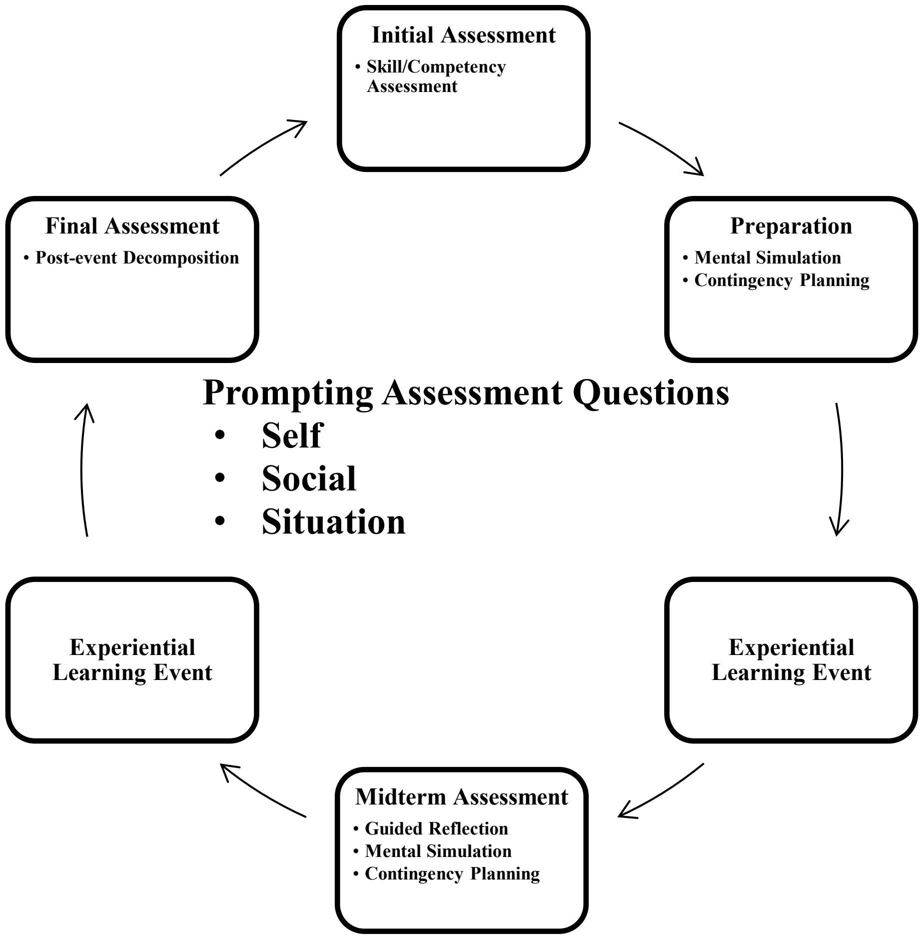

Figure 3. Guided mindfulness framework.

Next, a learner engages in a preparation phase that involves planning and mental simulation of the event. During this phase, a learner may engage in a mental rehearsal of how the event is anticipated to unfold and what behavioral responses would be most appropriate if a particular event transpires. Here, the learner is performing an if-then mental exercise that aligns with the action-interpretation cycle of sensemaking. The result of this activity is a contingency plan and a further enhanced mental representation that likely includes bracketing of expected cues and planned responses. This prospective sensemaking activity should enhance self-regulation during an event and free up cognitive resources, allowing for mindful observation during an event and robust reflection during and after an event.

The midterm assessment[1] is a review that provides the learner with an opportunity to engage in reflection on how the event is progressing, their performance, the application of skills and/or competencies to the activity, and whether the event is meeting pre-formed expectations. This retrospective sensemaking activity allows for further refinement of the mental representation. Additionally, the learner may engage in prospective sensemaking through probing questions about the rest of the learning activity or through further mental simulation and contingency planning based upon cues observed during the event. Again, both activities will aid in refinement of the mental representation. Conceivably, short duration events may not allow for conduction of a midterm assessment in favor of conducting only a final assessment.

[1] The midterm assessment is a slight departure from the Griffith et al. (2018) GM framework. The framework depicted here includes a midterm assessment, which was not included in the original work.

The final assessment[2] is comprised of a post-event reflection and decomposition of the event. The event is reviewed in terms of the initial self-assessment of skills and competencies, social awareness, and situational awareness. Lessons learned may be compiled and future learning goals set. This retrospective sensemaking activity allows for an additional cycle of mental representation change and consolidation and is meant to result in improved future performance in the same or similar circumstances.

GM as originally envisioned was meant to address in situ, on-the-job experiential learning events and specifically, interpersonal skills in cross-cultural management environments (Griffith et al., 2018). While this is an important application for the framework, its applicability spans beyond these types of learning activities and is extensible beyond interpersonal skills to other complex skill sets. For example, GM can also be considered for incorporation into a comprehensive human capital development strategy spanning an organization's training pipeline. Training activities that involve simulation or scenario-based learning are considered experiential learning activities (e.g., Laird, 1978). Most of these types of activities involve some sort of post-event reflection and may also include planning, depending upon scope. However, rarely do they include formalized event-based probing questions or guided reflection during an event. In

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[2] In Griffith et al. (2018), the final assessment period is envisioned to be an annual performance appraisal period involving 360º feedback and review of the performance trends captured as a part of GM activities throughout the review period. While this is an important developmental activity, the focus of the present study is on the individual going through a single learning event.

this learning context, sensemaking strategies may influence learning and should be considered in the pedagogy of formal training environments prior to less-structured learning activities so that the strategy is well-understood by the learner (Schwandt, 2005). The effects predicted of this approach includes improvements in a learner's self-regulation, skill acquisition, and learning as a result of enhanced attention and encoding through scaffolded sensemaking activities at key points. Based upon the embeddedness of guided mindfulness practice within the specific learning event as opposed to the general unguided nature of traditional mindfulness practices , it is hypothesized that participants will learn significantly more than the mindfulness group for overall learning and higher order learning.

Sensemaking

Sensemaking is the process of discovering, assessing, and interpreting contextual cues dynamically as events unfold in an ongoing situation (Brown et al., 2015; Weick, Sutcliffe, & Obstfeld, 2005). In this process, cues are organized to derive categories that provide meaning and can structure and guide behaviors (Brown et al., 2015). Sensemaking is not evaluative, but, rather, is a precursor to self-regulation (e.g., metacognition) and central element to determine human behaviors. The simplest representation of this process is a loop between performing an action and interpreting the implicit, explicit, and tacit cues to extract meaning from the context (Schwandt, 2005). Cues or pieces of information are distributed throughout the context and can be derived from artifacts such as the environment, technology, or culture in place (Rosness, Evjemo, Haavik, & Waero, 2016).

Cues from the context are bracketed to simplify the mental representation as it is forming or being revised. This results in labeling or categorizing, which is a stabilization of the sensemaking experience. Labels or categories have plasticity in that they are subject to change. Once meaning materializes through the sensemaking process, an individual will have expectations of how the event will unfold and will act informed by presumption. In a presumptive state, interpretations range from abstract to concrete. The presumption drives action in a situation while the actor observes changes and adjusts behaviors. Weick and colleagues (2005) describe this as “progressive approximations” (p. 412). Presumption answers the question, “what do we do now?” After each approximation, a retrospective account, or sensemaking process, can be undertaken to develop a more exact approximation than the initial model formed. Retrospection answers the question, “what’s the story?”

One area of sensemaking theory not often addressed in the empirical literature is that of prospective sensemaking (Brown et al., 2015; Rossness et al., 2016). Prospective sensemaking is a proactive response to non-events, when ambiguity and uncertainty are not necessarily involved, but cues are being gathered ahead of an event and brackets are being created. That is, plausible explanations for what may be expected in an environment are considered and contingency plans or potential courses of action are devised. Specifically, this type of a priori thought may be preservative, if not enhancing, of performance in the face of dilemmas in that cognitive resources that would be devoted to making sense of the dilemma retrospectively to formulate a response may be conserved, thereby enabling a swift response. Prospective sensemaking, much like retrospective sensemaking, relies upon experience, working with other people and systems to name a few cue sources.

Sensemaking is not a solitary act, but one that is social in that it involves extraction of cues from other humans or artifacts left in place by humans such as systems, instructions, or procedures (Weick et al., 2005). As such, sensemaking can follow the same iterative process of developing models as stated above but follows a looping action and talk process. In this process, situations, events, or organizations are discussed and actively encoded as symbolic representations. Then, plans are formulated to address the situation. The more salient the information and the better coordination across the system, the better the product of sensemaking.

Adaptive tutoring systems are human-created artifacts meant to impart learning of knowledge and skill acquisition. These systems utilize features that mimic action, interpretation, and talk sensemaking processes to facilitate learning. Students are afforded the opportunity to both perform activities during lessons and interpret the results of that act and engage in dialogues with tutoring algorithms to make sense of acquired information. The education community has been focused on detangling how sensemaking can be used to induce learning both in the classroom and adaptive training environments (e.g., Rau et al., 2017). While there is a modest amount of empirical work on sensemaking, results have begun to accumulate (Brown et al., 2015). Empirical results support the inclusion of features designed to foster sensemaking (see Table 5). These features include the provision of verbal explanations as concepts requiring connection to complex concepts are introduced (e.g., important cues); actively making comparisons to other concepts; providing assistance or feedback to students; and offering a variety of practice examples.

The constructs of sensemaking and learning are inextricably linked with some question arising in the literature as to whether the constructs are distinct (Schwandt, 2005). Attempts to disambiguate the constructs have included pointing toward the academic discipline from which each construct is most oft studied, how each is studied (i.e., laboratory, field), and the nature of each construct (e.g., learning is an individual-level construct whereas sensemaking is a team- or organization-level construct). While these attempts are indeed appreciated, the constructs cross academic disciplines (i.e., education, management, psychology) and are studied in a variety of ways. Further, both learning and sensemaking can be considered multilevel in nature starting at the individual level and moving up depending upon operational definition in use. At the individual level, learning is most often seen as a product of sensemaking. Moreover, they are exhibited in tandem with one another; that is, as an individual engages in sensemaking processes, self-regulatory adjustments in behavior are exhibited.

Self-Regulated Learning

Self-regulated learning theories all share four assumptions (Pintrich, 2000). First, learners are assumed to be active in the process of learning, constructing meaning, and goals. Second, learners possess the potential for control. Through monitoring, learners' control, or regulate, their cognition, motivation, behavior, and environment. Third, learners set goals, criterion, or standards against which cognition, motivation, behaviors, and environments are regulated. Fourth, self-regulatory activities are mediators between personal and contextual characteristics and performance outcomes. Self-regulation is posited to follow four phases of planning, monitoring, regulating self and context, and reflecting. These phases are not linear in nature and any phase can be active at any time. In alignment with these assumptions, Pintrich (2000) defined self-regulated learning as: "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features of the environment" (p. 453). Conceptually, this definition and framework has presented abundant opportunities to test many constructs attached to the assumptions and learning strategies across the phases.

Sitzman and Ely (2011) undertook reviewing the self-regulated learning literature to synthesize findings into a broad heuristics framework and conduct a meta-analysis to understand the effectiveness of constructs addressed as supporting self-regulated learning. They identified 16 constructs covered both the theoretical and empirical literature. Meta-analysis revealed intercorrelations between the constructs. Based upon their findings, they proposed the parsimonious framework for self-regulated learning to provide a manageable framework upon which to base future research and practice. The framework contains nine constructs that were found to be most related to learning outcomes. The outer band of the model contains goal level and self-efficacy to predict learning at a moderate to strong level. The inner band of the model contains weak to moderate predictors of learning, which are metacognitive strategies, attention, time management, environmental structuring, motivation, effort, and attributions.

Metacognition is a regulatory mechanism that likely serves as a mediator between the concepts of mindfulness and guided mindfulness, respectively, and learning. Self-regulated learning theory most readily explains the hypothesized nature of these relationships.

Self–regulated Learning Theory

The theory of self-regulated learning posits that self-regulation enables adaptation. That is, “self-generated thoughts, feelings, and actions that are planned and cyclically adapted” to attain personal goals (p. 14, Zimmerman, 2005). Self-regulation is proposed as a process model involving the reciprocal, interdependent interaction of three open feedback loops resident in the person, environment, and behavior. These interactions result in self-management of environmental contingencies and the application of knowledge and skills during periods of action (Schunk & Zimmerman, 2003; Zimmerman, 2005). The person-feedback loop consists of covert-regulatory processes to monitor and adjust cognitive and affective states. The behavior-feedback loop consists of observing one's own performance and making strategic adjustments to performance. The environment-feedback loop consists of observation of the environmental context and adjusting the environment to achieve outcomes. These feedback loops are continuously active during self-regulatory cycles. Performance is contingent upon consistent monitoring of the feedback loops and accurate interpretation. Mindfulness practice is likely to better enable more consistent and accurate monitoring of these loops across the self-regulatory cycle.

The cycle of self-regulation follows a three-phase process: forethought, performance or volitional control, and self-reflection (Zimmerman, 2005). Each of these phases include sub-processes or strategies to enhance performance. Mindfulness practice is likely to play a key role during each of these phases.

Forethoughts are the processes that precede performance or volitional control and are designed to plan or prepare for performance. Subprocesses underlying forethoughts include task analysis (i.e., goal setting, strategic planning) and self-motivational beliefs (i.e., self-efficacy, outcome expectations, intrinsic interest, and value). In a self-regulated state, both goals and choice of strategy need to be continuously adjusted as skills and environmental contexts evolve. Key to maintenance of self-regulated efforts are motivational beliefs; specifically, an individual must believe that she can succeed in planning for and managing performance. Mindfulness practice can facilitate planning and management of performance by focusing attention during task analysis and acknowledging any motivational beliefs that may impeded or facilitate performance without judgement (Leyman et al., 2019).

Performance or volitional control processes occur during exertion of effort and affect attention or action. Subprocesses of performance and volitional control include self-control (i.e., self-instruction, imagery, attention focusing, task strategies) and self-observation (i.e., self-recording, self-experimentation). These sub-processes are meant to focus attention and/or describe how to execute a task with the intent of improving performance. There is evidence that mindfulness induction contributes to sustained attention (Leyland et al., 2019). Mindfulness practices can explicitly call for participants to focus attention, with traditional mindfulness practice content directing attentional focus at a general level (e.g., breathe following, body scan) and guided mindfulness content addressing contextualized content to drive task performance. Successful employment of these sub-processes is dependent upon the temporal proximity of self-observations with self-feedback closer in time to the event being more effective, informativeness of the self-feedback, accuracy of the self-observation, and the valence of the behavior. Self-recording is a process involving capturing the details of an experience within close proximity of the event. This activity enables the capture of more accurate data that can be nested within meaningful structural models. This information can inform future activities showing progress towards goals and/or lead to self-experimentation to address decrements in performance. These self-regulatory processes are explanatory of the results predicted by the metacognitive model of mindfulness proposition that temporal and translational dissociations will be reduced resulting from a state of mindfulness (Jankowski & Holas, 2014). Contemplative practices are designed to facilitate self-observation in the moment without passing judgement, which should facilitate challenges attached to temporal proximity and accuracy in self-recording. Guided mindfulness is specifically designed for contextualized self-feedback throughout the process from taking stock of one's level of skill and competence to engaging in reflection after a learning event.

Self-reflection processes occur post-performance and affect responses to the performance and future self-regulatory cycles. Subprocesses of self-reflection include self-judgement (i.e., self-evaluation, causal attribution) and self-reaction (i.e., self-satisfaction, affect, adaptive-defensive). Self-judgement is an evaluation of personal performance that results in a causal attribution. This process is crucial in self-reflection; however, the nature of causal attributions can have either positive or negative effects on motivation and performance. Poor performance that is linked to an individual's abilities can result in a negative performance spiral; conversely, poor performance that is linked to a learning strategy over one's ability enables adaptation and is protective of self-efficacy. Self-reactions are a result of an evaluation of progress toward meeting goals (Schunk & Zimmerman, 2003). These reactions have an effect on task motivation. Self-satisfaction is an individual's affect involving level of satisfaction with performance. Positive self-satisfaction can lead individuals to adapt their learning strategy or set higher goals. Dissatisfaction can lead to defensive interference whereby the individual goes into an ego protective mode to avoid further dissatisfaction through avoidance behaviors. There is evidence to support mindfulness inductions resulting in enhanced emotion regulation reducing the demands placed on cognitive resources necessary for effective executive function necessary for performance (Leyland et al., 2019). Guided mindfulness is a learning strategy that should facilitate emotional regulation through planned adaptations prior to a learning event with the result being a reduction in the tax on cognitive resources. Traditional mindfulness practices are general in nature and not structured as a learning strategy and are less likely to be as effective in reducing the demands on cognitive resources attached to an experiential learning event.

Development of self-regulatory skills can be challenging, taxing both physical and mental resources (Zimmerman, 2005). Four levels of self-regulatory skills are proposed. These skills include observation of models, emulation of a model's skill with feedback to facilitate refinement, self-control in structured situations, and independent self-regulation of personal and environmental conditions to meet performance goals. While it is desirable to meet the self-regulatory skill-level, it is not expected that an individual will possess self-regulation in all situations. Additionally, dysfunctions in self-regulation related to forethought, performance control, or apathy toward the activity can hamper performance. It is posited that the social and physical environment are resources that can enhance the cyclical phases of self-regulation, inducing a proactive rather than reactive approach to performance and assisting with any dysfunction that may be present. Engaging in metacognitive activities spontaneously can be difficult for learners (Bannert & Mengelkamp, 2013) thus, mindfulness practices may facilitate these activities. Self-regulatory or metacognitive prompts are instructional support activities designed with the intent of focusing learners on thoughts and understanding of learning. Finally, cues from the environment can serve to trigger self-regulatory metacognition (Bannert & Mengelkamp, 2013). Traditional mindfulness and guided mindfulness practices delivered via applications provided in the context of learning activities may be considered as instructional support provided from the environment to facilitate self-regulatory metacognition.

Metacognitive Self-regulation

Metacognition is colloquially described as “thinking about thinking” (McCormick, 2003). While this is a simple and accurate description, it does little to provide clarity on the nature of the construct. Metacognition is conscious, purposeful thinking with the goal of regulating task achievement. It is internal feedback provided to the self (Tokuhama-Espinosa, 2014). Feedback is key to learning and metacognition enables monitoring and managing learning. McCormick (2003) dichotomizes the construct as knowledge and control over cognition. Knowledge is relatively stable and contains knowledge of self/abilities (i.e., what do I know), processes (i.e., how do I work through the task), and conditions (i.e., when and why do I employ certain strategies). Control, also described as executive control, is planning (i.e., devising a strategy), evaluating (i.e., revising the strategy), and regulating (i.e., self-assessment of progress and predicting the outcome). The concepts dovetail with the cyclic phases of self-regulation, making this construct a natural fit under self-regulation theory. However, metacognition is only considered a dimension of self-regulation as motivation is not addressed.

The result of metacognition is activation of existing knowledge or establishment of a scaffold upon which to systematically build knowledge (Bannert & Mengelkamp, 2013; Pintrich, 2000). Knowledge activated can be metacognitive knowledge, or knowledge of learning strategies, or content knowledge. Once strategies are selected, metacognitive skills are engaged to self-regulate during learning or problem-solving activities. The learning episode then results in a metacognitive experience upon which monitoring, and judgments are made. Metacognitive prompting strategies to assist with the development of a mental scaffold span the phases of self-regulation. Mindfulness practice activities are designed to prompt metacognitive self-regulation (Dorjee, 2016).

Bannert and Mengelkamp (2013) offer three design guidelines for effective metacognitive prompts. First, prompts should be integrated in instructional content. This guideline should assist learners in maximizing available working memory to learn by minimizing cognitive shifting between tasks and determining how the content and prompted strategy work in conjunction with one another (Kanfer & Ackerman, 1989). Second, the usefulness of the metacognitive strategy should be explained. This evaluation is supported by basic training principles of adult learners that state that adults need to understand why they are undertaking a training activity (Noe, 1999). Third, learners need to be provided with sufficient time to use the newly acquired metacognitive skills. The benefit of allowing time to use the skill provides the opportunity to master the skill and commit it to long-term memory. The guided mindfulness framework meets the design guidelines through integration with the specific experiential learning event, supporting learners understanding in readiness for the experiential learning event in terms of evaluation of skills and competencies, and provides specific time periods to prepare for and reflect on the experiential learning event. Traditional mindfulness activities are not structured for learning so the degree to which any general practice meets these guidelines is questionable at best.

Metacognitive strategies may be explicitly taught (e.g., metacognitive training) or be provided implicitly within an environment with no explicit explanation (Bannert & Mengelkamp, 2013). The choice to make metacognitive support explicit or indirect is dependent upon the ability of the target training audience. The zone of proximal development should drive tool design (Ge, 2013). If the learners have a mediation deficit, extensive training is necessary as it is the case that the learners have little or no skills upon which to intuit what to do with an unexplained, embedded prompt. On the other hand, if a production deficit is present, learners possess the skills, but are not motivated to use the skills (Bannert & Mengelkamp, 2013). Metacognitive skill development begins in primary school and progresses through secondary education. Given this, adults should possess a solid foundation of metacognitive skills.

Environmental supports such as software applications designed to prompt self-regulatory strategies hold promise to aid learners in gaining self-regulatory skill and increasing learning (McCormick, 2003; Tokuhama-Espinosa, 2014). Metacognitive prompts vary in design based upon when and how often the prompt is presented, who is involved, and the structure of the prompt. Prompts can be presented during any phase of self-regulation. How often prompts are presented is dependent upon a learner's skills, with continuous prompts helping keep learners engaged early in the learning process with gradual fading as skills develop (Bannert & Mengelkamp, 2013). Habituated reflection is an umbrella term for self-questioning strategies that span the self-regulatory phases (e.g., Tokuhama-Espinosa, 2014). Questions vary along a continuum in terms of complexity and specificity with general learning-heuristic questions anchoring one end and detailed question-prompts requiring substantial elaboration and justification anchoring the other end (e.g., Bannert & Mengelkamp, 2013; Cuevas, 2004; Ge, 2013). The nature of guided mindfulness explicitly supports habituated reflection through guided reflection questions to foster participants development of mental models situated in the learning context.

Empirical findings concerning the efficacy of different habituated reflection strategies used at varying phases of self-regulation on learning are generally positive but mixed (see Table 5). Evidence supports that reflection prompts result in better performance, problem solutions, increased metacognitive activity, and transfer of learning. Findings concerning habituated reflection involving detailed elaboration-questions embedded within instructions findings were conflicted in the case of Cuevas (2004) and Bannert and Mengelkamp (2013). Two out of the four studies reported in Table 6 found positive transfer of learning; none of the studies found improvements to content-learning. Metacognitive planning prompts appear to have a positive effect on metacognitive activity and the performance of students. Given these findings, it is likely that guided mindfulness will have a positive effect on trainees in the task of learning through both planning and reflection activities by building an initial mental scaffolding upon which to assist with learning and refinement.

Table 5. *Empirical evidence regarding metacognition and learning.*

Article	Study Type	Sample	Key Findings
Cuevas (2004)	Laboratory	- *N* = 51 - Undergraduates	- No effect of metacognitive self-regulation on post-training performance in a study on elaboration queries
Bannert & Mengelkamp (2013)	Laboratory	- Study 1: *N* = 48 - Study 2: *N* = 40 - Study 3: *N* = 40 - Undergraduates	- Reflection prompts to provide rational for choices embedded in instruction resulted in significantly more metacognitive activities during training and greater transfer of learning - Metacognitive prompts prior to, during, and after training resulted in significantly more metacognitive activities but did not affect learning or transfer performance - Detailed reflection prompts presented during training resulted in significantly greater transfer

Article	Study Type	Sample	Key Findings
Donker, de Boer, Kostons, van Ewijk, & van der Werf (2014)	Meta-analysis	- *K* = 58 - Primary and secondary school students	- Metacognitive planning and metacognitive knowledge (aka, reflection) learning strategies were significantly related to student performance regardless of student background characteristics
Follmer & Sperling (2016)	Cross-sectional	- *N* = 117 - Undergraduates	- Metacognition is a mediator between executive function and self-regulated learning
Ge, Planas, & Er (2010)	Laboratory	- *N* = 75 - Undergraduates	- Students asked to reflect and revise solutions significantly improved performance
Kauffman, Ge, Xie, & Chen (2008)	Laboratory	- *N* = 54 - Undergraduates	- Students that received prompts to guide them through problem solving processes had significantly better problem-solving performance and answer clarity

Article	Study Type	Sample	Key Findings
Ohtani & Hisaka (2018)	Meta-analysis	- K = 149	- Metacognition predicted academic performance after controlling for intelligence - Survey-based measures have a moderate relationship between metacognition and academic performance - Specific academic performance tasks evidenced a stronger relationship with metacognition than broad performance tasks

Empirical findings concerning metacognition provide evidence that metacognition mediates the relationship between executive function and self-regulated learning (Follmer & Sperling, 2016). Both mindfulness and guided mindfulness operate on executive function and thus should have a positive relationship with metacognition. Moreover, metacognition should mediate the relationship with learning performance. A recent meta-analysis provides evidence of the linkage between metacognition and academic performance (Ohtani & Hisaka, 2018). Specifically, metacognition is predictive of academic success when controlling for intelligence. This effect may be the result of cognitive flexibility enabled using metacognitive skills.

Cognitive Flexibility Theory

Cognitive flexibility theory (CFT) was developed as a means of informing the development of learning technologies to foster a change in individuals' habits of thought to be more flexible in complex, ill-structured learning environments (Spiro, Collins, Thota, & Feltovich, 2003). The theory serves as a meta-theory bridging the relationship between educational constructivist theory of learning and cognitive psychology schema theories and enhancing the shortfalls in each (e.g., Purichia, 2004; Spiro et al., 2003). Schema theories did not address the need for flexibility of thought and re-assembly of schemas in novel contexts (i.e., it is impossible to have a schema for every conceivable situation). Irregularity in contexts necessitates variability in the way that knowledge and skills need to be applied.

There are four overarching goals of CFT (Spiro et al., 2003). First, CFT is meant to assist in learning complex content central to success. This learning is accomplished through accelerating the acquisition of expertise via presentation of multiple cases from different perceptual vantage points. Second, knowledge and skill in thinking is developed to be flexibly used in practical contexts (Spiro, Feltovich, Jacobson, & Coulson, 1991). The objective of this development is the far transfer of knowledge in novel circumstances or contexts; Spiro et al. (2003) characterize this as "schemas of the moment" (p. 5). Third, CFT is meant to adjust thought processes or epistemologies when acquiring knowledge and skills to overcome oversimplification or reductive biases that interfere with accuracy in learning and impedes learning downstream (Spiro et al., 1991; Spiro, Feltovich, & Coulson, 1996). This process requires an open mind to perceive interconnections and the acquisition of nuanced understanding of concepts. Mindfulness practices may facilitate a deeper understanding and making interconnections. Fourth, the study of CFT is meant to inform the functional features of technologies that support development of cognitive flexibility for the most difficult knowledge and skill to acquire. The technology should include building blocks for knowledge and skill assembly. Examples of features designed to accomplish this goal are active participation of learners, faded control of the instructional algorithms or human teacher as learning progresses, and customization by the learner of the environment (Spiro et al., 1991).

CFT forwards seven propositions for learning in complex and/or ill-structured learning environments with the intent of learners mastering complex content and adaptively assembling schema or cognitive sets (Spiro et al., 1988). As originally conceived, the theory was designed for implementation and testing in adaptive training systems. However, the theory acknowledges the importance of active learners in the acquisition of knowledge and skills. Indeed, the learner is ultimately responsible for demonstrating competence in the task environment (Purichia, 2004).

CFT evolved from studies addressing the epistemology of learners dealing with complex and ill-structured concepts. Spiro et al., 1996 propose that an individual's epistemology allows him/her to be flexible in knowledge and skill acquisition and application. Two epistemologies arose from this work the (1) reductive world view and (2) expansive/flexible world view. These bipolar worldviews are subdivided into seven facets as identified in Table 6 below. Both world views can be functional depending upon the characteristics of the learning situation. Individuals with a reductive world view learn better in highly structured training environments with well-defined concepts. Further, individuals who hold a reductive world view are subject to reductive biases that impede learning in less structured more complex and uncertain environments. Conversely, individuals with an expansive/flexible world view perform better in complex, ill-structured environments.

Table 6. *Bipolar world view facets from cognitive flexibility theory.*

Reductive World View	**Expansive/Flexible World View**
- Encompassing single conceptual representation	- Multiple partial representations
- Analytic decomposition	- Synthetic integration and interconnectedness
- Orderliness and theological homogeneity	- Disorderliness and heterogeneity
- Preference for simplicity and intolerance for ambiguity	- Preference for complexity and tolerance for ambiguity
- Rigid prescriptions from memory	- Flexible, situation-adaptive assembly of knowledge
- Ideas lacking experiential tone	- Ideas having experiential tone
- Passive reception, adherence to authority, extrinsic motivation	- Active learning, self-reliance, and intrinsic motivation

Holding a reductive world-view results in biases observed in learners that the theory seeks to overcome. First, learners oversimplify complex knowledge sets, attending to unimportant characteristics to organize or link concepts. Second, rigidity in cognitive sets is observed with learners utilizing previously learned content models as organizational schemes, often overlooking important features of the new concepts. Third, learners may be over reliant on generalized, theoretical models to the exclusion of relevant details of the case. Fourth, learners may fail to factor in the context in which the concept is being utilized, treating all contexts as uniform in nature. Fifth, learners may over-rely on knowledge structures provided to them and use the structures inappropriately in different contexts or cases. Sixth, learners may develop false taxonomies of knowledge assuming mutual exclusivity of knowledge components where such an assumption is inappropriate. Finally, learners may passively accept knowledge transmitted by an authoritative source absent active attempts to refine or develop cognitive sets further. While an individual may hold a predisposition toward one world view, it is likely that one can shift toward the other as the situation dictates, which the propositions of CFT seek to enable through careful curriculum structuring.

The first proposition of CFT states to avoid oversimplifying complex content by demonstrating the complex nature of the content, component interactions, and combinatory patterns of the underlying concepts. The benefit of this is to allow for a more fluid assembly of knowledge when faced with a complex situation due to depth of understanding. Next, the theory posits that cognitive flexibility is enabled through learning multiple representations of a concept across a wide variety of cases. This enhances the likelihood of selecting a correct response when faced with uncertain circumstances. Multiple representations can be achieved through presentation of integrated multiple analogies to highlight the complexity of the concepts underpinning the content. Another approach is to review the conceptual landscape from multiple directions and/or present it in novel contexts.

Spiro et al. (1988) posit that general theoretical guidelines are difficult to follow in ill-defined contexts. Rather, it is of central importance to understand that, while theory may serve as a guide, reasoning through future cases is most likely to be influenced by practical experience. Indeed, this is related to the multiple representations with the added emphasis of hands-on application of knowledge and skills. Relatedly, the next proposition states that the meaning of knowledge is derived from its use in practice. That is, activation of a knowledge set cannot be prescribed from a consistent pattern of cues. Ideally, reoccurring themes or patterns across past observations of cues should be utilized to infer the appropriate application of knowledge and skills.

The next proposition builds upon these propositions to state that interconnections between cases or concepts must be made to form flexible and adaptive schemas. Making interconnections between concepts salient enables the establishment of alternative pathways when faced with complexity. This saliency can be accomplished by breaking concepts down into segments enabling multiple-conceptual encoding. This is further facilitated by gaining experience in controlled settings such as an adaptive training system. The overall benefit of this approach is to forestall the development of cognitive sets contrived of misconceptions by presenting correct representations and the associated multiple interconnections.

Finally, Spiro et al. (1988) posit that active participation is imperative to cognitive flexibility. First, learners must be active in the process to dispel any lack of understanding. Second, any systems involved in the learning process should be structured to support developing cognitive flexibility of the concepts being taught. That is, the system should be structured to support understanding of multiple representations and interconnectedness. Finally, any instructors, mentors, or coaches involved in facilitating understanding in complex concepts should be armed with appropriate strategies to diagnose student deficiencies and prescribe resources to overcome learning shortfalls.

Departure from Cognitive Flexibility Theory

Spiro et al. (2003) note that CFT is not always applied or tested as originally conceived. Cognitive flexibility is of interest to many academic disciplines such as psychology (e.g., clinical, education, experimental, industrial/organizational, neurocognitive), management, and communications. The variety of academic disciplines has driven diversity in treatment of the construct and follow-on models. While these departures do make it difficult to come to consensus on many aspects of the construct, they are useful in painting a broad picture of the mechanisms that likely underpin cognitive flexibility.

Departures from the original theory typically adopt an operational definition stemming from the original theory that is vastly simplified. For example, Dajani and Uddin (2015) define cognitive flexibility as "an emergent property of efficient executive function; the ability to appropriately and efficiently adjust one's behavior according to a changing environment" (p. 579). They further break this definition down into the executive functions of the brain involved in cognitive flexibility. First, in salience detection, the salience of a cue determines if attention is captured. Second, attention is either goal-directed, involving top-down processing, or bottom-up directed in response to cues in the environment. Third, in response to an update in the necessary actions or goals to achieve success, inhibition of a learned response occurs. Fourth, cognitive flexibility requires two or greater representations in working memory for successful task completion. Further, certain operationalizations of cognitive flexibility are more difficult and place greater demand on working memory (e.g., task switching).

Maddox, Baldwin, and Markman (2006) take a similar simplified approach to defining cognitive flexibility. In their view, cognitive flexibility is an individual's skill or willingness to utilize a variety of strategies to achieve an objective or goal. They subdivide the construct into three factors in their model.

First, cognitive flexibility is characterized by the ability to adapt to change. Second, cognitive flexibility is the ability to think of a variety of categories or concepts (e.g., cognitive sets). Third, they depart from the original theory by adding that cognitive flexibility is enabled by individual self-efficacy in being flexible and adaptive (Martin & Rubin, 1995). Self-efficacy has a long history of being linked to individual's learning, making it a positive addition to understanding learner engagement and willingness to be flexible.

Cognitive Flexibility Operationalizations

The construct has been treated as both a trait and a state construct absent explicit acknowledgement supporting that fact. Spiro et al. (2003) proposed the need to be determined if training could facilitate gaining skill in cognitive flexibility as both a state and a trait construct. Additionally, they propose that the effects of shifts in epistemic views on learning following a training intervention is a key question (Spiro et al., 1996). Similarly, Dajani and Uddin (2015) propose that scientific inquiry should address if training inventions can alleviate cognitive inflexibility and ruminative thought patterns in neurodivergent populations; indeed, this is a question just as applicable to neurotypical populations. Finally, studies that have attempted to administer a comprehensive cognitive flexibility test battery have failed to find significant correlations between state and trait operationalizations of cognitive flexibility (e.g., Johnco, Wuthrich, & Rapee, 2014; Tchanturia et al., 2004).

Existing operationalizations of cognitive flexibility can be crudely grouped as attitudinal or behavioral in nature. First, attitudinal self-report instruments are expressed at a trait level wherein lies a lack of consistency in self-report measures with variations existing due to practical applications (e.g., decision-making, communications). Next, behavioral operationalizations are expressed as a state. Generally, CF has been studied as a skill to set shift, task shift, categorize items in novel ways, flexibly form cognitive representations, and flexibly use language (Ionescu, 2012). Only set and task-shifting will be covered here due the importance to the current study. Set shifting is an attentional shift in the schema to different features or cues to complete the same instruction successfully. Task-switching is a switch between tasks with different instructions for successful completion. There is a differential effect on switch-costs, or the slowing in response time and decrease in accuracy, between task and set shift operationalizations, with task shift representing the most difficult form of cognitive flexibility. Despite these nuances in operationalizations, findings have begun to accumulate on this construct as it relates to this study, as described below.

Cognitive Flexibility and Learning

Findings regarding the relationship between learning and cognitive flexibility are mixed. Table 9 documents the key findings exploring this relationship across studies. Existing studies use a range of research designs, measures (i.e., attitudinal, behavioral), and populations (e.g., adolescents, young adults, older adults; neurodivergent). Unfortunately, the diversity in populations further confounds the ability to come to consensus regarding the relationship as the nature of cognitive flexibility changes over the course of human life peaking between the ages of 21-30 (e.g., Dajani & Uddin, 2015; Purichia, 2004). The studies explore different parts of the nomological network (e.g., learning agility, cognitive reasoning, critical thinking, intelligence quotient). Finally, the studies utilize a mix of state, trait, and state and trait measures. Behavioral measures used follow set-shifting tasks, which are a lower form of cognitive flexibility and easier to perform (Dajani & Uddin, 2015); therefore, the lack of findings may be an artifact of measurement chosen. Future efforts, such as the one proposed, should seek to use a task-switching paradigm to detect differences due to interventions (e.g., effects of mindfulness on learning through mediating mechanisms).

Table 9. *Cognitive flexibility and learning*.

Article	Study Type	Sample	Key Findings
Allen (2016)	Cross-sectional validation studies	- *N* = 149 - Males & females	- Cognitive flexibility is positively related to learning agility
Glass, Maddox, & Love (2013)	Laboratory - longitudinal	- *N* = 72 - Females - Undergraduates	- Cognitive flexibility skill was significantly improved after 40 hours of video game play - Gaming features of maintenance and rapid switching between information & action sources resulted in increased cognitive flexibility
Hauser, Iannaccone, Walitza, Brandeis, & Brem (2015)	Laboratory	- *N* = 36 - Males and females - *n* = 19 adolescents - *n* = 17 adults	- Adolescents significantly more sensitive to reward prediction errors & adapt responses quicker than adults in reinforcement learning
Johnco, Wuthrich, & Rapee (2014)	Quasi-experiment	- *N* = 44 - Older adults - Males and females	- Pretreatment measures of cognitive flexibility were significantly related to qualitative assessment of cognitive restructuring skill post-treatment

Article	Study Type	Sample	Key Findings
Maddox, Baldwin, & Markman (2006)	Laboratory	- First $N = 118$ - Second $N = 41$ - Undergraduates	- Regulatory fit between task and reward structure leads to greater cognitive flexibility - Regulatory fit leads to good performance only if cognitive flexibility is required for the task
Purichia (2004)	Cross-sectional validation study	- $N = 107$ - University faculty and undergraduates	- Cognitive flexibility is significantly related to intelligence quotient - Cognitive flexibility is significantly related to age such that older individuals exhibited more flexibility
Suryavanshi (2015)	Laboratory	- $N = 49$ - Males & females - Undergraduate	- Cognitive flexibility did not have a significant effect on learning performance

Cognitive Flexibility and Mindfulness

Existing findings concerning the relationship between mindfulness meditation and cognitive flexibility are mixed. The four studies in Table 10 all utilized set-shifting operational tests of cognitive flexibility. Three studies utilized the Stroop Task and found a significant positive relationship between mindfulness meditation practice and cognitive flexibility (Keng, Tan, Eisenlohr-Moul, & Smoski, 2017; Moore, 2013; Moore & Malnowski, 2009). Additionally, relationships were found between cognitive flexibility and flow-state and attention (Moore, 2013).

The first study utilized the Wisconsin Card Sort Task as the operational test of cognitive flexibility and found no significant relationship between mindfulness and cognitive flexibility (Herlache, 2017). As noted earlier, set-switching is a simpler task to perform and it may be the case that the Wisconsin Card Sort Task is less likely to show significant differences when used with neurotypical populations as the original test was designed for use in clinical settings.

Table 10. *Cognitive flexibility and mindfulness.*

Article	**Study Type**	**Sample**	**Key Findings**
Herlache (2017)	Laboratory	- *N* = 275 - Undergraduate - Males and females	- No significant effect of mindfulness meditation on cognitive flexibility
Keng et al., 2017	Laboratory	- *N* = 123 - Undergraduate - Males and females	- Mindfulness induction group experienced significantly less cognitive interference on a set-shifting task than emotional suppression group
Moore (2013)	Cross-sectional	- *N* = 64 - Undergraduate - Males and females	- Mindfulness and cognitive flexibility significantly predict flow state when age, gender, and history of mindfulness meditation are held constant

Article	Study Type	Sample	Key Findings
Moore & Malinowski (2009)	Cross-sectional	- *N* = 50 - Males and females - Buddhist meditators and non-meditators	- Meditators show significantly higher levels of mindfulness, attentional performance, and higher cognitive flexibility - Cognitive flexibility and performance positively related to mindfulness
Ben-Soussan, Berkovich-Ohana, Piervincenzi, Glicksohn, & Carducci, 2016	Longitudinal	- *N* = 27 - Females - Undergraduate	- Four weeks of interoceptive practice increased cognitive flexibility & ideational fluency - Cognitive flexibility positively correlated with changes in brain volume in the right cerebellum, left cerebellum, left frontal lobe

Cognitive Flexibility and Metacognition

Metacognitive theory classically subdivides metacognition into metacognitive knowledge and metacognitive regulation (Flavell, 2009). Metacognitive knowledge is subdivided into knowledge of individual strengths and weaknesses attached to learning, the nature of the task and associated processing demands, and strategies to flexibly complete the task. Based upon this knowledge, metacognitive regulation is employed to flexibly adjust control of learning.

Metacognitive regulation activities can consist of planning, managing information, monitoring and evaluation of progress towards meeting a learning goal. Metacognition is envisioned to exist at a meta level which monitors and controls an object level below where cognition takes place (Fernandez-Duque, Baird, & Posner, 2000). The results of activity at the metacognitive level are transmitted to cognitive processing and are viewable through behavioral expression. The metacognitive model of mindfulness adopts this theoretical perspective and a graphic depiction can be viewed in Figure 2 focusing on the meta level, objective level, and behavior in the external environment (Jankowski & Holas, 2014; Shute, 2018).

Fernandez-Duque et al. married the metacognitive literature with the executive control literature to map executive brain functions to proposed metacognitive functioning. The work cited for demonstrative purposes addresses progress on performance of set shifting tasks across stages of development along with psychophysiological monitoring. Performance on set shifting tasks as children aged show less latency in response and perseverative errors. Additionally, conflict monitoring is identified as an activity of the anterior cingulate and conflict resolution as an activity of the lateral prefrontal area. A more recent review of empirical work shows a linkage between metacognitive activities and the plasticity of cognitive flexibility in children performing set-shifting and task-shifting tasks in experiments (Buttelmann & Karbach, 2017). While this work is in developing children, the framework of core systems and processes modified by contemplative practices suggests that as metacognitive self-regulatory capacity so do modes of existential awareness and subsequent flexibility in adults (Dorjee, 2016). These findings and existing theory support metacognition as an antecedent to cognitive flexibility in behavior. For the purposes of this study, in alignment with metacognitive theory, the metacognitive model of mindfulness, and empirical findings metacognition is proposed to be an antecedent of cognitive flexibility in a behavioral task switching paradigm.

Current Study

By engaging learners in structured sensemaking activities of prospection and retrospection through mindfulness practices, this study aims to: 1) show how different mindfulness practices can facilitate higher order learning and 2) to test the influence of these practices on learning through the mechanisms of metacognition and cognitive flexibility (Jankowski & Holas, 2014; Spiro et al., 2003). The effectiveness of each intervention will be directly compared against each other and a control condition. The practices will be delivered through a mobile application and lesson content will be delivered through an adaptive training system. Figure 3 provides a graphic depiction of the model under test with hypotheses associated with each link and the proposed covariates.

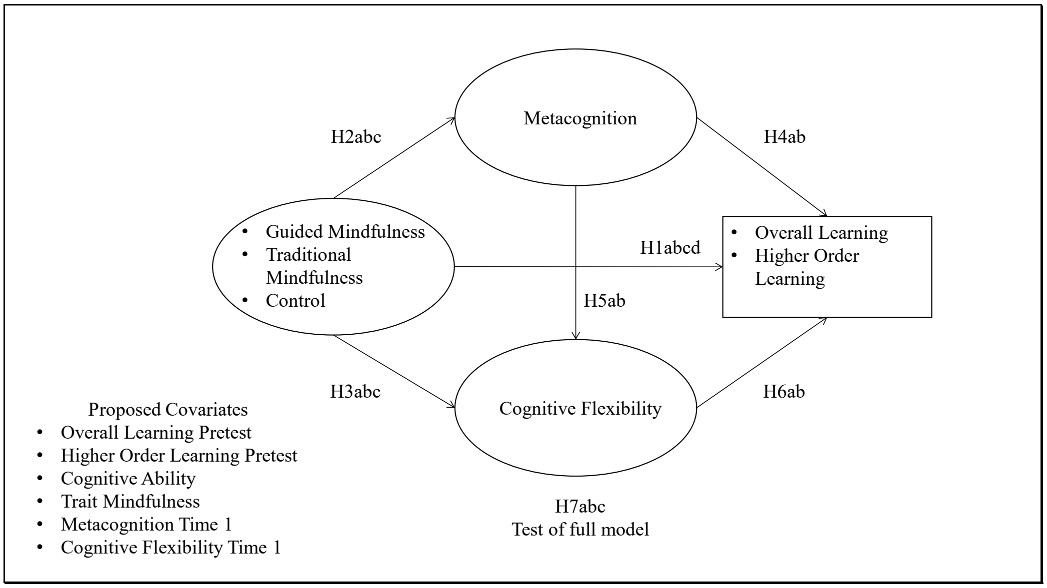

Figure 4. Model under test with associated hypotheses and proposed covariates.

Hypotheses

The first set of hypotheses test the effectiveness of guided mindfulness and traditional mindfulness practices on both overall learning and higher order learning. Overall learning is the score for the entire test spanning the entirety of the revised taxonomy of educational objectives (i.e., lower order learning and higher order learning). Higher order learning is a composite score of items extracted from the overall test, that involve applying, analyzing, evaluating, and creating cognitive processes. These two contemplative practices differ in the proposed mediating mechanisms and outcomes. Guided mindfulness meditations are embedded concentrative psychoeducational practice. Guided mindfulness involves self-inquiry to drive awareness of thoughts and the use of metacognitive skills. The proposed outcome of the practice is to generate positive perspectives and enhance behavioral responses. It is likely that through engaging in guided mindfulness introspections learners will experience less temporal and translational dissociations in alignment with the propositions of the metacognitive model of mindfulness (Jankowski & Holas, 2014). Traditional mindfulness meditations are embodied/interoceptive practices that facilitate focused attention in the present moment, noticing physiological states, and acknowledging thoughts in a non-judgmental way. The purpose is to gain focused attention. It is likely that through engaging in traditional mindfulness meditations that learners will be more focused on the present moment activity of learning, and experience less cognitive drift.

The empirical literature provides support for embodied traditional mindfulness practices enhancing learning in classroom settings (e.g., Bonamo et al., 2015; Calma-Birling & Gurung, 2017; Lin & Mai, 2018; Zenner et al., 2014). Guided mindfulness as an embedded concentrative psychoeducational practice is situated in an experiential learning context involving prospective and retrospective sensemaking activities with habituated metacognitive prompts. These sensemaking activities are proposed to enable learners to acquire complex skills (Griffith et al., 2017). Specifically, participants in the guided mindfulness condition are expected to exhibit the greatest amount of applying, analyzing, evaluating, and creating, which are higher-order learning concepts (Anderson & Krathwol, 2001; Bloom, 1956). Moreover, guided mindfulness is predicted to have the greatest effect on learning due to the practices being situated within the context the learners will be engaged. Traditional mindfulness meditation practices are also predicted to have a significant positive influence on learning but will be less impactful due to the general nature of the practices.

Hypothesis 1abcd: The guided mindfulness group will learn significantly more than either the (a) traditional mindfulness group or the (b) control group on the overall test. (c) The traditional mindfulness group will learn significantly more than the control group on the overall test. (d) The guided mindfulness group will score significantly higher on the high order learning composite test than the traditional mindfulness or control groups.

The second set of hypotheses test the relationship between the mindfulness practices and metacognition. Metacognition is conscious purposeful thinking about the goal of task achievement. It is subdivided into metacognitive knowledge and metacognitive regulation. Metacognitive knowledge is knowledge about individual strengths and weaknesses, the nature of the task, and strategies to complete the task. Metacognitive knowledge interacts reciprocally with metacognitive regulation. Metacognitive regulation involves flexible adjustment of responses through planning, monitoring, and managing task achievement. The measure used in this study addresses metacognitive regulation because it explicitly asks questions about planning, monitoring, and regulation. Mindfulness and metacognition are conceptually linked under theories of self-regulation (e.g., Pintrich, 2000; Zimmerman, 2005). Both concepts are intended to change the relationship with thoughts by exercising knowledge and control over cognition (Hussain, 2015). This is facilitated through induction of a self-regulatory state (Hussain, 2015). Self-regulation enables adaptation through monitoring feedback loops and applying knowledge and skill to achieve goals (Zimmerman, 2005). Self-regulated learning is posited to follow a three-phase process of forethought, performance or volitional control, and self-reflection (Zimmerman, 2005). Participants will follow this phased approach with two types of mindfulness interventions hypothesized to influence metacognition. The metacognitive model of mindfulness posits that mindfulness is a higher order metacognitive skill set that enables lower-level metacognitive skills to be optimized (Jankowski & Holas, 2014). Through the activity of inducing a mindfulness state, learners will be cued to observe their thought patterns. The two classes of mindfulness practice differ in focus, with embodied practices focusing on general activities such as breathe awareness and body scan and embedded practices focusing on thought awareness and focused attention on the experiential learning event. Guided mindfulness, as a concentrative psychoeducational practice focused on responding to questions that should foster better metacognitive knowledge and regulation, is hypothesized to exercise a larger positive effect on metacognition than traditional mindfulness practices. Learning activities that encourage self-assessment and a priori strategy formulation foster metacognition absent self-judgement (Bannert & Mengelkamp, 2013). Guided mindfulness is structured exactly this way so that explicit contemplative thought can systematically be paid to the event with the net result being that the learner knows what to focus on for self-feedback. The learner begins to build a mental scaffold prior to the event through a series of habituated reflection questions contextualized for the event with initial questions enabling a general self-assessment during the prospection period and more detailed questions during retrospection period to refine the mental model and adjust performance. This scaffolding should allow for less tax to be placed on working memory, allowing for easier adjustments to thought patterns (e.g., Bishop et al., 2004; Glomb et al., 2011).

Hypothesis 2abc: The guided mindfulness group will report engaging in significantly greater metacognition than either the (a) mindfulness group or the (b) control group. (c) The mindfulness group will report engaging in significantly more metacognition than the control group.

The third set of hypotheses test the effectiveness of the different contemplative practices on cognitive flexibility. Cognitive flexibility is a schema that allows for adaptive response to environmental cues. While flexibility is a subset of metacognitive regulation, this study is designed to assess behavioral response in the form of a task-switching tests Guided mindfulness, as a sensemaking intervention, is intended to enable a cognitive state of openness to recognize internal and external cues while inhibiting superfluous cognitive processing (Bishop et al., 2004; Glomb et al., 2011). This cognitive state is likely to enable greater cognitive flexibility through cue recognition. Sensemaking follows a three-phase process of prospection, action, and retrospection during which cues are labeled, categorized, and bracketed. While embodied mindfulness practices are intended to enable better cue recognition in a general sense, embedded concentrative psychoeducational practices are directed at systematic observations of contextualized cues. The systematic process followed under guided mindfulness should enable a presumptive state of what cues could be expected during training (prospection), a refinement of those cues during the training activity (action), and a more exact approximation of the cues observed after the event (retrospection). Through the process of preparing for directed cue recognition, performance should be preserved through a more cognitively flexible behavioral response. While participants in both the mindfulness and guided mindfulness conditions are predicted to demonstrate significant cognitive flexibility, the guided mindfulness group will demonstrate greater cognitive flexibility.

Hypothesis 3abc: The guided mindfulness group will demonstrate significantly more cognitive flexibility than either the (a) traditional mindfulness group or (b) control group. (c) The traditional mindfulness group will demonstrate significantly more cognitive flexibility than the control group.

The fourth set of hypotheses tests the relationship between metacognition and learning across the conditions. It is predicted that the relationship will be positively correlated in both conditions with the guided mindfulness showing a stronger effect. GM as series of sensemaking activities should enable better identification and classification of cues and thus should result in enhanced metacognition and learning outcomes. Theoretically, metacognition is considered a form of internal feedback used to support learning (Tokuhama-Espinosa, 2014). Metacognition enables the development of a mental model against which to formulate this feedback as knowledge and skills are acquired (Bannert & Mengelkamp, 2013; Pintrich, 2003). Models formed in conjunction with sensemaking prospection and retrospection should make the product of metacognition more detailed and accurate. Empirical tests of the relationship between metacognition and learning have been largely positive (Bannert & Mengelkamp, 2013; Ge et al., 2010; Kauffman et al., 2008; Ohtani & Hisaka, 2018). A test of metacognitive reflection prompts resulted in greater transfer of learning (Bannert & Mengelkamp, 2013), supporting the supposition that the relationship between metacognition and learning will be significant regardless of mindfulness group with guided mindfulness showing a greater effect.

Hypothesis 4ab: Metacognition will be significantly and positively related to overall learning in the (a) guided mindfulness and (b) traditional mindfulness conditions.

The fifth hypothesis states that there will be a positive unidirectional causal relationship between metacognition and cognitive flexibility. The basis for this assertion rests in metacognitive theory which posits that metacognitive activity rests at a meta level above an object level where cognitive processing resides (Fernandez-Duque et al., 2000). Metacognitive regulation monitors activity of the object level and subsequently regulates cognitive processing. The result of cognitive processing drives behavioral response. In the current study, metacognitive regulation is assessed through questions about planning, monitoring, and regulation, whereas, cognitive flexibility is assessed behaviorally as a test of task-switching. Given the theoretical ordering of metacognitive, cognitive, and behavioral response, metacognition is hypothesized as an antecedent to cognitive flexibility.

The proposed relationship is the nexus of sensemaking and self-regulation. Mindfulness practices enable broader observation of cues at the object level (sensemaking) through controlled thought processes (self-regulation; metacognition), which in combination enable cognitively flexible behavioral response. The relationship is expected to be stronger in the guided mindfulness group than the mindfulness group due to the nature of the practice. Guided mindfulness activities result in the development and refinement of a mental scaffold attached to a learning event. Whereas, traditional mindfulness practices engage focused attention on thoughts in a general, non-judgmental way and are not guaranteed to include thoughts on the task of learning in a structured way.

Hypothesis 5ab: Metacognition and cognitive flexibility will be significantly and positively related in the (a) guided mindfulness and (b) traditional mindfulness conditions.

The sixth set of hypotheses state that there will be a positive relationship between cognitive flexibility and learning. Spiro et al. (1996) proposed that holding an epistemological expansive/flexible world view is likely to enhance learning outcomes. Empirical evidence for the linkage between cognitive flexibility and learning is overall positive. For example, cognitive flexibility has been enhanced by training (Glass et al., 2013), has been supportive of learning outcomes (Johnco et al., 2014), and positively associated with constructs associated with enhancing learning outcomes (Allen, 2016; Maddox et al., 2006). This evidence is in alignment with theory and thus, points to a significant and positive correlation between cognitive flexibility and learning.

Hypothesis 6ab: Cognitive flexibility will be significantly and positively related to overall learning in the (a) guided mindfulness and (b) traditional mindfulness conditions.

The final set of hypotheses test the proposed mediation model (see figure 3 above). The model proposes that the contemplative practices will transmit influence on learning through metacognition and cognitive flexibility in a serial mediation model. The purposes of contemplative practices are to develop self-regulatory capacity through the mechanisms of adaptive goal-directed metacognition and attention regulation, emotion regulation, and conceptual processing with the end goal of developing better understanding of self and reality and adapting thoughts and behaviors accordingly (Dorjee, 2016). While the mechanisms work in tandem with one another to influence understanding, the development of metacognitive self-regulatory capacity enhances understanding. The intention and context of the different practices may influence the operation and development of each mechanism. In the current study, the embedded practice of guided mindfulness should most strongly influence metacognition, directing attention to the context of learning and have a weaker influence on emotional regulation and conceptual processing as tangential outcomes. Whereas, the embodied practice of traditional mindfulness meditations should have a stronger influence on emotion regulation and conceptual processing and a weaker influence on metacognition. Metacognition, measured as metacognitive regulation, will influence cognitively flexible set and task-switching behavior. In the case of guided mindfulness, the effect should be greater given the hypothesized relationship with metacognition and less in the mindfulness group. Cognitive flexibility resulting from these relationships is then proposed to influence both overall learning and higher order learning. Specifically, given the contextualization of the guided mindfulness practice with sensemaking questions and metacognitive habituated guides to consider self and the experiential learning event is likely to exert a greater influence in this causal chain and result in greater overall and higher order learning than traditional mindfulness meditations.

Hypothesis 7abc: (a) The relationship between guided mindfulness and higher order learning will be fully mediated by metacognition and cognitive flexibility. (b) The relationship between mindfulness and higher order learning will be fully mediated by metacognition and cognitive flexibility. (c) The relative indirect effects of guided mindfulness on higher order learning will be greater than the relative indirect effects of mindfulness on higher order learning.

Overall, the hypotheses test each relationship in the model arguing that the three phase processes underpinning sensemaking and self-regulation enable enhanced recognition and scaffolding of cues through improved cognition. Mindfulness interoceptive practices have been empirically shown to result in better short term learning in classroom quiz scores and word recall in comparison to standard educational practices such as class lectures (e.g., Bonamo et al., 2015; Calma-Birling & Gurung, 2017). It is likely that present moment awareness absent judgement and minimization of affective response will contribute significantly to enhanced metacognition and cognitive flexibility in the mindfulness condition. Guided mindfulness is predicted to improve upon the predicted relationship through directed sensemaking activities that are contextualized for the specific experiential learning activity. These cognitive activities should allow participants to engage in better metacognition and be more cognitively flexible in response to the task of learning. The net result should be enhanced higher order learning (*apply*, *analyze*, *evaluate*, and *create)* culminating in significantly better responses to novel problems in the guided mindfulness condition.

Chapter 2

Method

Participants

Three hundred thirty-six adults from a southeastern city in the United States of America participated in this experiment. Participants were recruited from temporary employment agencies (*n* = 267) and a Southeastern university (*n* = 62). Participation in the experiment was open to anyone over the age of 18, regardless, of age, ethnicity, gender, or national origin. Participants from the temporary employment agencies were compensated at an hourly rate set by the agency for participation; participants from the university were given an option of receiving a gift card or course credit for participation. To ensure inclusion of only naïve participants in the analysis of results, a screening form was used to identify participants prior to participation who had vocational or educational training in electricity or who worked as an apprentice, journeyman, or master electrician; additionally, regular participation in meditation practices served as a screening out factor. Data from 115 participants were excluded from analysis due to failure to complete the experiment (*n* = 74), scoring an attention check average of less than 60% (*n* = 15), or through outlier and extreme score analyses (*n* = 31) resulting in an overall *N* of 214. The split on source of participant recruitment favored the temporary agency (*n* = 163) over university participants (*n* = 51). The sample included 142 males, 69 females, 1 preferred to self-describe gender, and 2 preferred not to say gender. The rational for a larger representation of males in the sample may possibly be due to a self-selection bias with females selecting out from learning a topic in a male dominated field. Mean age for the sample was 27.38 years with a mode of 21 years of age, and a range of 18 to 65 years of age. The majority of participants did not complete college (high school n = 109; technical school n = 6; some college n = 59; associate degree n = 15; bachelor n = 13; master n = 9, doctoral n = 3). In comparison with 2018 US Census Data for educational achievement of individuals age 18-24, the sample had a higher proportion of high school graduates (51.2% v. 30%), a lower percentage of participants with some college (27% v. 37%), about the same percentage of associate degrees (7% v. 6%), a higher number of bachelor degrees (6% v. 11%), and a larger percent of graduate degrees (Master 4.2% v. 1%; Doctoral 1% v. < 1%). The likely source of difference in educational achievement is due to the large age range of participants and the sources of recruitment. Participants reported sleeping a mean of 6.69 hours the previous night with a range of 0 to 12 hours. Seventy-four participants indicated being a smoker (35%). Eighty-seven participants reported yes to consuming caffeine on the day of the experiment (41%). Participants were asked about comfort with technology on a 5-point scale ranging from very uncomfortable (1) to very comfortable (5). Mean comfort level with personal computers was 4.08 and 4.15 for comfort with software applications. Final distribution of participants across conditions was guided mindfulness (*n* = 77), traditional mindfulness (*n* = 65), and control (*n* = 72).

Power Analysis

Power analyses were conducted to determine the necessary sample size to detect mediation in linear regression. Utilizing G*Power to estimate sample size for linear multiple regression, a medium effect size of $f^2 = .25$ was used given the range of existing estimates for contemplative practice interventions existent in the literature, $\alpha = .05$, and five predictors. This yielded $N = 138$ and power of .95. Utilizing the same information with 2 df, 3 groups, and 3 covariates, G*Power was used to estimate the sample size for ANCOVA analyses. This yielded an $N = 251$ and power of .95. Based upon the achieved sample size of $N = 214$ and a modest observed effect size of .02, power expected for the planned repeated measures ANCOVA analyses is .06 and .44 for the planned hierarchical multiple regression analyses. Observed power was calculated for each hypothesis test and is reported in the results section.

Recruitment

Adults from a temporary employment agency and a small Southeastern university were recruited to participate in the study. Temporary employment agency participant recruitment was handled by the practices in place at the five agencies used to recruit participants. All participants must have obtained either a GED or high school diploma. Participants who had vocational training or education in electricity, or who have worked as an apprentice, journeyman, or master electrician were barred from participation due to the nature of the adaptive training module. The screening survey in Appendix B was used to eliminate participants from the study. The survey was administered prior to informed consent.

Participants were compensated at an hourly rate for four hours of participation. In the case of temporary agencies, participants were compensated at a rate agreed upon between each individual and the temporary agency employing them to participate in the study. In the case of students from the university, participants were either compensated with a gift card or research participation credits depending upon their preference. Participants dismissed after the pre-screen or chose to leave at any point during the experiment were compensated for their time.

Design

This study employed a one-way, between-groups, repeated measures design, with the type of contemplative practice serving as the independent variable of interest. Specifically, two practices served as the intervention: guided mindfulness and traditional mindfulness practice. The contemplative practices were delivered on a mobile learning application running on a tablet. The modules on each application took participants approximately 10 minutes to complete. The traditional mindfulness application, SHIELD, presents interoceptive contemplative practices of mindful breathing, diaphragmatic breathing, and body scan. The guided mindfulness application presents concentrative psychoeducational contemplative practices of preparation and reflection prompting and journaling. Additionally, there was an active control condition where participants learned study skills. The study skills training was delivered via a PowerPoint presentation mockup of a mobile application and took participants approximately 10 minutes to complete. Study skills topics covered included learning styles, using a study skills checklist, habits of highly effective students, and time management. Additional details for each manipulation are provided below. Participants were randomly assigned to conditions using a computer-generated algorithm.

Following each manipulation, participants underwent basic electricity knowledge and skills adaptive training designed to impart concepts such as voltage and circuits. Training content was presented through an interactive adaptive training system called Basic Electricity and Electronics Tutorial Learning Environment (BEETLE). Participants underwent one BEETLE module divided in half, which allowed for two cycles of the intervention and repeated measures of the proposed mediators to be undertaken. To investigate the impact of the interventions on the dependent variables of lower order learning (i.e., remembering and understanding questions) and higher order learning (i.e., applying, analyzing, evaluating, and creating questions), participants were given a pre-test on their knowledge and skill in electricity and then administered a post-test again at the end of the experiment.

Materials

Manipulations

Guided Mindfulness Application

The Guided Mindfulness mobile application contains two modules designed to guide participants through gaining competency in sensemaking. Participants were instructed to consider the questions within the context of electricity training prior to beginning the intervention. The first module is a preparation module (i.e., prospective sensemaking). Participants were asked six open-ended questions designed to plan for undertaking the learning activity. All answers to questions were typed. An example preparation question is “How will you identify patterns when solving a problem?” The preparation module took approximately 10 minutes to complete. The second module is the reflection module (i.e., retrospective sensemaking). Participants were asked seven open-ended questions designed to foster reflection on how they performed during the adaptive training intervention. A sample question from the reflection module is “How has your training shown that there are multiple reasons for an event?” This module also takes 10 minutes to complete. The prepare and reflect questions can be viewed in Appendix A.

Traditional Mindfulness Application

Traditional mindfulness meditation practices were delivered via the Strengthening Health and Improving Emotional Defenses (SHIELD) mobile application (version 0.9.12). This application was designed to deliver relaxation training to promote psychological flexibility (Elkin-Frankston, Wollocko, & Niehaus, 2018). Three modules designed to foster self-regulation were utilized by participants. Each module is designed to take 10 minutes to complete. The Mindfulness Meditation module provides a meditation that focuses participants on breathing patterns and observation of thought patterns. The Diaphragmatic Breathing module provides a mediation to train participants to attend to and control breathing. The Body Scan module provides a meditation to facilitate maintenance of focus while managing body pain and tightness.

Study Skills

The control condition received an automated PowerPoint presentation containing content adapted from and modeling the free Study Skills application. The Study Skills application contains advertisements, which would have served as a confound to this condition necessitating mimicking the application. Participants engaged in three modules designed to take 10 minutes each to complete. The first module is entitled Discover Your Learning Style, which contains text-based content on seven learning styles. The second module is entitled Ten Habits of Highly Effective Students, which contains ten tips on how to study outside of class. The third module is entitled Using Time Management to Improve Study Skills, which contains content on scheduling, time management skills, and tips on life management to support studying.

Training Program

Basic Electricity and Electronics Tutorial Learning Environment

The Basic Electricity & Electronics Tutorial Learning Environment (BEETLE) is an adaptive training system. The system is designed to impart knowledge and skill in content such as open and closed paths, serial and parallel circuits, voltage, and fault finding in series circuits (Steinhauser, Campbell, Moore, Dzikouska, & Perez, 2015). The system is divided into three activities, which include reading, question and answer interactions with an electronic tutor focused on answering "why" questions, and circuit simulator exercises to build and test circuit properties (Callaway et al., 2007). The primary instructional strategy utilized by the system is conceptual change whereby participants are asked about pre-conceptions, which are followed up with change conceptions reinforced through concrete evidence. Participants interact with the tutor through a message window where dialogue between the tutor and student is displayed; all participant responses are typed. There is no structured sequence of steps to follow – participants should name a correct set of objects and relationships. In the cases where the student is incorrect or partially correct, the tutor follows up with questions to elicit a more complete response. Participants underwent one BEETLE module subdivided into two parts.

Measures

Participant Pre-Experiment Questionnaire

Screen out factors from study participation included: having experience or training with electricity and having significant experience meditating. The participant pre-experiment questionnaire served as both a screening out device to determine eligibility for participation in the experiment and an initial set of demographic questions. The questionnaire contains eight items. Participants were administered the questionnaire and those not meeting the criteria for participation were thanked and dismissed from participating in the experiment. The questionnaire can be viewed in Appendix B.

Demographics Questionnaire

The demographics questionnaire consists of 15 questions. The questions cover gender, age, scores on standardized tests, and education level. Two questions cover comfort with technology. Two questions cover caffeine consumption on the day of the experiment. Two questions cover status as a smoker and quantity smoked on the day of the experiment. Two questions inquire about the amount of sleep the participant had the night prior and the average number of hours of sleep the participant typically gets per night. Finally, the participants received a series of questions that ask about their experience working with computer-based training systems. The questionnaire can be viewed in Appendix B.

Mindfulness Attention Awareness Scale - Trait

The Mindful Attention Awareness Scale (MAAS) is a measure designed to assess dispositional or trait mindfulness (Brown & Ryan, 2003). The scale represents a single factor and consists of 15 items. An example item is: "I find myself doing things without paying attention." Participants are asked to respond on a 6-point Likert-type scale ranging from 1 = almost always and 6 = almost never. All items are averaged with a higher overall score indicating greater trait mindfulness. The scale can be viewed in Appendix C. The reliability for the scale is reported as $\alpha = .86$ (Brown & Ryan, 2003).

Mindfulness Attention Awareness Scale - State

The MAAS to assess momentary-level, or state, mindfulness was derived from items from the original MAAS scale for dispositional mindfulness (Brown & Ryan, 2003). The scale represents a single factor and consists of 5 items. The instructions for answering the MAAS items were modified to reflect the present moment state of mindfulness during the BEETLE training module. The prompt reads "To what degree were you having the following experiences during the BEETLE training?" Participants are asked to respond on a 6-point Likert-type scale ranging from 1 = almost always and 6 = almost never. An example item is "I did tasks automatically, without being aware of what I was doing." All items are averaged to derive an overall index of expressed state mindfulness with a higher score reflecting greater state mindfulness. The scale can be viewed in Appendix C. The reliability for the scale is reported as α = .92 (Brown & Ryan, 2003). Covariance between the dispositional and momentary-level mindfulness scales is .19 (Brown & Ryan, 2003).

International Cognitive Ability Resource (ICAR)

The ICAR provides cognitive ability measures that are publicly available for use in academic settings (ICAR Catalogue, 2017)[3]. The ICAR Sample Test is designed to test general cognitive ability in un-proctored online settings (Condon, & Revelle, 2014). The test contains four sub-scales with four different item types. The item types are letter and number series, matrix reasoning, verbal reasoning, and three-dimension rotation. Each subscale contains four items. The letters and numbers items require the identification of the next position in a sequence of numbers and letters. Responses to these items can be selected from six choices. The reliability for the letters and numbers series sub-scale is reported as α = .77 (Condon & Revelle, 2014). The matrix reasoning test assesses non-verbal, abstract cognitive functioning and is roughly equivalent to Raven's Progressive Matrices. Each item consists of a 3x3 grid of geometric shapes with one missing shape. Response choices are presented as six stimuli from which they must select the best

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[3] To utilize the resources of ICAR, researchers have to agree to not publish the test or any of the psychometric data associated with the test. Basic information concerning the test are contained in this paragraph.. A sample of the test can be furnished by applying with ICAR for access.

shape to complete the grid. The reliability for the matrix reasoning sub-scale is reported as α = .68 (Condon & Revelle, 2014). The verbal reasoning items requires reasoning through logic, facts, and vocabulary. Six response choices are presented. The reliability for the verbal reasoning sub-scale is reported as α = .76 (Condon & Revelle, 2014). The three-dimensional cube rotation items present a series of cubes with patterns on each side. Response choices as six cubes, only one of which is the best answer to complete the next rotation in the presented sequence. The reliability for the three-dimensional cube rotation sub-scale is reported as α = .93 (Condon & Revelle, 2014). The overall reliability for the ICAR Sample Test is reported as α = .81 (Condon & Revelle, 2014). All items are averaged to derive an overall index of cognitive ability with a higher score reflecting greater cognitive ability.

Positive Affect Negative Affect Survey (PANAS)

The PANAS consists of two scales measuring the experience of positive and negative affect (Watson, Clark, & Tellegen, 1988). Each scale contains ten items. An item consists of a single word reflective of a positive or negative affect state. For example, the word "interested" reflects positive affect, whereas, the word "nervous" reflects negative affect. Participants rate each item on a 1-5 scale, with 1 = very slightly or not at all and 5 = extremely. The instructions provided to the participants request ratings of present moment affect. The scale can be viewed in Appendix C. The internal consistency reliability with the present moment instruction for the positive affect scale is reported as α = .89 and α = .85 for the negative affect scale.

Self-efficacy for Learning and Performance Subscale (SLP)

The Motivated Strategies for Learning (MSLQ) is a self-report questionnaire designed to assess students' motivation and use of learning strategies in a classroom setting (Pintrich, Smith, Garcia, & McKeachie, 1991). The subscales of the MSLQ are designed to be used together or separately. In this study, *only* the Self-efficacy for Learning and Performance subscale was used. The SLP assesses self-efficacy for mastering a learning task. The subscale contains eight items. For the purposes of this study, the items have been modified to reflect working within the context of an adaptive training system. The scale has been used successfully in computer-based instructional settings (Duncan & McKeachie, 2005). An example item is: "Considering the difficulty of this course, the intelligent tutor, and my skills, I think I will do well in this class." Participants are asked to respond on a 7-point Likert-type scale ranging from 1 = not at all true of me and 7 = very true of me. All items are averaged with a higher overall score indicating greater self-efficacy. The scale can be viewed in Appendix C. Reliability of the SLP is reported as α = .93 (Pintrich et al., 1991).

Metacognitive Self-regulation Scale - Revised

Metacognition was assessed with the Metacognitive Self-regulation Scale-Revised (MSR-R) which is a revision to the original Metacognitive Self-regulation subscale of the MSLQ (Tock & Moxley, 2017; Pintrich & DeGroot, 1990). The revision addressed a lack of psychometric information for the MSLQ, clarified the factor structure of the instrument, improved the reliability, and established construct validity of the scale. The original scale was intended to measure metacognition as a single construct that addresses planning, monitoring, and regulation. Factor analysis of the original fifteen item scale revealed two and three factor structures as a better fit; however, examination of the items revealed that two reverse-coded items performed poorly and a third item measured performance assessment as opposed to planning, monitoring, or regulation. The MSR-R consists of nine items that align with the original intent of the scale to measure a single construct. For the purposes of this study, the items have been modified to assess momentary-level metacognition. This was done to support temporal separation of the repeated measures to best capture participant experiences in the module in which they just participated. An example item is: "I tried to think through a topic and decide what I was supposed to learn from it rather than just reading it over when progressing through the module." Participants are asked to respond on a 7-point Likert-type scale ranging from 1 = not at all true of me and 7 = very true of me. All items are averaged with higher overall score indicating greater metacognitive self-regulation. The scale can be viewed in Appendix C. Reliability of the scale is reported as $\alpha = .78$ (Tock & Moxley, 2017).

Trail Making Test

The Trail Making Test (TMT) serves as a measure of cognitive flexibility (Mitrushina, Boone, Razani, & D'Elia, 2005). The TMT requires the use of task switching, working memory, and visual speed. The TMT contains two parts, part A and part B. To support short duration temporal separation in measurement of cognitive flexibility, the alternate form, part C and part D, was also used in the experiment to reduce practice effects observed from administering parts A and B within a short period of time. Parts A and C consist of 25 circles containing numbers distributed across a page that the participant needs to connect in ascending order by drawing lines between the circles. This is considered a measure of visual search and motor speed (Bowie & Harvey, 2006) Parts B and D contain 25 circles with numbers and letters distributed across the page that participants need to connect in ascending order switching between numbers and letters. This part is considered a measure of higher order cognitive skills such as cognitive flexibility (Bowie & Harvey, 2006). The TMT score is an index of cognitive flexibility derived from the time to complete each part, which is an estimate of the switch costs (or level of interference) resulting from the set and task switch between parts A and B (or C and D). This is calculated as the difference in time in seconds to complete parts B and A respectively (or the difference between parts D and C) such that lower time to complete the test is equates to greater cognitive flexibility. Reliability for the test is reported as ranging between .76 to .89 for part A/C and .86

to .94 for part B/D depending upon form used (Wagner, Helmreich, Dahmen, Lieb, & Tadic, 2011). The test can be found in Appendix C.

BEETLE Pre and Post-tests

The BEETLE Pre-test is designed to assess baseline knowledge of the content of the curriculum. The test contains 20 items after it was shortened in alignment with the use of only one, subdivided BEETLE module. The pre-test was used to determine the baseline level of electricity knowledge and skill possessed by each participant and served as a control variable to support determination of the amount of learning achieved in each condition. The BEETLE post-test contains 26 items after the test was shortened to align with the content of only BEETLE module one (18 items) and the addition of an experimental sub-test described below (8 items). The items across the pre and post-test are different to address learning effects; however, there are parallel items across the forms. Multiple choice items across tests are designed to identify commonly held misconceptions for how electricity operates to target adaptive instructional interventions more effectively (Campbell, 2012). The items are a mix of lower order learning (i.e., remembering, understanding) and higher order learning (i.e., applying, analyzing, evaluating, creating) questions along Bloom's revised taxonomy (Anderson et al., 2001). The pre-test contains 7 lower order learning items and 13 higher order learning items. The post-test contains 5 lower order learning items and 13 higher order learning items.

The post-test has 8 experimental multiple-choice items added to the end of the test. These items are designed as a sub-test of *adaptable* application of non-traditional materials using concepts learned in the modules. The experimental test items represent 7 higher order learning questions and 1 lower order learning question. Both tests are scored based upon the average of the number of items answered correctly. Three scores were calculated for each test - the overall score for each test, a lower order learning score, and a higher order learning score. New items scores will be segregated from overall BEETLE post-test scores and will be treated as an independent sub-scale for the purpose of validation. The pre-test and post-test can be viewed in Appendix D.

Open-ended Post-experiment Reactions

The open-ended post-experiment reactions questionnaire asks participants three questions concerning the usefulness of the pre and post module activities. An example questions is, "Were the activities prior to each training module useful? Why or Why not?" The participants were also asked to share any comments that they had about the experiment overall.

Procedures

Upon arrival, participants were screened for criteria for participation. Individuals who were long time practitioners of meditation or had extensive electricity training were eliminated from participation. Both criteria could confound results. Once screened, participants were administered informed consent and a demographics form. Next, participants were randomly assigned to one of three conditions: guided mindfulness, traditional mindfulness, or a control group. Participants were then administered baseline measures counter-balanced to eliminate ordering effects. Baseline measures included the BEETLE pre-test, MAAS-T, MAAS-S, ICAR, PANAS, and SLP. Upon completion of baseline measures, participants engaged in either the Guided Mindfulness Application for *preparation*, the SHIELD application for mindfulness meditation, or the Study Skills application for learning styles dependent upon assigned condition. Figures, 4-6 offer a graphic depiction of the flow of the study by condition. Next, participants engaged in the first half of module one of the BEETLE. Following the first half of the module, participants engaged in a ten-minute intervention activity of either guided mindfulness *reflection*, traditional mindfulness diaphragmatic breathing, or study skills checklist in alignment with assigned condition. After this activity, participants engaged in a mid-point assessment counter-balanced for ordering effects, consisting of the TMT parts A and B, MAAS-S, and the MSR-R scale.

The second learning event began with either guided mindfulness *preparation*, a traditional mindfulness body scan, or a study skills activity covering the ten habits of highly effective students depending upon condition. Then participants engaged in the second half of the BEETLE module. After completing the module, participants either received a guided mindfulness reflection, mindfulness meditation, or a study skills time management intervention. Then the final assessment was administered. The final assessment was comprised of the BEETLE Post-Test, TMT parts C and D, MAAS-S, MSR-R, PANAS, SLP, and the open-ended post-experiment reactions survey. All participants were debriefed on the study and asked not to discuss the study with anyone to safeguard the integrity of the experiment. On average, the experiment took four hours to complete from the informed consent through the post-experiment debrief.

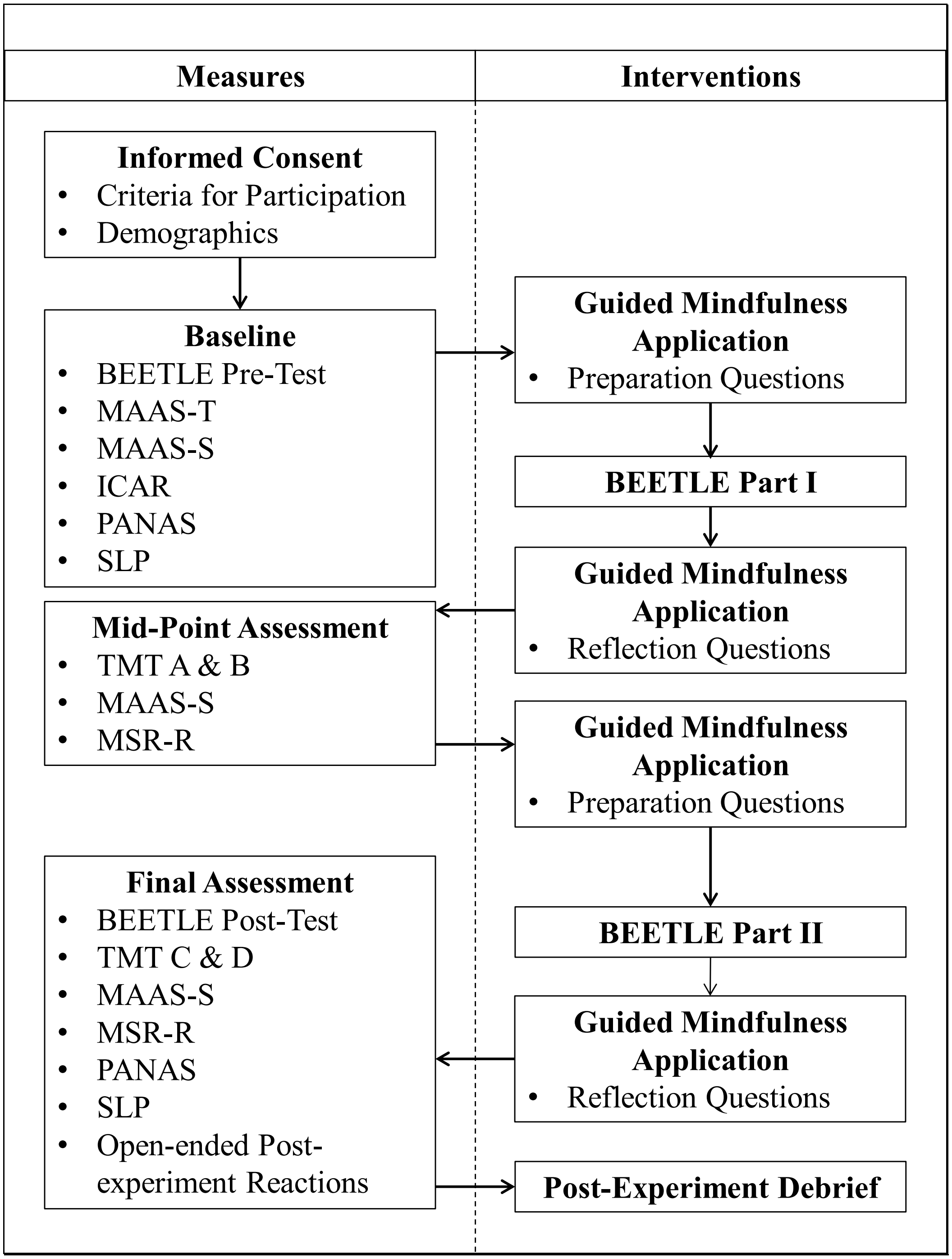

Figure 5. Flow of study for the guided mindfulness condition.

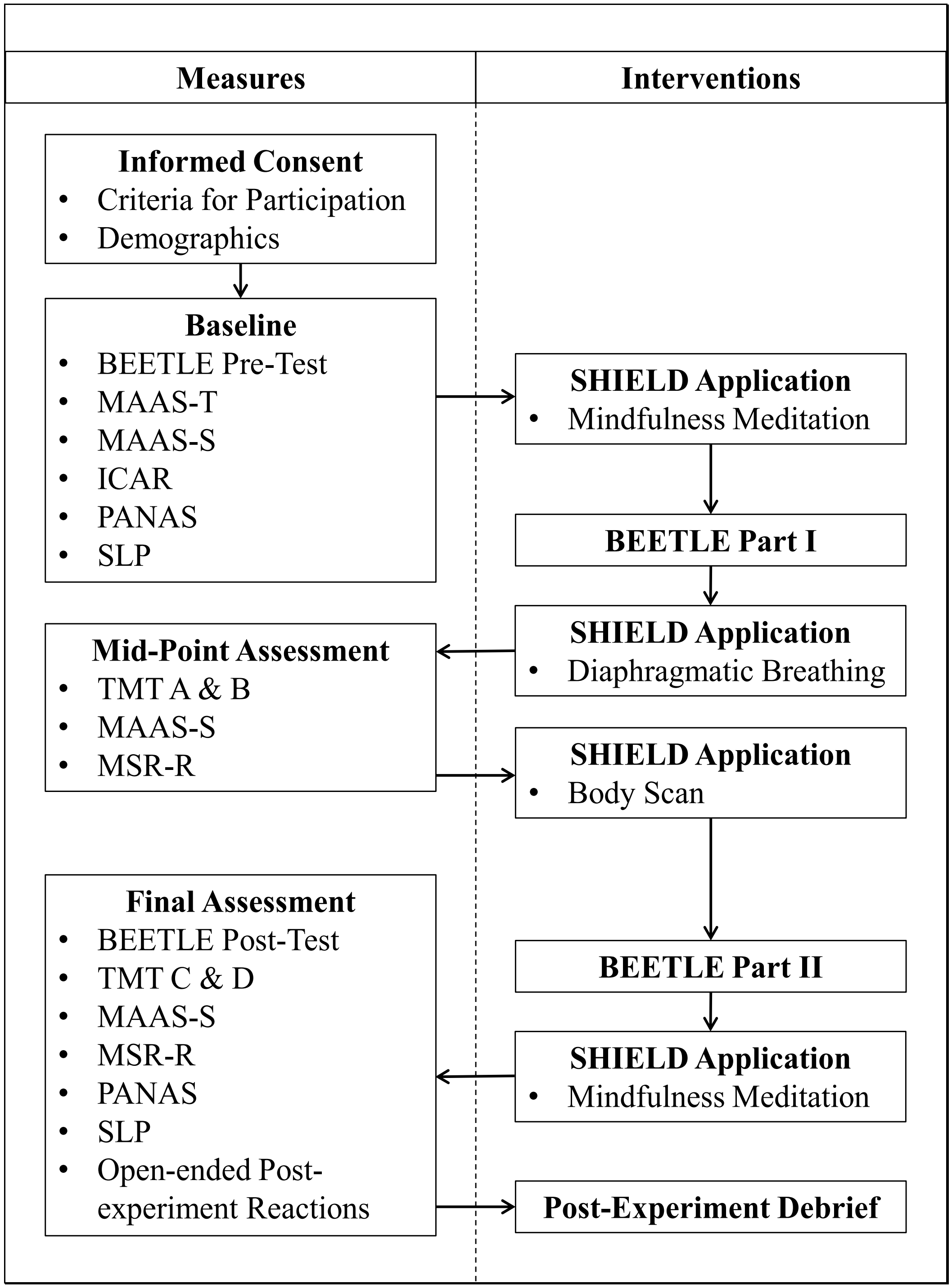

Figure 6. Flow of study for the traditional mindfulness condition.

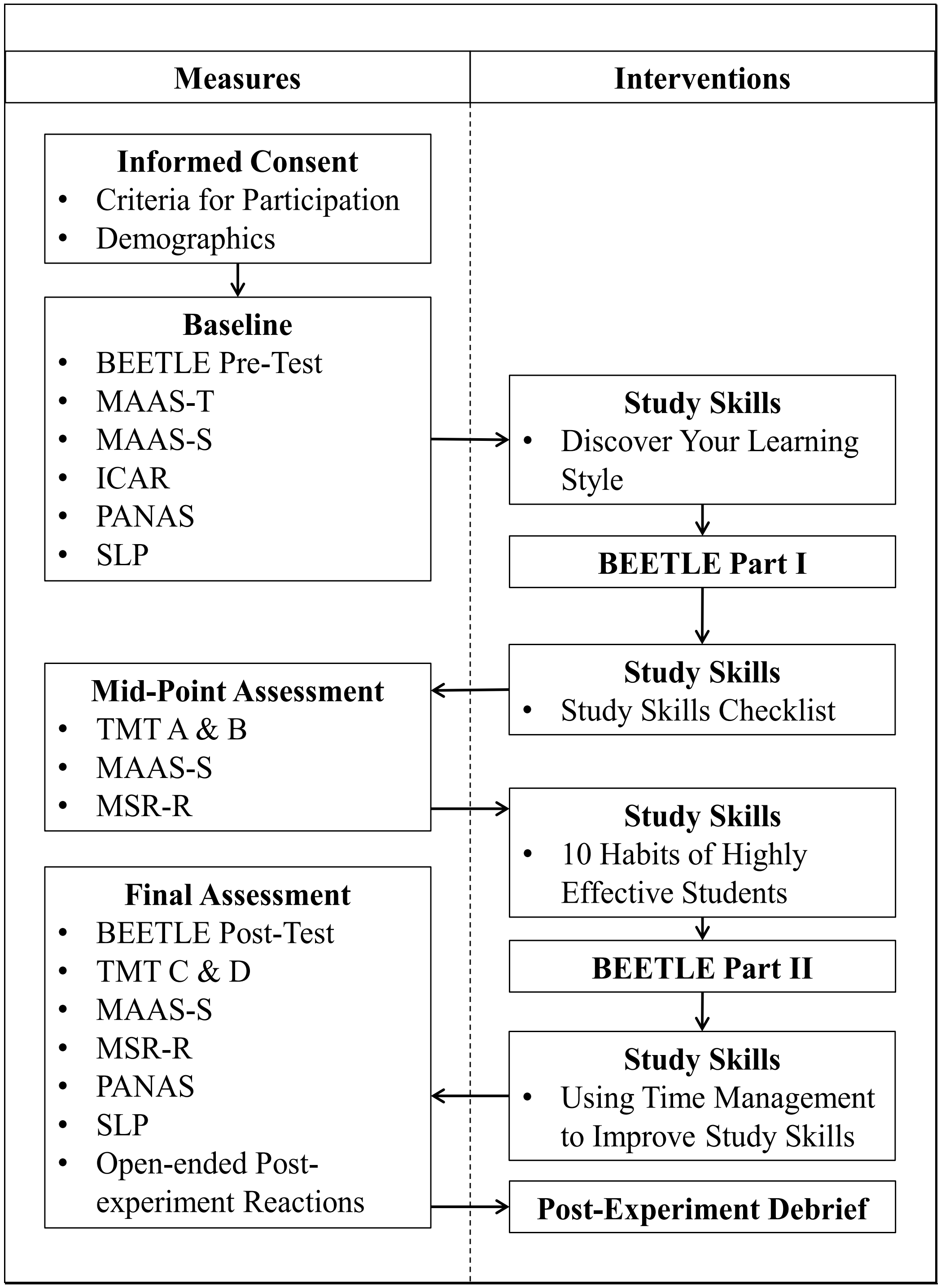

Figure 7. Flow of study for the control condition.

Apparatus

All applications were run on 10-inch Android tablet with wireless keyboards. Surveys were administered through Qualtrics on the tablets. Participants were provided with a stylus for ease of administration of tests, such as the TMT, but more often found using their fingers was more efficient. The BEETLE was run on Dell Laptops running Windows 10. Participants were provided with a mouse. All participants were supplied with noise cancelling headphones to hear the content of the interventions when applicable and reduce distraction from any noise in the room. Participants were seated in carrel desks to avoid visual distractions resulting from other participants or experimenters in the room.

Chapter 3

Results

Prior to analysis the data were screened for participant completion of the experiment and attention checks. Cases where participants failed to complete the experiment or achieved less than 60% on the attention checks were dropped (i.e., 15 cases). The remaining cases were further examined through in SPSS v. 26 for outliers, missing values, and fit between distributions and the assumptions of the multivariate analyses. The variables were examined separately for the guided mindfulness, traditional mindfulness, and the control group participants remaining after the attention check analysis.

Outlier and Extreme Score Analyses

An outlier analysis was conducted revealing 57 cases in need of inspection. Outlier cases were identified on the BEETLE pre and post-tests, MSR-R mid and final tests, the PANAS positive and negative scales pre and post-test, the MAAS-T, and the TMT AB, and TMT CD. Extreme low and high scores analysis were concurrently conducted. Results revealed extreme scores across the battery of tests. Each case was examined manually to determine if exclusion from further data analysis was appropriate. Cases where social desirability response sets were detected, random responding was apparent, and participants expressed a lack of utility in the intervention in qualitative responses were excluded from further analyses. Outlier cases flagged because of extreme scores on the negative and positive PANAS were kept because it was deemed inappropriate to drop cases expressing individual perceived personal affect absent other measurement indicators such as a peer rating to confirm level of positive and negative affect. Outlier cases on positive PANAS fell out naturally as cases were removed for extreme scores on other measures. However, negative PANAS outliers remain. Outlier cases of MAAS-T fell out naturally as cases were examined as outliers for other measures; one outlier case for MAAS-T remains in the dataset as it was deemed a genuinely occurring extreme score. Extreme low and high scores on cognitive ability were examined in conjunction with BEETLE pre and post-test scores. Cases where a pattern of learning was apparent were considered genuinely occurring extreme scores and were kept. TMT AB and CD scores were examined and those that fell outside of the 90 second cutoff time were removed from analysis. Several cases were flagged for scores falling below 90 seconds; these cases were retained for analysis. Following these analyses, 26 cases were retained, and 31 cases were dropped from analysis, leaving $N = 214$.

Missing Values Analysis

Missing Value Analysis revealed a substantial amount of missing values in 11-13% of cases for TMT A-D. Missing values on the TMT AB were identified for 25 cases and 29 cases for TMT CD, making calculation of time differences between TMT AB and TMT CD impossible. Cases that were missing data on TMT A, B, C, and D were considered not salvageable and deleted. Despite the deletions, a large number of cases still remained with missing data. Options identified by Tabachnik and Fidell (2013) that fit with a large amount of missing data confined to a single measure were listwise deletion, mean substitution, and multiple imputation. Given the criticality of the measure of cognitive flexibility to the analyses, an empirical approach was taken to select missing value treatment method in alignment with Cheema's (2014) guidelines for choosing missing data handling methods in educational research.

Cheema utilized a simulated data set (no missing values), which was then modified for different quantities of missing data (1% - 20%), sample sizes, and imputation methods to assess the effects on the results of various statistical analysis methods. Results revealed that when performing multiple regression analyses on a medium sample size, multiple imputation is the best choice in the case of large quantities of missing data and expectancy maximization as the best choice in the case where missing data is small. However, the increase in power is estimated at 1.2% for multiple imputation and 1% using expectancy maximization. In the case of either multiple imputation or expectancy maximization, Root Mean Squared Error increased. Further, in sample sizes that exceeded 200, statistical power was not an issue for any of the missing value methods in the study. Following the decision tree developed by Cheema to determine most appropriate missing data handling method indicated the need to determine: (1) if missing data are Missing Completely At Random (MCAR), Missing At Random (MAR), or Not Missing At Random (NMAR); (2) if the sample is still representative of the population after listwise deletion if the data are determined to be MAR; and (3) if there is adequate power for test of hypotheses.

A Missing Completely At Random (MCAR) analysis was conducted utilizing Little's MCAR Test on TMT A, B, C and D scores. Results of the test indicate that the data met the assumption of MCAR ($X^2 = 8.299$, $df = 10$, $p = .60$). Since the data met the MCAR assumption, a further analysis of sample representativeness was not warranted. Analyses of power for the study using G Power 3.1 for ANCOVA and linear regression tests for a power of .80 revealed that the sample size of $N = 164$ after listwise deletion is enough to proceed with test of hypotheses.

Tests of Assumptions

Reliability and Item Analysis

Reliability and item analysis were conducted for each of the measures. Overall, the reliability estimates were in alignment with estimates reported in the literature. Table 11 below contains the reported reliability estimates along with those obtained within this study, except for the BEETLE tests as no pre-existing reliability estimates could be obtained making this study the first to estimate reliability. For the purposes of this study, the original BEETLE pre and post tests were shortened to fit within the time allotted. The shortened BEETLE pre-test exhibited a low Cronbach's alpha of α = .36. Item analysis was conducted and five items (3, 5, 9, 15, 17) were determined to contain confusing content and were dropped from the test. Reliability estimates for the BEETLE pre-test and subscales were recalculated and Cronbach's alpha was improved α = .50 but is still low. This is not surprising given that participants were naïve to electricity knowledge and content. While these reliability estimates are of concern, the test content is reflective of the content covered in the module. The shortened BEETLE post-test exhibited a reliability estimate of α = .66. Item analysis was conducted and five items (4, 11, 13, 21, 32) were identified as problematic due to question wording and changes in the expected response option structure. Removal of these items raised the BEETLE post-test reliability estimate to α = .69. The experimental BEETLE post-test adaptability items had a low reliability estimate of α = .35. Item analysis was conducted and three items (37, 39, 43) were identified as problematic. Items were examined and wording for two items was determined to be confusing and the third covered concepts in a later BEETLE module. These items were dropped, which raised the reliability estimate to α = 50.

The ICAR Composite score for the original 16 item test was estimated at α = .79. All subscales exhibited acceptable reliability with the exception of the matrix reasoning items α = .21. Dropping this scale from the composite score would bring the reliability estimate down to α = .73. The scale was kept intact for analyses.

The TMT AB test exhibited lower reliability (α = .52) than reported estimates (α = .76-.89). The TMT CD test also exhibited lower reliability (α = .52) than reported estimates (α = .86-.94). The nature of the tests prohibited any adjustments to be made for bad items.

Table 11. *Reliability estimates for measures.*

Test	**Reported Reliability (α)**	**Study Reliability (α)**	***n***
Shortened BEETLE Pre-test	-	.50	214
Lower Order Learning			
Higher Order Learning	-	.38	
	-	.42	
Shortened BEETLE Post-test	-	.69	214
Lower Order Learning			
Higher Order Learning	-	.38	
Experimental	-	.65	
Adaptability Subscale	-	.50	
MAAS-T	.86	.90	214
MAAS-S	.92	.79	214
ICAR composite	.81	.79	214
3-D Rotation	.93	.62	
Matrix	.68	.21	
Letter & Numbers	.77	.61	
Verbal	.76	.58	
ICAR Composite Matrix Scale dropped (12 items)		.73	
MSR-R	.78	.80	214
Positive PANAS	.89	.90	214
Negative PANAS	.85	.84	214
SLP	.93	.96	214
TMT AB	.76 - .89	.52	190
TMT CD	.86 - .94	.52	187

Multicollinearity

A correlation analysis was conducted with the hypothesized measures, as well as measures intended for exploratory analyses to identify any relationships that were r = .80 or higher. No correlations between measures reached this level as can be seen in Table 12. Multicollinearity diagnostics were conducted with each analysis and VIFs and tolerances were examined. There was no evidence of multicollinearity.

Normality

The normality of the measures was assessed through examination of histograms, Normal Q-Q plots by condition, results of the Kolmogorov-Smirnov and Shapiro-Wilk tests, by condition, and by calculation of Z scores for skewness and kurtosis to determine if the tests exceeded plus or minus 2.58 on the normal distribution across conditions. Most measures had a linear distribution on the Q-Q plot, except for the negative PANAS scale. The Kolmogorov-Smirnov and Shapiro-Wilk tests were mostly found to be significant except for the MSLQ and MSR-R. Calculation of Z scores for skewness and kurtosis showed all measures as having a normal distribution, except for the negative PANAS scale, which violated the plus or minus 2.58 cutoff for skewness and kurtosis across conditions. This is likely, in part, due to the number of outlier cases (8 cases) that remain in the data for this measure. Due to the absence of normality in this measure, any future analyses should consider the use of non-parametric tests that do not have normality as an assumption.

Table 12. *Correlation matrix for dependent variables and covariates.*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Trait Mindfulness	--																				
2. State Mindfulness - Baseline	-.30**	--																			
3. State Mindfulness - Time 1	-.31**	.56**	--																		
4. State Mindfulness - Time 2	-.28**	.49**	.68**	--																	
5. Overall Lrng - Pre	-.02	-.11	-.12	-.07	--																
6. Higher Order Lrng - Pre	-.01	-.07	-.08	-.07	.86**	--															
7. Lower Order Learning Pre	.01	-.11	-.11	-.03	.73**	.29**	--														
8. Overall Lrng - Post	-.17*	-.02	-.12	-.06	.47**	.44**	.29**	--													
9. Lrng - Adaptability	-.10	-.02	-.09	-.08	.40**	.34**	.30**	.49**	--												
10. Lower Order Lrng Post	-.17*	-.02	-.08	-.05	.44**	.42**	.27**	.94**	.43**	--											
11. Higher Order Lrng - Post	-.08	-.01	-.14*	-.08	.32**	.29**	.21**	.71**	.41**	.43**	--										
12. Metacog- Time 1	-.11	-.09	-.02	-.15*	-.13	-.12	-.08	-.05	-.15*	-.07	.01	--									
13. Metacog - Time 2	-.18**	-.02	-.07	-.12	.01	.01	.00	.07	.00	.02	.14*	.64**	--								
14. Cognitive Flex- Time 1	.04	-.08	-.02	-.11	-.09	-.07	-.08	-.14	-.13	-.07	-.23**	.13	.01	--							
15. Cognitive Flex - Time 2	.15*	-.03	-.01	-.08	-.19**	-.17*	-.13	-.29**	-.24**	-.18*	-.26**	.17*	-.00	.46**	--						
16. Cognitive Ability	-.06	.00	-.05	-.02	.40**	.35**	.29**	.53**	.34**	.46**	.44**	-.11	-.01	-.19*	-.26**	--					
17. Positive Affect - Baseline	.21**	-.26**	-.23**	-.27**	-.12	-.16*	-.01	-.16*	-.14*	-.17*	-.07	.32**	.36**	.08	.13	-.07	--				

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
18. Positive Affect - Final	.17*	-.23**	-.23**	-.29**	-.02	-.05	.02	-.03	-.01	-.04	.01	.26**	.43**	.04	-.02	-.11	.81**	--			
19. Negative Affect - Baseline	-.37**	.12	.19**	.19*	.01	-.07	.12	.01	-.00	.05	-.08	.13	.10	.03	-.11	-.06	.13	.10	--		
20. Negative Affect - Final	-.29**	.17*	.20**	.15*	-.11	-.16*	.01	-.09	-.11	-.07	-.09	.03	.03	-.02	.03	-.09	.05	-.02	.62**	--	
21. Self-efficacy - Baseline	.14*	-.16*	-.24**	-.27**	.12	.12	.06	.12	.13	.09	.10	.19**	.29**	-.00	-.01	.27**	.39**	.31**	-.11	-.10	--
22. Self-efficacy - Final	.05	-.15*	-.25**	-.27**	.22**	.21**	.14*	.32**	.28**	.31**	.20**	.13	.35**	-.00	-.18*	.25**	.37**	.50**	.03	-.19**	.54**

** p <.01 *p < .05

Equivalence of Group Checks

One-way between-subjects of ANOVA were conducted to test for the equivalence of groups utilizing select demographics and baseline measures. The *p* value was set to .05. Demographics tested included age, sleep, and education. Baseline measures included the overall pre-test of electricity knowledge and higher order cognitive process scale (BEETLE pre-test), trait mindfulness (MAAS-T), state mindfulness (MAAS-S), cognitive ability (ICAR), self-efficacy (SLP), and positive and negative affect (PANAS). The results of all tests are reported below in Table 13. No significant differences were found among the groups on age, amount of sleep the night before, or education level. No significant differences were found among the groups on any of the baseline measures. Taken together, these results indicate that the groups were equivalent prior to the manipulations.

Table 13. *Results of the one-way between subjects ANOVA tests for group equivalence.*

Variable	Results
Education	F (2, 214) = .67, *ns*, partial η^2 .01
Age	F (2, 214) = 1.63, *ns*, partial η^2 .02
Sleep	F (2, 214) = 1.16, *ns*, partial η^2 .01
Overall Pre-experiment Knowledge	F (2, 214) = 1.50, *ns*, partial η^2 .01
Higher Order Cognitive Processes Pre-experiment	F (2, 214) = 1.66, *ns*, partial η^2 .01
Trait Mindfulness	F (2, 214) = 2.07, *ns*, partial η^2 .02
State Mindfulness	F (2, 214) = 2.20, *ns*, partial η^2 .02
Cognitive Ability	F (2, 214) = .49, *ns*, partial η^2 .01
Self-efficacy	F (2, 214) = .30, *ns*, partial η^2 .01
Positive Affect	F (2, 214) = .94, *ns*, partial η^2 .01
Negative Affect	F (2, 214) = .18, *ns*, partial η^2 .00

Manipulation Checks

A one-way repeated measures ANCOVA was conducted to test whether reported state mindfulness was achieved as expected in the guided mindfulness and traditional mindfulness groups following the interventions using the self-report MAAS-S survey. The independent variable consisted of group membership (i.e., Guided Mindfulness, Traditional Mindfulness, or Control). The covariate held constant was trait mindfulness as measured by the MAAS-T. The dependent variable consisted of state mindfulness assessed at three points. The assumption of reliability of measures and multicollinearity were met as described in earlier sections. The homogeneity of variance assumption failed as assessed by Levene's Test of Equality of Error Variances (p = .56) for state mindfulness at Time 1, Time 2 (p = .03), and Time 3 (p = .93). A significant Box's M test (p = .00) indicates that the assumption of homogeneity of variance across the groups was not met. Given this violation, a more stringent p value of .025 will be applied to tests of main and interaction effects (Tabachnik & Fidell, 2013). The assumption of homogeneity of regression slopes was met as the interaction terms was not statistically significant $F(2, 208) = 1.45$, $p = .24$.

Mean reported state mindfulness at Time 1 was greater in the control group ($m = 2.15$, $sd = 1.84$) than either the guided mindfulness ($m = 1.58$, $sd = 1.76$) or traditional mindfulness ($m = 2.06$, $sd = 1.75$) groups, respectively. At Time 2, mean reported state mindfulness was greater in the control group ($m = 2.69$, $sd = 1.74$) than in the guided mindfulness ($m = 1.90$, $sd = 1.80$) or traditional mindfulness ($m = 2.14$, $sd = 2.07$) groups, respectively. At Time 3, mean reported state mindfulness was greater in the control group ($m = 2.89$, $sd = 1.71$) than in the guided mindfulness ($m = 2.04$, $sd = 1.86$) or traditional mindfulness ($m = 2.61$, $sd = 1.72$) groups, respectively. Reported state mindfulness was greater in the control group ($m = 2.51$. $se = .12$) than the guided mindfulness group ($m = 1.93$, $se = .12$) or the mindfulness group ($m = 2.24$, $se = .12$). There was not a statistically significant difference in post-intervention reported state mindfulness between the interventions $F(2, 210) = 3.28$, $p = .04$, $\eta^2 = .03$, power = .62 after applying the corrected $p = .025$ value due to violation of the homogeneity of variance assumption. Even if statistical significance was achieved for the between subjects tests, mean scores indicate that the control group had greater state mindfulness than either the guided mindfulness or traditional mindfulness groups, counter to what was intended from the experimental induction.

Hypotheses Analyses

Hypothesis 1a-c predicted that the guided mindfulness group would learn significantly more than the (a) traditional mindfulness group or the (b) control group. Hypothesis 1c predicted that the traditional mindfulness group would learn significantly more than the control group. To test this set of hypotheses, a one-way between-subjects analysis of covariance (ANCOVA) was conducted. The between-subjects factor comprised three groups: participants who practiced guided mindfulness, participants who practiced traditional mindfulness, and a control group who learned about learning styles and study skills. The dependent variable was overall post-test learning scores. Proposed covariates included the pre-test of knowledge, cognitive ability, and trait mindfulness. Inspection of the correlation matrix showed a non-significant relationship with trait mindfulness so it was dropped from the analysis. Analyses were performed using SPSS 26.

Results of evaluation of the assumptions of normality of sampling distributions, linearity, homogeneity of variance, and homogeneity of regression were all satisfactory. The shortened BEETLE pre-test exhibited lower reliability ($\alpha = .50$). Mean overall post-test scores were greater in the traditional mindfulness group ($m = .54$, $sd = .20$) than either the guided mindfulness ($m = .52$, $sd = .2$) or control group ($m = .52$, $sd = .23$) groups, respectively. No statistically significant difference was found in overall learning by condition F (2, 209) = .60, p = .55, partial η^2 = .01, power = .15. Hypotheses 1a-c were not supported.

Hypotheses 1d-e predicted that the guided mindfulness group would score significantly higher on the higher order learning scale than either the (d) mindfulness group or the (e) or control group. To test these hypotheses, a one-way between-subjects analysis of covariance (ANCOVA) was conducted. The between-subjects factor comprised three groups: participants who practiced guided mindfulness, participants who practiced traditional mindfulness, and a control group who learned about learning styles and study skills. The dependent variable was higher order post-test learning scores. Proposed covariates included higher order learning pre-test scores, cognitive ability, and trait mindfulness. Inspection of the correlation matrix showed a non-significant relationship with trait mindfulness so it was dropped from the analysis. Analyses were performed using SPSS 26.

Results of evaluation of the assumptions of normality of sampling distributions, linearity, homogeneity of variance, and homogeneity of regression were all satisfactory. The shortened BEETLE pre-test higher order learning scale exhibited lower reliability (α= .42). Mean higher order post-test scores were greater in the traditional mindfulness group (m = .50, sd = .22) than either the guided mindfulness (m = .47, sd = .22) or control group (m = .47, sd = .25) groups, respectively No statistically significant difference was found in higher order learning by condition F (2, 212) = .95, p = .39, partial η^2 = .01, power = .21. Hypotheses 1d-e were not supported.

Hypotheses 2 a-c predicted that the guided mindfulness group would report engaging in significantly more metacognition than either the (a) traditional mindfulness group or (b) the control group, with the mindfulness group reporting greater metacognition than (c) the control group. To test these hypotheses, a one-way between subjects repeated measures ANCOVA was conducted. The independent variable was group membership and the dependent variable was metacognition. Proposed covariates were cognitive ability and trait mindfulness. Inspection of the correlation matrix revealed a non-significant relationship between metacognition and cognitive ability. Therefore, cognitive ability was not included as a covariate in the analysis. Trait mindfulness had a significant negative correlation with metacognition only at time 2 (r = -.18, $p < .01$) and approached significance at time 1 (r = -.11, $p < .06$), given these results, trait mindfulness was included in the analysis.

Results of evaluation of the assumptions of normality, reliability, linearity, homogeneity of variance, and homogeneity of regression were all met. Mean reported metacognitive state at Time 1 was greater in the guided mindfulness group (m = 3.83, sd = 1.00) than either the traditional mindfulness (m = 3.69, sd = 1.16) or control (m = 3.64, sd = 1.14) groups. At Time 2, mean reported metacognitive state was greater in the traditional mindfulness group (m = 3.66, sd = 1.24) than in the guided mindfulness (*m* = 3.59, *sd* = 1.23) or control (*m* = 3.50, *sd* = 1.16) groups. There was a statistically significant interaction effect between the groups across time 1 and time 2 metacognition, partial η^2 = .01, power = .56, 95% confidence limits from .01 to .26 in alignment with the means reported above. There was no statistically significant main effect was found in metacognitive state across the groups F (2, 210) = .73, p = .48, partial η^2 = .01, power = .17. Hypotheses 2 a-c were not supported.

Hypothesis 3 a-c predicted that the guided mindfulness group would exhibit significantly greater cognitive flexibility than the (a) mindfulness group and (b) control group as defined by lower calculated differences between the Trail Making Test parts AB and CD, respectively. It was also predicted that the mindfulness group would demonstrate significantly greater cognitive flexibility than the (c) control group. To test these hypotheses, a one-way between subjects repeated measures ANCOVA was conducted. The independent variable was group membership and the dependent variable was cognitive flexibility. Proposed covariates were cognitive ability and trait mindfulness. Inspection of the correlation matrix revealed a statistically non-significant relationship between cognitive flexibility and trait mindfulness. Therefore, trait mindfulness was not included as a covariate in the analysis. Cognitive ability had a statistically significant negative correlation with cognitive flexibility at time 1 and time 2 given these results, cognitive ability was included as a covariate in the analysis.

Results of evaluation of the assumptions of normality, reliability, linearity, homogeneity of variance, and homogeneity of regression were all met. Mean cognitive flexibility at Time 1 was better in the guided mindfulness group (*m* = 39.21, *sd* = 19.20) than either the traditional mindfulness (*m* = 42.29, *sd* = 17.77) or control (*m* = 43.53, *sd* = 17.71) groups. At Time 2, cognitive flexibility was better in the guided mindfulness group (*m* = 35.99, *sd* = 13.10) than in the traditional mindfulness (*m* = 40.41, *sd* = 16.89) or control (*m* = 36.77, *sd* = 17.06) groups. There was a statistically significant interaction effect between the groups across time 1 and time 2 with the traditional mindfulness group performing worse than the control group at time 2, partial η^2 = .05, power = .79, 95% confidence limits from 1.14 to 6.75 in alignment with the means reported above. No statistically significant main effect was found in cognitive flexibility across the groups F (2, 160) = 1.05, p = .35, partial η^2 = .01, power = .23. While the groups exhibited cognitive flexibility in the predicted way for hypothesis 3a (i.e., the guided mindfulness group would have greater cognitive flexibility than the traditional mindfulness or control groups), hypotheses 3 a-c were not supported since there was not a statistically significant difference found between the groups.

Hypothesis 4a states that metacognition will be significantly and positively related to overall learning in the guided mindfulness condition. A hierarchical multiple regression was conducted to determine if the addition of metacognition, measured at two points, made a statistically significant and positive contribution over and above the linear combination of pre-test assessment and cognitive ability to the prediction of overall learning. See Table 14 for full details on each regression model. There was linearity as assessed by partial regression plots and a plot of studentized residuals against predicted values. There was independence of residuals as assessed by a Durbin-Watson statistic of 1.75. There was homoscedasticity as assessed by visual inspection of a plot of studentized residuals versus predicted values. There was no evidence of multicollinearity as assessed by the variance inflation factor. There were no studentized deleted residuals greater than plus or minus 3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was met as assessed by the Q-Q plot.

The full model of pre-test score, cognitive ability, and metacognition to predict overall learning was statistically significant $R^2 = .27$ F (2, 74) = 13.36, $p <$ .00; adjusted $R^2 = .25$. The addition of metacognition to the prediction of overall learning at time 1 (Model 2) was not statistically significant $R^2 = .27$ change in F (1, 73) = .07, $p = .80$; change in $R^2 = .00$. The addition of metacognition to the prediction of overall learning at time 2 (Model 3) was not statistically significant $R^2 = .29$ change in F (1, 72) = 2.40, $p = .13$; change in $R^2 = .02$. Hypothesis 4a was not supported.

Table 14. *Hierarchical multiple regression predicting overall learning from pretest of overall learning, cognitive ability, and metacognition in the guided mindfulness condition.*

	Overall Learning					
	Model 1		Model 2		Model 3	
Variable	B	β	B	β	B	β
Constant	.26**		.24*		.24*	
Pre-test of Learning	.24	.18	.24	.18	.21	.15
Cognitive Ability	.45**	.44**	.45**	.44**	.45**	.44**
Metacog Time 1			.01	.03	-.02	-.12
Metacog Time 2					.04	.21
R^2	.27		.27		.29	
F	13.36**		8.82**		7.34**	
ΔR^2	.27		.00		.02	
ΔF	13.36**		.07		2.40	

$N = 77$. $*p < .05$, $**p < .001$.

Hypothesis 4b states that metacognition will be significantly and positively related to overall learning in the traditional mindfulness condition. A hierarchical multiple regression was conducted to determine if the addition of metacognition, measured at two points, made a statistically significant and positive contribution over and above the linear combination of pre-test assessment and cognitive ability to the prediction of overall learning. See Table 15 for full details on each regression model. There was linearity as assessed by partial regression plots and a plot of studentized residuals against predicted values. There was independence of residuals as assessed by a Durbin-Watson statistic of 1.86. There was homoscedasticity as assessed by visual inspection of a plot of studentized residuals versus predicted values. There was no evidence of multicollinearity as assessed by the variance inflation factor. There were no studentized deleted residuals greater than plus or minus 3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was met as assessed by the Q-Q plot.

The full model of pre-test score, cognitive ability, and metacognition to predict overall learning was statistically significant $R^2 = .32$ F (2, 62) = 14.76, $p < .00$; adjusted $R^2 = .30$. The addition of metacognition to the prediction of overall learning at time 1 (Model 2) was not statistically significant $R^2 = .34$ change in F (1, 61) = 1.34, $p = .25$; change in $R^2 = .00$. The addition of metacognition to the prediction of overall learning at time 2 (Model 3) was not statistically significant $R^2 = .34$ change in F (1, 60) = .10, $p = .76$; change in $R^2 = .00$. Hypothesis 4b was not supported.

Table 15. *Hierarchical multiple regression predicting overall learning from pretest of overall learning, cognitive ability, and metacognition in the traditional mindfulness condition*.

	Overall Learning					
	Model 1		Model 2		Model 3	
Variable	B	β	B	β	B	β
Constant	.25**		.17		.18	
Pre-test of Learning	.37*	.28*	.37*	.27*	.36*	.27*
Cognitive Ability	.44**	.41**	.45**	.42**	.46**	.43**
Metacognition Time 1			.02	.12	.03	.16
Metacognition Time 2					-.01	-.05
R^2	.32		.34		.34	
F	14.76**		10.34**		7.66**	
ΔR^2	.32		.02		.00	
ΔF	14.76**		1.34		.10	

N = 65. *p < .05, **p < .01.

Hypothesis 5a states that metacognition will be significantly and positively related to cognitive flexibility in the guided mindfulness condition. A hierarchical multiple regression was conducted to determine if the addition of metacognition, measured at two points, made a statistically significant and positive contribution over and above the linear combination of cognitive flexibility time 1 and cognitive ability to the prediction of cognitive flexibility at time 2. See Table 16 for full details on each regression model. There was linearity as assessed by partial regression plots and a plot of studentized residuals against predicted values. There was independence of residuals as assessed by a Durbin-Watson statistic of 1.97. There was homoscedasticity as assessed by visual inspection of a plot of studentized residuals versus predicted values. There was no evidence of

multicollinearity as assessed by the variance inflation factor. There were no studentized deleted residuals greater than plus or minus 3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was met as assessed by the Q-Q plot.

The full model of cognitive flexibility time 1, cognitive ability, and metacognition to predict overall learning was statistically significant $R^2 = .16$ F (2, 52) = 4.89, $p < .01$; adjusted $R^2 = .12$. The addition of time 1 metacognition to the prediction of cognitive flexibility (Model 2) was not statistically significant $R^2 =$ .16 change in F (1, 51) = .15, $p = .70$; change in $R^2 = .00$. The addition of time 2 metacognition to the prediction of cognitive flexibility (Model 3) was not statistically significant $R^2 = .18$ change in F (1, 50) = 1.31, $p =.26$; change in $R^2 =$ .02. Hypothesis 5a was not supported.

Table 16. *Hierarchical multiple regression predicting time 2 cognitive flexibility from time 1 cognitive flexibility, cognitive ability, and metacognition in the guided mindfulness condition.*

	Cognitive Flexibility Time 2					
	Model 1		Model 2		Model 3	
Variable	B	β	B	β	B	β
Constant	24.07**		26.83**		28.17**	
Cognitive Flexibility Time 1	.327**	.40**	.27**	.40**	.26**	.38**
Cognitive Ability	2.91	.05	2.80	.04	2.73	.04
Metacognition Time 1			-.68	-.05	1.05	.08
Metacognition Time 2					-2.02	-.20
R^2	.16**		.16		.18	
F	4.89**		3.25*		2.78*	
ΔR^2	.16**		.00		.02	
ΔF	4.89**		.70		.26	

$N = 55$. $*p < .05$, $**p < .01$.

Hypothesis 5b states that metacognition will be significantly and positively related to cognitive flexibility in the traditional mindfulness condition. A hierarchical multiple regression was conducted to determine if the addition of metacognition, measured at two points, made a statistically significant and positive contribution over and above the linear combination of time 1 cognitive flexibility and cognitive ability to the prediction of time 2 cognitive flexibility. See Table 17 for full details on each regression model. There was linearity as assessed by partial regression plots and a plot of studentized residuals against predicted values. There was independence of residuals as assessed by a Durbin-Watson statistic of 2.44. There was homoscedasticity as assessed by visual inspection of a plot of studentized residuals versus predicted values. There was no evidence of

multicollinearity as assessed by the variance inflation factor. There were no studentized deleted residuals greater than plus or minus 3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was met as assessed by the Q-Q plot.

The full model of time 1 cognitive flexibility, cognitive ability, and metacognition to predict time 2 cognitive flexibility was statistically significant $R^2 = .23$ $F(2, 49) = 7.19$, $p < .00$; adjusted $R^2 = .20$. The addition of time 1 metacognition to the prediction of cognitive flexibility (Model 2) was not statistically significant $R^2 = .23$ change to $F(1, 48) = .43$, $p = .52$; change to $R^2 = .01$. The addition of time 2 metacognition to the prediction of cognitive flexibility (Model 3) was not statistically significant $R^2 = .24$ change to $F(1, 47) = .21$, $p = .65$; change to $R^2 = .00$. Hypothesis 5b was not supported.

Table 17. *Hierarchical multiple regression predicting time 2 cognitive flexibility from time 1 cognitive flexibility, cognitive ability, and metacognition in traditional mindfulness condition.*

	Cognitive Flexibility Time 2					
	Model 1		Model 2		Model 3	
Variable	B	β	B	β	B	β
Constant	26.61*		23.11*		23.29*	
Cognitive Flexibility Time 1	.42**	.44**	.40**	.42**	.40**	.42**
Cognitive Ability	-9.07	-.10	-9.58	-.11	-10.85	-.12
Metacognition Time 1			1.22	.08	.15	.01
Metacognition Time 2					1.22	.10
R^2	.23**		.23		.24	
F	7.19**		4.88**		3.65**	
ΔR^2	.23**		.01		.00	
ΔF	7.19**		.43		.21	

$N = 52$. $*p < .05$, $**p < .001$.

Hypothesis 6a states that cognitive flexibility will be significantly and positively related to overall learning in the guided mindfulness condition. A hierarchical multiple regression was conducted to determine if the addition of cognitive flexibility, measured at two points, made a statistically significant and positive contribution over and above the linear combination of pre-test assessment and cognitive ability to the prediction of overall learning. See Table 18 for full details on each regression model. There was linearity as assessed by partial regression plots and a plot of studentized residuals against predicted values. There was independence of residuals as assessed by a Durbin-Watson statistic of 1.97. There was homoscedasticity as assessed by visual inspection of a plot of studentized residuals versus predicted values. There was no evidence of

multicollinearity as assessed by the variance inflation factor. There were no studentized deleted residuals greater than plus or minus 3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was met as assessed by the Q-Q plot.

The full model of pre-test score, cognitive ability, and cognitive flexibility to predict overall learning was statistically significant $R^2 = .26$ F (2, 52) = 9.13, $p <$ .00; adjusted $R^2 = .23$. The addition of cognitive flexibility to the prediction of overall learning at time 1 (Model 2) was not statistically significant $R^2 = .26$, F (1, 51) = .17, $p = .68$; change to $R^2 = .00$. The addition of cognitive flexibility to the prediction of overall learning at time 2 (Model 3) was not statistically significant R^2 = .27 change to F (1, 50) = .53, p =.47; change to $R^2 = .01$. Hypothesis 6a was not supported, cognitive flexibility was not significantly and positively related to overall learning in the guided mindfulness condition.

Table 18. *Hierarchical multiple regression predicting overall learning from pretest of overall learning, cognitive ability, and cognitive flexibility in the guided mindfulness condition.*

	Overall Learning					
	Model 1		Model 2		Model 3	
Variable	B	β	B	β	B	β
Constant	.30**		.27**		.31**	
Pre-test of Learning	.18	.14	.20	.15	.18	.14
Cognitive Ability	.43**	.44**	.44**	.45**	.44**	.45**
Cognitive Flexibility Time 1			.00	.05	.00	.09
Cognitive Flexibility Time 2					-.00	-.10
R^2	.26**		.26		.27**	
F	9.13**		6.04**		4.62**	
ΔR^2	.26**		.00		.01**	
ΔF	9.13**		.17		.53**	

$N = 55$. *$p < .05$, **$p < .001$.

Hypothesis 6b states that cognitive flexibility will be significantly and positively related to overall learning in the traditional mindfulness condition. A hierarchical multiple regression was conducted to determine if the addition of cognitive flexibility, measured at two points, made a statistically significant and positive contribution over and above the linear combination of pre-test assessment and cognitive ability to the prediction of overall learning. See Table 19 for full details on each regression model. There was linearity as assessed by partial regression plots and a plot of studentized residuals against predicted values. There was independence of residuals as assessed by a Durbin-Watson statistic of 1.73. There was homoscedasticity as assessed by visual inspection of a plot of studentized residuals versus predicted values. There was no evidence of multicollinearity as assessed by the variance inflation factor. There were no studentized deleted residuals greater than plus or minus 3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was met as assessed by the Q-Q plot.

The full model of pre-test score, cognitive ability, and cognitive flexibility to predict overall learning in the mindfulness condition was statistically significant $R^2 = .38$ $F(2, 49) = 14.93$, $p < .00$; adjusted $R^2 = .35$. The addition of cognitive flexibility to the prediction of overall learning at time 1 (Model 2) was not statistically significant $R^2 = .38$ change in $F(3, 48) = .16$, $p < .69$; change to $R^2 = .00$. The addition of cognitive flexibility to the prediction of overall learning at time 2 (Model 3) was not statistically significant $R^2 = .39$ change in $F(4, 47) = .87$, $p < .36$; change to $R^2 = .01$. Hypothesis 6b was not supported, cognitive flexibility was not significantly related to overall learning in the traditional mindfulness condition.

Table 19. *Hierarchical multiple regression predicting overall learning from pretest of overall learning, cognitive ability, and metacognition in the traditional mindfulness condition*.

	Overall Learning					
	Model 1		Model 2		Model 3	
Variable	B	β	B	β	B	β
Constant	.23**		.27**		.33	
Pre-test of Learning	.31	.23	.29	.22	.25	.18
Cognitive Ability	.55**	.14**	.54**	.48**	.54**	.48**
Cognitive Flexibility Time 1			-.00	-.06	.00	-.01
Cognitive Flexibility Time 2					-.00	-.13
R^2	.38**		.38		.39	
F	14.93**		9.91**		7.63**	
ΔR^2	.38**		.00		.03	
ΔF	14.93**		.29		.87	

$N = 164$. $*p < .05$, $**p < .001$.

Hypothesis 7a predicts that guided mindfulness indirectly influences higher order learning through its effect on metacognition and metacognition's effect on cognitive flexibility. The proposed serial mediation was tested using PROCESS model 6 in SPSS 26. Covariates included cognitive ability, pre-test of higher order learning, trait mindfulness, metacognition at time 1, and cognitive flexibility at time 1. The assumptions of absence of outliers, normality, linearity, and homogeneity were met. Figure 8 below depicts the model under test and basic results of the analyses.

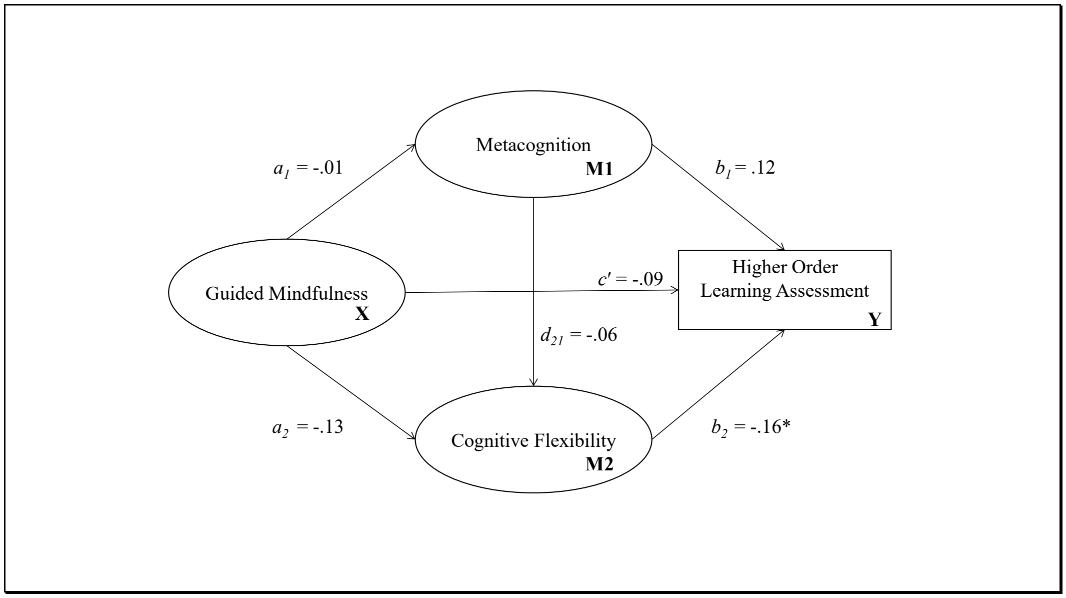

Figure 8. Serial multiple mediator model of the effect of guided mindfulness on higher order learning indirectly through metacognition and cognitive flexibility.

The direct effect of guided mindfulness on metacognition was not statistically significant (*b* = -.01, *t* (157) = -.07, *p* = .94). The direct effect of guided mindfulness on cognitive flexibility was negative, but not statistically significant (*b* = -.13, *t* (156), -.88, *p* = 38). The direct effect of metacognition on cognitive flexibility was not statistically significant (*b* = -.06, *t* (156) = -.63, *p* = .53). The direct effect of guided mindfulness on higher order learning was not statistically significant (*b* = -.09, *t* (155) = -.66, *p* = .51). The direct effect of metacognition on higher order learning was not significant (*b* = .12, *t* (155) = 1.39, *p* = .17. The direct effect of cognitive flexibility on higher order learning was significant (*b* = -.16, *t* (156) = -2.19, *p* = .03). The total effect of guided mindfulness on higher order learning was not significant (*b* = -.07, *t* (156) = -.51, *p* = .61)

The indirect effect of guided mindfulness via metacognition (IE = .00) was not significant, 95% CI (-.04, .04). The indirect effect of guided mindfulness through cognitive flexibility (IE = .02) was not significant, 95% CI (-.02, .09). The full proposed serial mediation model of guided mindfulness indirectly influencing higher order learning through metacognition and cognitive flexibility (IE = -.00) was not significant 95% CI (-.01, .01). The model summary from this analysis can be viewed in Table 20 below. Hypothesis 7a was not supported, guided mindfulness does not indirectly effect higher order learning through metacognition and cognitive flexibility; all proposed mediating effects cross zero in the confidence intervals.

Table 20. *Regression coefficients, standard errors, and model summary information for guided mindfulness serial multiple mediator model.*

	Consequent											
		M_1				M_2				Y Hghr Ordr Lr		
Antecedent		*b*	*SE*	*p*		*b*	*SE*	*p*		*b*	*SE*	*p*
X Guided Mindful	a_1	-.01	.13	.94	a_2	-.13	.15	.38	c'	-.09	.13	.51
M_1 Metacog		-	-	-	d_{21}	-.06	.09	.53	b_1	.12	.08	.17
M_2 Cog Flex		-	-	-		-	-	-	b_2	-.16	.07	-.30
Constant	i_{M1}	.02	.08	.78	i_{M2}	.02	.08	.78	i_Y	.06	.08	.40
		$R^2 = .48$				$R^2 = .24$				$R^2 = .24$		
		F (6, 157) = 24, $p < .00$				F (7, 156) = 7.21, $p < .00$				F (8, 155) = 10.22, $p < .00$		

Hypothesis 7b predicts that traditional mindfulness indirectly influences higher order learning through its effect on metacognition and metacognition's effect on cognitive flexibility. The proposed serial mediation was tested using PROCESS model 6 in SPSS 26. Covariates included cognitive ability, the pre-test of higher order learning, metacognition at time 1, cognitive flexibility at time1, and trait mindfulness. The assumptions of absence of outliers, normality, linearity, and homogeneity were met. Figure 9 below depicts the model under test and basic results of the analyses.

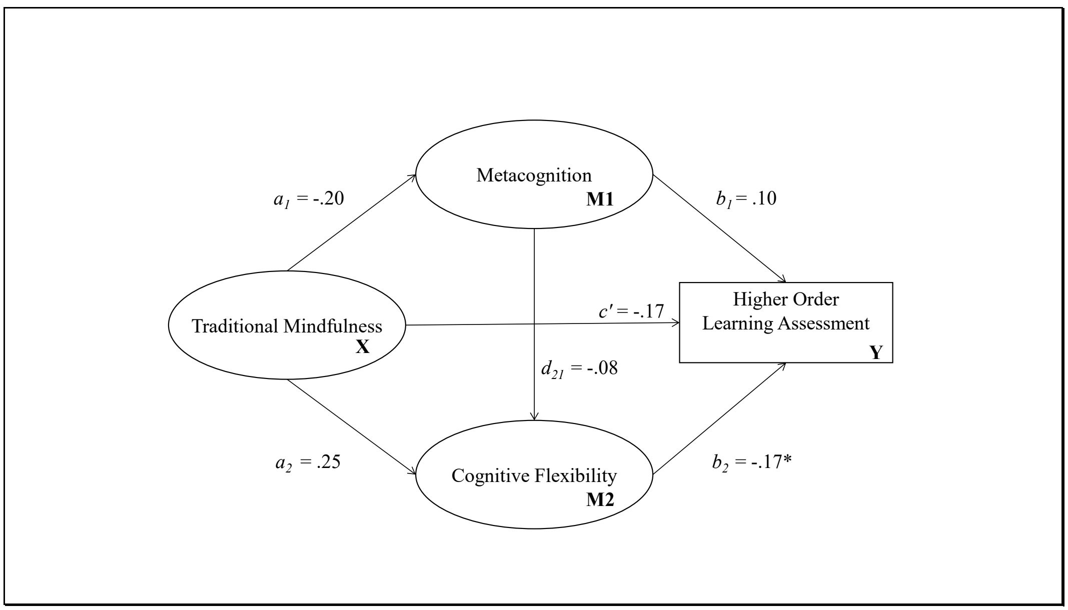

Figure 9. Serial multiple mediator model of the effect of traditional mindfulness on higher order learning indirectly through metacognition and cognitive flexibility.

The direct effect of traditional mindfulness on metacognition was not statistically significant (b = .20, t (157) = 1.58, p = .12). The direct effect of traditional mindfulness on cognitive flexibility was not statistically significant (b =

.25, *t* (156), 1.69, *p* = 09). The direct effect of metacognition on cognitive flexibility was not statistically significant (*b* = -.08, *t* (156) = -.84, *p* = .40).

The direct effect of traditional mindfulness on higher order learning was not significant (*b* = .17, *t* (155) = 1.25, *p* = .21). The direct effect of metacognition on higher order learning was not statistically significant (*b* = .10, *t* (155) = 1.23, *p* = .22). The direct effect of cognitive flexibility on higher order learning was significant (*b* = -.17, *t* (155) = -2.30, *p* = .02).

The total effect of traditional mindfulness on higher order learning was not significant (*b* = .15, *t* (159) = 1.12, *p* = .27). The indirect effect of traditional mindfulness via metacognition (IE = .02) is not significant, 95% CI (-.01, .08). The indirect effect of traditional mindfulness through cognitive flexibility (IE = -.04) was not significant, 95% CI (-.13, .01). The full proposed serial mediation model of traditional mindfulness indirectly influencing higher order learning through metacognition and cognitive flexibility (IE = .00) was not significant 95% CI (-.01, .02). The model summary from this analysis can be viewed in Table 21 below. Hypothesis 7b was not supported, traditional mindfulness does not indirectly effect higher order learning through metacognition and cognitive flexibility; all proposed mediating effects cross zero in the confidence intervals.

Table 21. *Regression coefficients, standard errors, and model summary information for traditional mindfulness serial multiple mediator model.*

	Consequent											
	M_1				M_2				Y Hghr Ordr Lr			
Antecedent		*b*	*SE*	*p*		*b*	*SE*	*p*		*b*	*SE*	*p*
X Traditional Mindful	a_1	.20	.13	.12	a_2	.25	.15	.09	c'	.17	.14	.21
M_1 Metacog		-	-	-	d_{21}	-.08	.09	.40	b_1	.10	.08	.22
M_2 Cog Flex		-	-	-		-	-	-	b_2	-.17	.07	.02
Constant	i_{M1}	-.06	.07	.44	i_{M2}	-.10	.08	.23	i_Y	-.02	.08	.80
		$R^2 = .49$				$R^2 = .25$				$R^2 = .35$		
		F (6, 157) = 24.79, $p < .00$				F (7, 156) = 7.60, $p < .00$				F (8, 155) = 10.44, $p < .00$		

$N = 164$

Hypothesis 7c predicts that the relative indirect effects on higher order learning would be greater in the guided mindfulness group than the traditional mindfulness group. Given that hypotheses 7a and 7b were not supported, no comparison between relative indirect effects is possible and the null hypothesis is accepted, there is no difference in the relative indirect effects between the guided mindfulness and traditional mindfulness conditions.

Post Hoc Analyses

Post hoc analyses were performed to gain a deeper understanding of why the experimental manipulations had relatively no impact on overall or higher order learning beyond the low N underpowering some of the analyses (i.e., ANCOVA). Source of recruitment may have presented a difference influencing the results of the analyses. The difference between the recruiting sources on performance on the variables under test in the study is explored and a retest of hypotheses 6a and 6b was conducted. Next, self-efficacy is a construct known to have a statistically significant relationship with both learning and contemplative practices; post-hoc tests are performed in alignment with findings from a study showing self-efficacy as a potential moderator between potential flexibility and practical flexibility (e.g., Liu et al., 2018).

Recruitment Sources

Independent sample t-tests were conducted subdividing the participants into the two sources of recruitment, a temporary agency group ($N = 163$) and a university group ($N = 51$). The manipulation check for achievement of state mindfulness was conducted for only the university group across conditions. After adjustment for pre-intervention reported trait mindfulness, there was not a statistically significant difference in post-intervention reported state mindfulness between the interventions $F\,(2, 47) = .51$, $p = .61$, $\eta^2 = .02$, power = .13. No difference was found between the groups on the overall learning pre-test ($t = -1.84$, df = 212, $p = .07$) or the pre-test higher order learning subscale ($t = -1.82$, df = 212, $p = .07$). However, there were significant differences across all other variables except for metacognition. Table 22 below presents the results of these tests. Metacognition had no statistically significant correlation with any of the tests of learning. While it did correlate significantly with several of the covariates, it will be dropped from further analysis. Overall, university participants performed significantly better than temporary agency participants.

Table 22. *Results of independent sample t-tests of differences between source of recruitment groups.*

Variable	Results	Agency	University
Post Overall Learning	t = -4.70, df = 212, p = .00	M = .48, SD = .20	M = .64, SD = .20
Post Higher Order Learning	t = -4.84, df = 212, p = .00	M = .44, SD = .22	M = .61, SD = .21
Metacognition Time 1	t = 1.85, df = 212, p = .07	M = 3.80, SD = 1.11	M = 3.48, SD = 1.02
Metacognition Time 2	t = 1.08, df = 212, p = .06	M = 3.63, SD = 1.26	M = 3.42, SD = 1.00
Cognitive Flexibility Time 1	t = 2.86, df = 182, p = .01	M = 43.90, SD = 18.29	M = 35.29, SD = 16.30
Cognitive Flexibility Time 2	t = 3.08, df = 100[1], p = .00	M = 40.08, SD = 16.63	M = 32.75, SD = 13.09
Cognitive Ability	t = -3.51, df = 212, p = .00	M = .35, SD = .21	M = .47, SD = .24

[1] Levene's Test of Equality of Variance was significant driving lower degrees of freedom.

Contemplative Strategies and Self-efficacy

Multiple regression analyses of whether guided mindfulness and traditional mindfulness practices, respectively, were predictive of post-experiment self-efficacy were conducted. The linear combination of baseline self-efficacy, guided mindfulness, and cognitive ability was significant R^2 = .30 F (3, 210) = 29.42, p < .00; adjusted R^2 = .29. Examination of the coefficients showed that neither guided mindfulness (β = .03, t (210) = .53, p = .59, CI (-.30, .53)), nor, cognitive ability (β = .08, t (210) = 1.29, p = .20, CI (-.35, 1.69)) were significant predictors of post-experiment self-efficacy. Only baseline self-efficacy was a significant predictor of post-experiment self-efficacy (β = .52, t (210) = 8.54, p < .00, CI (.43, .69)).

The linear combination of baseline self-efficacy, traditional mindfulness, and cognitive ability was significant $R^2 = .30$ F (3, 210) = 29.31, $p < .00$; adjusted $R^2 = .30$. Examination of the coefficients showed that neither traditional mindfulness ($\beta = .01$, t (210) = .20, $p = .84$, CI (-.39, .48)), nor, cognitive ability ($\beta = .08$, t (210) = 1.31, $p = .19$, CI (-.34, 1.70)) were significant predictors of post-experiment self-efficacy. Only baseline self-efficacy was a significant predictor of post-experiment self-efficacy ($\beta = .56$, t (210) = 8.56, $p = .00$, CI (.43, .69)).

Cognitive Flexibility and Self-efficacy as Moderators

Liu et al. (2018) conducted a cross-sectional study to test whether the linear combination of potential flexibility, self-efficacy, and use of flexible cognition is predictive of performance on assessment of mathematical flexibility controlling for most recent math scores and procedural skill. Further, they tested the moderating effect of self-efficacy between potential flexibility and practical flexibility in eighth grade students performing linear math equations. The constructs of potential flexibility, practical flexibility, and use of flexible cognition are contextualized variables that nest under the construct of cognitive flexibility. Potential flexibility is the knowledge of strategies that enable flexible performance. Potential flexibility is an antecedent to practical flexibility. Practical flexibility is defined as solving a problem with the most appropriate strategy. Despite knowledge of the most efficient problem-solving strategy (i.e., potential flexibility), individuals may choose level of engagement in practical flexibility based upon switch costs. The authors speculate that this may arise for two reasons. First, use of flexible cognition, or the habit to utilize particular strategy on task performance, may moderate the relationship between potential flexibility and practical flexibility. Second, self-efficacy beliefs on skill at performing flexibly may moderate the relationship. Results of this study indicate that both use of flexible cognition and self-efficacy may moderate the relationship between potential flexibility and practical flexibility.

Contemplative strategies allow for individuals to consider their potential to flexibly perform in different circumstances. This is especially the case with guided mindfulness where participants explicitly engage in planning and reflection on knowledge, skills, behaviors, and strategies to *potentially perform flexibly* embedded within a specific experiential learning situation and context. This could certainly be the case in a traditional mindfulness contemplation as well; however, individuals are provided with general instruction on how to address thoughts (e.g., see thoughts as objects) and where to focus attention (e.g., breathe awareness, body state). As such, it is likely that guided mindfulness will have a greater indirect effect on the experimental BEETLE adaptability subscale of electrical knowledge and skill.

The adaptability subscale of electrical knowledge and skill was built to assess learner's flexibility in the use of novel materials and circumstances to address practical problems. This test is in alignment with the concept of *practical* *flexibility* in that learners are asked to select the most appropriate strategy when solving the problem. The test of cognitive flexibility in this study is more in alignment with Liu et al.'s concept of *use of flexible cognition* as it is a general measure of task and set shifting as opposed to situated within a context. Cognitive flexibility is tested as a moderator between the two different contemplative strategies, respectively, and the adaptability subscale of electrical knowledge and skill. The overall learner's pre-test, cognitive ability, and cognitive flexibility at time one will be held constant. Additionally, a measure of self-efficacy was collected as a part of this study. The measure assesses leaners self-efficacy for learning and performing in the specific class. This measure is also tested as a moderator between contemplative strategies and the adaptability subscale of electrical knowledge and skill. The overall learner's pre-test, cognitive ability, and cognitive flexibility at time 1 or self-efficacy at time 1 will be held constant. Figure 10 below contains a graphical depiction of the conceptual models under test.

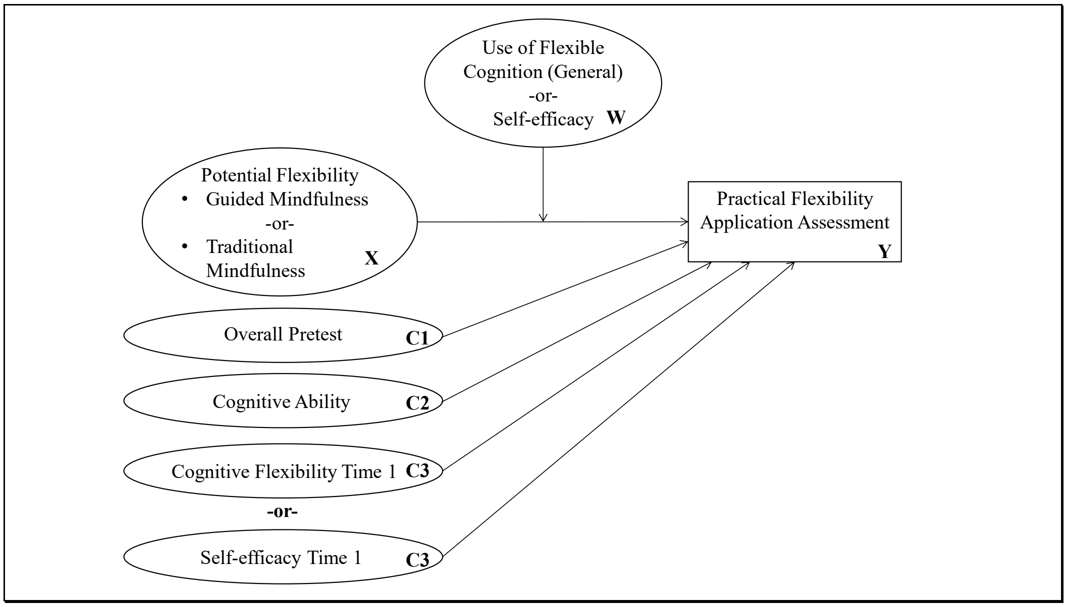

Figure 10. Conceptual diagram of the relationship between contemplative practices and learner's performance on adaptive strategy application post-test moderated by cognitive flexibility or self-efficacy with covariates.

To test whether the use of flexible cognition in general moderates the relationship between potential flexibility, resulting from participating in contemplative practice activities (i.e., guided mindfulness, traditional mindfulness), and practical flexibility test performance a moderated multiple regression analysis was performed using PROCESS 3.1 Model 1. The outcome variable for the analysis was practical flexibility application assessment. The predictor variable for the first analysis was guided mindfulness. The moderator variable was the use of flexible cognition in general. Covariates were overall pre-test score, cognitive ability, and cognitive flexibility measured at time 1. The results of this analysis can be seen in Table 24 below. The interaction between guided mindfulness and use of cognitive flexibility was not statistically significant [*B* = .70, 95% CI (-.23, .48), *p* = .48]. The relationship between guided mindfulness (potential flexibility) and practical flexibility learning performance is not moderated by use of cognitive flexibility in general.

Table 23. *Moderated Multiple Regression of the effect of guided mindfulness on practical flexibility learning performance by cognitive flexibility time 2, controlling for cognitive flexibility time 1, pre-test of overall learning, and cognitive flexibility time 1.*

Predictor		Practical Flexibility Learning Performance		
		Coeff	*SE*	*t*
Constant	i_Y	.11	.09	1.20
Guided Mindfulness (X)	b_1	-.09	.16	-.60
Cognitive Flexibility Time 2 (W)	b_2	-.20*	.10*	-2.06*
Guided Mindfulness x Cognitive Flexibility Time 2 (XW)	b_3	.13	.18	.70
Cognitive Ability (C1)		.14	.08	1.63
Pre-test of Overall Learning (C2)		.25**	.08**	3.11**
Cognitive Flexibility Time 1 (C3)		.01	.08	.14
Overall *F*	5.28**			
Overall R^2	.17**			
ΔF	.49			
ΔR^2	.003			
	$R^2 = .17$, $MSE = .88$; $F(6, 157) = 7.03$, $p < .00$			

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

To test whether the use of flexible cognition in general moderates the relationship between potential flexibility, resulting from participating in traditional mindfulness and practical flexibility test performance, again, a moderated multiple regression analysis was performed using PROCESS 3.1 Model 1. The outcome variable for the analysis was practical flexibility application assessment. The predictor variable was the traditional mindfulness. The moderator variable was the use of flexible cognition in general. Covariates were overall pre-test score, cognitive ability, and cognitive flexibility measured at time 1. The results of this analysis can be seen in Table 25 below. The interaction between traditional mindfulness and use of cognitive flexibility was not statistically significant [B = .10, 95% CI (-.21, .41), p = .51]. The relationship between traditional mindfulness (potential flexibility) and practical flexibility learning performance is not moderated by use of cognitive flexibility in general.

Table 24. *Moderated Multiple Regression of the effect of traditional mindfulness on practical flexibility learning performance by cognitive flexibility time 2, controlling for cognitive ability, pre-test of overall learning, and cognitive flexibility time 1.*

Predictor		Practical Flexibility Learning Performance		
		Coeff	*SE*	*t*
Constant	i_Y	.03	.09	.32
Traditional Mindfulness (X)	b_1	.12	.16	.77
Cognitive Flexibility Time 2 (W)	b_2	-.21*	.10*	-2.03*
Traditional Mindfulness x Cognitive Flexibility Time 2 (XW)	b_3	.10	.16	.65
Cognitive Ability (C1)		.13	.08	1.65
Pre-test of Overall Learning (C2)		.26**	.08**	3.21**
Cognitive Flexibility Time 1 (C3)		.02	.08	.26
Overall *F*	5.31**			
Overall R^2	.41**			
ΔF	.42			
ΔR^2	.00			
	$R^2 = .17$, $MSE = .88$; $F(6, 157) = 5.31$, $p < .00$			

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

To test whether self-efficacy moderates the relationship between potential flexibility, resulting from participating in guided mindfulness activities, and practical flexibility test performance a moderated multiple regression analysis was performed using PROCESS 3.1 Model 1. The outcome variable for the analysis was practical flexibility application assessment. The predictor variable was the guided mindfulness condition. The moderator variable was self-efficacy. Covariates were overall pre-test score, cognitive ability, and self-efficacy measured at time 1. The results of this analysis can be seen in Table 26 below. The interaction between guided mindfulness and self-efficacy was not statistically significant [$B = -.17$, 95% CI (-.43, .08), $p = .19$]. The relationship between guided mindfulness (potential flexibility) and practical flexibility learning performance is not moderated by self-efficacy.

Table 25. *Moderated Multiple Regression of the effect of guided mindfulness on practical flexibility learning performance by self-efficacy time 2, controlling for cognitive ability, pre-test of overall learning, and self-efficacy time 1.*

Predictor		Practical Flexibility Learning Performance		
		Coeff	*SE*	*t*
Constant	i_Y	.04	.08	.52
Guided Mindfulness (X)	b_1	-.10	.13	-.75
Self-efficacy Time 2 (W)	b_2	.28**	.09**	3.02**
Guided Mindfulness x Self-efficacy Time 2 (XW)	b_3	-.17	.13	-1.32
Cognitive Ability (C1)		.19**	.07**	2.64**
Pre-test of Overall Learning (C2)		.22	.07	3.15
Self-efficacy Time 1 (C3)		-.06	.08	-.84
Overall F	7.59**			
Overall R^2	.18**			
ΔF	1.75			
ΔR^2	.01			
	$R^2 = .43$, $MSE = .84$; $F(6, 207) = 7.59$, $p < .00$			

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

To test whether the self-efficacy moderates the relationship between potential flexibility, resulting from participating in traditional mindfulness activities, and practical flexibility test performance a moderated multiple regression analysis was performed using PROCESS 3.1 Model 1. The outcome variable for the analysis was practical flexibility application assessment. The predictor variable was the mindfulness condition. The moderator variable was self-efficacy. Covariates were overall pre-test score, cognitive ability, and self-efficacy measured at time 1. The results of this analysis can be seen in Table 27 below. The interaction between mindfulness and self-efficacy was not statistically significant [$B = .05$, 95% CI (-.23, .32), $p = .74$]. The relationship between traditional mindfulness (potential flexibility) and practical flexibility learning performance is not moderated by self-efficacy.

Table 26. *Moderated Multiple Regression of the effect of traditional mindfulness on practical flexibility learning performance by self-efficacy time 2, controlling for cognitive ability, pre-test of overall learning, and self-efficacy time 1.*

Predictor		Practical Flexibility Learning Performance		
		Coeff	*SE*	*t*
Constant	i_Y	-.03	.08	-.36
Traditional Mindfulness (X)	b_1	.09	.14	.65
Self-efficacy Time 2 (W)	b_2	.19	.09	2.20
Traditional Mindfulness x Self-efficacy Time 2 (XW)	b_3	.05	.14	.33
Cognitive Ability (C1)		.19	.07	2.66
Pre-test of Overall Learning (C2)		.22	.07	3.28
Self-efficacy Time 1 (C3)		-.07	.08	-.94
Overall *F*	7.21**			
Overall R^2	.17**			
ΔF	.11			
ΔR^2	.00			
	$R^2 = .17$, $MSE = .85$; $F(6, 207) = 7.21$, $p < .00$			

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

Summary

Overall, the results indicate that the contemplative practices of guided mindfulness and traditional mindfulness had no statistically significant effect on overall or higher order learning. Moreover, the effect on learning was not transmitted through metacognition or cognitive flexibility separately or through serial mediation.

Post-hoc tests examining the differences between recruitment sources indicated no statistically significant difference between participants from the temporary agencies and university on the pre-test of overall learning or higher order learning. Additionally, repeating the manipulation check to determine if university participants achieved state mindfulness showed no statistically significant difference between the groups. However, the university participants performed better on all other measures, except for metacognition. Temporary agency participants performed -.17 standard deviations below the mean and university participants performed .55 standard deviations above the mean on the post-test of overall learning.

The contemplative strategies produced a modest effect size of roughly 2% of the variance in overall learning being accounted for by guided mindfulness or traditional mindfulness practices. Based upon these estimates, the study was underpowered for the planned tests leaving opportunity to explore these questions using different research designs that may produce more definitive evidence.

Chapter 4

Discussion

The present study sought to understand the relationship between the contemplative practices of guided mindfulness and traditional mindfulness on overall learning and higher order learning, as well as how the proposed mechanisms of metacognition and cognitive flexibility mediate the relationships. The use of technology to induce state mindfulness through interaction with applications were paired with an adaptive training system to acquire knowledge and skills. The hypotheses were largely unsupported. The first three hypotheses tested for differences between the groups on overall learning, higher order learning, cognitive flexibility, and metacognition. As mentioned earlier, the study was underpowered, but, particularly for the use of ANCOVA. Unfortunately, conducting ANOVA tests absent accounting for the covariates would have confounded the results and any results would be meaningless. Hypotheses 1a-c stated that there would be statistically significant differences in overall learning between the groups with the guided mindfulness group learning significantly more than the traditional mindfulness or control groups, and the traditional mindfulness group learning significantly more than the control group. Hypothesis 1d made a similar prediction with the guided mindfulness group predicted to exhibit greater higher order learning than the traditional mindfulness or control group. These hypotheses were not supported. The power of the overall test was .17 - .24 and the overall effect size was .02. There are many reasons why these hypotheses may have not been supported beyond the lack of power and modest effect size. Participants motivation to learn the module content or engage in the interventions may have been low based upon comments made in the post-experiment open-ended questions. Participants may have suffered mental fatigue due to the intervention activities paired with skill and behavior-based assessments over a four-hour period such that expected performance would decline. The use of participants naïve to contemplative strategies may not have worked in this short-term experiment involving content that extended beyond lower order learning. Past laboratory experiments have shown statistically significant results in lower order learning (e.g., recognition of non-sense words). In addition, quasi-experiments with students in classroom-based settings have shown differences between groups in formative assessments with no statistically significant differences being realized in summative assessments. This experiment only assessed summative learning.

Hypotheses 2 a-c predicted that the guided mindfulness group would report engaging in significantly more metacognition than either the (a) traditional mindfulness group or (b) the control group, with the traditional mindfulness group reporting greater metacognition than (c) the control group. These hypotheses were not supported. Despite the lack of statistical significance, the guided mindfulness group did express greater metacognition at time 1 than did the other groups; however, the traditional mindfulness group expressed greater metacognition at time 2. The test of metacognition did not work particularly well in this study. Participants indicated very little metacognition across the groups. It is entirely possible that the novelty of the situation combined with interactive, adaptive training technology may have confounded the amount of metacognition in which the participants recognized engaging. A better approach to measure metacognition in future efforts involving interactive technologies, be it an adaptive training system or a guided mindfulness application, could be coding transcripts for indicators of metacognition (e.g., Steinhauser et al., 2015). Additionally, marrying these tests with psychophysiological measures may be particularly fruitful (e.g., Fernandez-Duque et al., 2000).

Hypothesis 3 a-c predicted that the guided mindfulness group would exhibit significantly greater cognitive flexibility than the (a) mindfulness group and (b) control group as defined by lower calculated differences between the measure of cognitive flexibility at times 1 and 2. It was also predicted that the mindfulness group would demonstrate significantly greater cognitive flexibility than the (c) control group. While the guided mindfulness group did show greater cognitive flexibility than both groups, hypotheses a-c were not supported because there was not statistically significant differences between the groups. Again, power for the overall test was .17 may explain this result. Participants in the guided mindfulness group engaged in planning and reflection activities on their learning that may not have enabled them to flex their thinking in response to what they were encountering while learning this type of content. Guided mindfulness was designed to support more tacit types of knowledge and skill, whereas, electricity knowledge and skill is more explicitly. Examination of the responses to the prompts during planning and reflection activities were brief to non-existent making this a tenuous assumption in need of further exploration in future efforts.

Hypotheses 4a and b predicted that metacognition in the guided mindfulness group and the traditional mindfulness group would be statistically significantly and positively related to learning. These hypotheses were not supported with metacognition at times 1 and 2 adding nothing above the pre-test of learning and cognitive ability to the prediction of overall learning. As mentioned previously, the test of metacognition did not perform well in this study. Bivariate correlations of metacognition with overall learning were not statistically significant.

Hypothesis 5a and b states that metacognition will be significantly and positively related to cognitive flexibility in the guided mindfulness and mindfulness conditions respectively. These hypotheses were not supported. Examination of bivariate correlations only showed a statistically significant relationship between these constructs at time 1 for metacognition with time 2 for cognitive flexibility. This may have been a result of the general nature of the test of cognitive flexibility.

A test that more closely aligns with metacognitive regulation and assesses adaptation strategies associated with the learning content directly would more likely yield better results.

Hypotheses 6a and b predicted that there would be a significantly positive relationship between cognitive flexibility and overall learning in the guided mindfulness and traditional mindfulness conditions. These predicted relationships were not supported. It is possible that cognitive flexibility takes time to manifest in novel situations such as engaging with an adaptive training situation never experienced before. Similarly, all participants were naïve to contemplative practices, which may require repeated practice prior to the theorized mechanisms becoming prevalent. Finally, the test of cognitive flexibility consisted of parallel forms. While the forms were administered such that the harder form was administered second, there may have been practice effects present in participant's performance.

Hypothesis 7ab predicted that guided mindfulness and traditional mindfulness indirectly influences higher order learning through effects on metacognition and metacognition's effects on cognitive flexibility. Hypothesis 7c predicted that the effect of guided mindfulness would be greater than traditional mindfulness in this serial mediation. None of these hypotheses were supported. As mentioned previously, the study was underpowered and the effect sizes for both contemplative practices did not exceed .02. Additionally, the lack of a statistically significant relationship between metacognition at time 2 and cognitive flexibility at time 2 in the bivariate correlations, this finding is not surprising.

Limitations

The present study found no indications across the groups in achievement of state mindfulness across the manipulation checks. There is a need for manipulation checks in empirical studies in this area going forward, which require careful planning (Goldberg et al., 2017; Jamieson & Tuckey, 2017). This study used a survey-based instrument to assess achievement of state mindfulness (Brown & Ryan, 2003). The manipulations in this study may not have functioned to produce a state of mindfulness. Alternatively, engaging in a mindfulness practice in an experimental setting may have hampered achieving a state of mindfulness. Finally, Participants naïve to contemplative practices may not have been able to readily identify reaching a state of mindfulness without being educated on what to expect from engaging in the practices a priori. Future research efforts should consider pairing such survey-based instruments with psychophysiological measurement instruments to understand if physiological indicators of mindfulness state are present even when participants are unprepared to identify the indicators of mindfulness state (e.g., expected heart rate, respiration, neurophysiological response).

The current study was underpowered for the modest effect size achieved across the two contemplative practices. Observed power ranged from .17-.22. To overcome this limitation, future efforts should plan for substantially more participants in short experimental designs involving naïve participants. The need for larger sample sizes is a known problem in the current empirical literature examining mindfulness practices across disciplines (Goldberg et al., 2017; Jamieson & Tuckey, 2017). Alternative research designs that utilize known groups of participants who regularly engage in contemplative practices could be used if larger effect sizes are anticipated as expertise in a practice are expected to compensate for larger sample sizes. Longitudinal research designs indicate significant changes in gray matter over time in alignment with the expected outcomes of different practices so this is an area with potential (e.g., Ben-Soussan et al., 2015; Singer, 2018). Conducting virtual experiments, or Design of Experiments, offers an opportunity to better scope and understand key experimental factors prior to conducting human subjects research efforts (Walwanis & Bryan, 2018). Factors such as individual background, amount and type of contemplative practices experienced, task expertise level, nature of the learning activity, and variables expected to interact across the nomological network can be modeled and simulated to achieve a better understanding of fruitful research paths in order to make prudent investments in research efforts where modest effect sizes are probable.

The current study asked the participants in the traditional mindfulness activity to engage in three different embodied meditation practices over the course of the experiment (i.e., mindful breathing, diaphragmatic breathing, body scan). While each of these practices are embodied interoceptive practices, each may have a differential effect on learning and should be addressed in isolation in future experiments. Extending the Matrix of Mindfulness-Related practices across the revised taxonomy of educational objectives may provide an opportunity to develop a systematic contemplative learning science research agenda to address practices believed to have the highest practical payoff to learning (Krathwohl, 2002; Lutz, Jha, Dunne, & Saron, 2015). Along these lines, contemplative practices are considered more of an art than a science and one of the known challenges is that it is not well understood what participants in any given study experience when a given practice is described by title only (Goldberg et al., 2017; Jamieson & Tuckey, 2017). A database of practices that can be utilized across experiments would offer the opportunity to provide one-to-one comparisons. In addition, if particular practices are found to be effective, they could be utilized by educators and trainers supporting the need for an evidence-base practice in this area (Shute, 2018).

Active control conditions are a known shortfall in the empirical literature base exploring mindfulness (Goldberg et al., 2017; Jamieson & Tuckey, 2017). While this study did have an active control condition, participants in this condition learned different study skills across the intervention points of the experiment that would not be useful to learning in a classroom-based environment and were not accommodated for in this study (e.g., participants were instructed on note-taking skills where no provision for taking notes was provided). Future studies should seek to have more parallel active control conditions where participants engage in the same activity during each intervention point.

Future Directions

The present research explored two contemplative practices – guided mindfulness and traditional mindfulness meditation to better understand the effects of each on learning. These practices fall at different levels in the metacognitive model of mindfulness with traditional mindfulness practices falling closer to "being" in the moment and guided mindfulness falling closer to focused "doing" in the moment thought patterns. Lyddy and Good's (2017) effort to build an inductive model of mindfulness in the workplace identified that workers jump between the cognitive modes of "being" and "doing" depending upon individual and situational factors present in the workplace. This state of cognitive cycling between being and doing modes, referred to as disentanglement, was found to be associated with positive functioning and feeling. Conversely, being enmeshed in a doing mode, referred to as entanglement, was associated with negative functioning and feeling. Interviewees in their study found it challenging to cycle back and forth between being and doing in the state of disentanglement or to move out of the entanglement state. It would not be unexpected for learners to experience similar phenomena over the course of learning activities.

Research is needed to better understand the state of disentanglement and what practice interventions could be put in place to facilitate moving between being and doing cognitive modes effectively while engaging in different types of tasks. Experiential learning systems that support both guided mindfulness and traditional mindfulness contemplative practices working in tandem with one another may offer promise to facilitate smooth transitions between these modes. Testing the additive value of each practice alone and in combination within a controlled laboratory experiment focused on experiential learning offers promise to understand both the effects on disentanglement processes, movement between being and doing modes more effectively across curriculum activities, and learning outcomes across the revised hierarchy of educational objectives. Such an approach, would also offer opportunities to utilize other forms of measurement that could illuminate the mechanisms underpinning contemplative practices (e.g., Lyddy & Good, 2017).

The present study explored the effects of an embedded psychophysiological practice and an embodied interoceptive practice. While each practice is expected to engage the executive functions of the brain, embodied interoceptive practices extend into other areas of the brain involved in physiological functioning. Ben-Soussan et al.(2015) conducted a longitudinal study exploring the effects of the whole body movement embodied practice of quadrato motor training[4], simple

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[4] Quadrato motor training is an embodied contemplative practice structured for individuals to move in accordance with oral instructions to move to a specific corner within a 50 x 50 cm square. The purpose of the practice is to develop coordinated motor response and focused cognitive processing

clockwise movement, and verbal training on cognitive flexibility as measured by an alternate use task and ideational fluency. Participants engaged in a daily practice for four weeks. Results revealed statistically significant differences in cognitive flexibility in the quadrato motor training group; there was no statistically significant difference found between the groups on ideational fluency. These differences positively correlated with structural changes in the brain with increased grey matter in the cerebellum, middle frontal gyri, and inferior frontal gyrus. These results provide evidence that changes in brain regions traditionally associated with motor activity play a role in higher order cognitive functioning. This is supportive of the notion that guided mindfulness, a largely verbal activity in the planning and reflection activities, may benefit from the addition of embodied practices. These additional practices could be in the form of an adjunct activity to the framework or a potential enhancement to the proposed simulation activity along the lines of mental simulations that professional athletes engage in, borrowing from the Sports Psychology literature. If neurocognitive measures are undertaken to better disentangle the differential effects of the practices separately and in combination, a significant contribution may be made to the neurocognitive science literature in provision of a more refined understanding of the role that the cerebellum plays in cognition and learning, which is ill understood at this time, in real world experiential learning tasks.

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with the end goal of fostering creativity and reflexivity (Ben-Soussan, Glicksohn & Berkovich-Ohana, 2015).

Along these lines, there is a need to triangulate on assessment of the effect of the different practices through measures beyond surveys for mindfulness state due to concerns of social desirability inflating responses (Jamieson & Tuckey, 2017). These authors suggest looking at cognitive processes associated with mindfulness such as increased working memory, focused attention, affect, and attentional bias. Future work could also utilize psychophysiological measurement techniques in conjunction with self-report measures to better understand the effects of different contemplative practices. For example, the present study looked at metacognition and cognitive flexibility as two theorized proximal outcomes of contemplative practices. The use of EEG could easily complement the measurement approach taken here to understand if manipulations are operating as expected based upon known brain activation patterns associated with these constructs. Similarly, heart rate arousal offers promise to understand the affects of mindfulness practice on stress and strain as it relates learning outcomes.

Conclusions

This study examined the impact of two different contemplative practices, guided mindfulness and traditional mindfulness, on overall and higher order learning. Specifically, it was proposed that these practices transmit effects on learning indirectly through a serial relationship between two proposed theoretical mechanisms arising from these practices - metacognition and cognitive flexibility. The effect was predicted to be greater in the guided mindfulness group than the traditional mindfulness group due to the nature of the practice being embedded within the learning context. Results indicate that there was no differences in the groups in overall or higher order learning across hypothesis. Metacognition tested as a moderating and mediating mechanism in overall learning and higher order learning was not supported. This could have been an artifact of the particular measurement instrument chosen or the absence of power in the study. The discussion section outlines specific recommendations to address this construct in the future from how it is operationalized and measured to more effective research methods to effectively isolate the construct and the associated nomological network. Cognitive flexibility was tested as a moderator between each contemplative practice respectively and overall learning. Based upon a significant correlation at times 1 and 2 with all measures of learning and the results of a recent study (i.e., Liu et al., 2018), this relationship was followed up on in post hoc testing exploring whether the relationship between contemplative practices, as facilitative of potential flexibility, and the use of flexible cognition in a test of non-traditional materials to solve electrical problems is moderated by practical flexibility. The proposed relationship was not supported using the data produced from this study. This relationship was also explored using self-efficacy as a moderator, which was also not supported. Future studies should consider examining these relationships further with materials designed explicitly for this purpose.

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Appendix A: Guided Mindfulness Prepare and Reflect Prompts

Guided Mindfulness Prepare and Reflect Prompts

Prior to Lesson 1

PREPARE QUESTIONS:

1. Think back on a time when you taught someone something. What strategies did you use to help that person learn better? How can you use those strategies to help you learn better today?
2. How would you solve a hard problem with limited facts? What strategies might you use?
3. How do you work through situations where things are not as organized as you would prefer?
4. Do you think you will feel frustrated during this training? How will you work through the parts of the training that may be hard to understand?
5. When learning something new, how do you relate to what you are learning? How do you think this will help you during this training?
6. How can you test yourself to increase your knowledge and skill?

After Lesson 1

REFLECT QUESTIONS:

1. How has your training shown that there are multiple reasons for the same event, or multiple ways to achieve the same solution?
2. Now that you have seen that learning events and concepts can be different but still related, how will you use this information to better prepare yourself to learn next time?
3. Did the training go as planned? How did you use confusion from the training during the learning process to your benefit?
4. In the training, how did you handle situations where tasks were unclear? How did you persevere despite this ambiguity?
5. How will you now adapt to new situations that challenge your learning?
6. Based on the lesson, what could you have done in order to better understand the ideas?
7. How did you make sure that you were really learning the new material during training? Describe the strategies you used.

Prior to Lesson 2

PREPARE QUESTIONS:

1. Think back to the training you just completed. What strategies can you use to help someone learn the material? How can you use those strategies to help you learn better today?
2. How would you solve a hard problem with limited facts? What strategies might you use?
3. How do you manage a disorganized situation?
4. Based on your previous experience, do you think you will feel frustrated during the second part of the training? How will you work through the parts of the training that may be hard to understand?
5. How can you relate to what you are learning? How will this help you during the second part of the training?
6. How can you test yourself to increase your knowledge and skill?

After Lesson 2

REFLECT QUESTIONS:

1. How has the second training shown you that there are multiple ways to achieve the same solution?
2. Now that you have seen that concepts can be different but related, how will you use this information to better prepare yourself to learn a new concept next time?
3. Did the training go as planned? How did you benefit from your confusion during the learning process?
4. In the training, how did you handle unclear tasks? How did you persist despite this ambiguity?
5. How will you now adapt to new situations that challenge your learning?
6. Based on the lesson, what could you have done differently in order to better understand the concepts?
7. How did you make sure that you were learning the material? Describe any strategies you used.

Appendix B: Pre-Experiment Materials

Participant Pre-Experiment Questionnaire

1. Have you undergone training to be an Electrician?
    a. Yes
    b. No
2. Have you taken classes in electricity?
    a. Yes
    b. No
3. Please list any courses you have taken that dealt with electricity and/or circuits:
4. Please list any experiences you have had building, installing, and/or fixing electrical devices/equipment:
5. How long ago were these classes? ______________________________
6. Do you regularly engage in meditation?
    a. Yes
    b. No
7. If yes, how long have you been practicing mediation? __________________
8. How often do you meditate? __________________________

Demographics Questionnaire

Participant Number: ________________

Demographic Questionnaire

1. Gender (circle one):

    Male

    Female

    Non-binary / third gender

    Prefer to self-describe ________________________

    Prefer not to say

2. Age (in years): ____________

3. SAT Score (if taken): ____________

4. ACT Score (if taken): ____________

5. ASVAB Score (if taken): ____________

6. G.P.A.: ____________

7. Education Completed:

    High School

    Technical School

    Some College

    Associate Degree

    Bachelor Degree

    Master Degree

    Ph.D.

8. Please indicate your level of comfort with using a personal computer:

Very Uncomfortable	Uncomfortable	Neutral	Comfortable	Very Comfortable

9. Please indicate your level of comfort with using mobile applications:

Very Uncomfortable	Uncomfortable	Neutral	Comfortable	Very Comfortable

10. Did you have caffeine today?

Yes No

11. If you answered yes, how many caffeinated beverages have you had today?

12. Are you a smoker?

Yes No

13. If you answered yes, how many times have you smoked today?

14. How many hours of sleep did you get last night?

What is the average number of hours you sleep per night?

15. Have you ever used a computer-based training system before? (circle one)

Never | Once | A few times | Many times

If so, please describe the context(s) in which you used them (work? school? personal?).

What topic(s) did you study?

How long were the training course(s)?

Rate your impression of the effectiveness of the system(s) you used?

Very Effective | Somewhat Effective | Neutral | Mostly Ineffective | Ineffective

Appendix C: Measures

Mindful Attention Awareness Scale – Trait (Brown and Ryan, 2003)

Below is a collection of statements about your everyday experience. Using the 1-6 scale below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what *really reflects* your experience rather than what you think your experience should be.

1 = almost always | 2 = very frequently | 3 = somewhat frequently | 4 = somewhat infrequently | 5 = very infrequently | 6 = almost never

1. I could be experiencing some emotion and not be conscious of it until sometime later.
2. I break or spill things because of carelessness, not paying attention, or thinking of something else.
3. I find it difficult to stay focused on what's happening in the present.
4. I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.
5. I tend not to notice feelings of physical tension or discomfort until they really grab my attention.
6. I forget a person's name almost as soon as I've been told it for the first time.
7. It seems I am "running on automatic" without much awareness of what I'm doing.
8. I rush through activities without being really attentive to them.
9. I get so focused on the goal I want to achieve that I lose touch with what I am doing right now to get there.
10. I do jobs or tasks automatically, without being aware of what I'm doing.
11. I find myself listening to someone with one ear, doing something else at the same time.
12. I drive places on "automatic pilot" and then wonder why I went there.
13. I find myself preoccupied with the future or the past.
14. I find myself doing things without paying attention.
15. I snack without being aware that I'm eating.

Mindful Attention Awareness Scale – State

To what degree were you having the following experiences during the BEETLE training?

0 = Not at all | 1 | 2 | 3 = somewhat | 4 | 5 | 6 very much

1. I found it difficult to stay focused on what was happening in the present.
2. I rushed through activities without being really attentive to them.
3. I did tasks automatically, without being aware of what I was doing.
4. I found myself preoccupied with the future or the past.
5. I found myself doing things without paying attention.

Metacognitive Self-Regulation Scale – Revised (Tock and Moxley, 2017)

The following questions ask about your experiences and attitudes going through the *BEETLE module*. **Remember there are no right or wrong answers, just answer as accurately as possible**. Use the scale below to answer the questions. If you think the statement is very true of you, check 7; if a statement is not at all true of you, check 1. If the statement is more or less true of you, find the number between 1 and 7 that best describes you.

1	2	3	4	5	6	7
Not at all true of me						Very true of me

1. During this module I often missed important points because I was thinking of other things.
2. When preparing for this module, I made up questions to focus my attention.
3. If I became confused about something from this module, I went back and tried to figure it out.
4. If the module material was difficult to understand, I changed the way I read the material.
5. Before I studied new module material thoroughly, I often skimmed to see how it was organized.
6. I asked myself questions to make sure I understood the material I have been studying in this module.
7. I tried to change the way I studied in order to fit the module requirements and the adaptive training system's teaching style.
8. I tried to think through a topic and decide what I was supposed to learn from it rather than just reading it over when progressing through the module.
9. When going through the module I tried to determine which concepts I didn't understand well.
10. Before going through the module, I set goals for myself to direct my activities during each segment.
11. If I got confused during the module, I made sure to sort it out afterwards.

Positive Affect Negative Affect Survey

The scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that work. Indicate to what extent you feel this way right now, that is, at the present moment.

1	2	3	4	5
Very slightly or not at all	A little	Moderately	Quite a bit	Extremely

______ interested	______ irritable
______ distressed	______ alert
______ excited	______ ashamed
______ upset	______ inspired
______ strong	______ nervous
______ guilty	______ determined
______ scared	______ attentive
______ hostile	______ jittery
______ enthusiastic	______ active
______ proud	______ afraid

Self-Efficacy for Learning and Performance Subscale

The following questions ask about your motivation for and attitudes about this class. Remember there are no right or wrong answers, just answer as accurately as possible. Use the scale below to answer the questions. If you think the statement is very true of you, circle 7; if a statement is not at all true of you, circle 1. If the statement is more or less true of you, find the number between 1 and 7 that best describes you.

1	2	3	4	5	6	7
Not at All True of Me						Very True of Me

1. I believe I will receive an excellent grade in this class.
2. I'm certain I can understand the most difficult material presented in the readings for this course.
3. I'm confident I can understand the basic concepts taught in this course.
4. I'm confident I can understand the most complex material presented by the instructor in this course.
5. I'm confident I can do an excellent job on the assignments and tests in this course.
6. I expect to do well in this class.
7. I'm certain I can master the skills being taught in this class.
8. Considering the difficulty of this course, the intelligent tutor, and my skills, I think I will do well in this class.

Trail Making Test

Trail Making Instructions

Follow these instructions exactly as the time includes the time for the instructor to correct errors made by the subject.

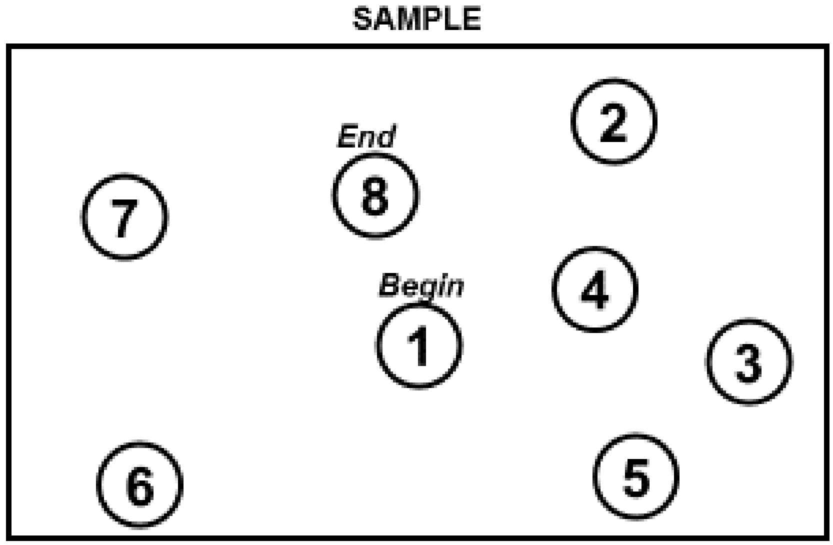
Equipment: Trail Making forms, tablet, stylus, stopwatch

1. Using the Trail Making Part A SAMPLE, demonstrate the test to the subject. "On this page are numbers. Begin at number 1 and draw a line to 2, then to 3, then to 4 and so on until you reach End. without lifting the stylus from the tablet. You should draw the lines as fast as you can. Like this." (demonstrate on the Sample).
2. Give subject stylus and Trail Making Part A. "Now it is your turn. Do you have any questions? Ready. Begin."
3. Time the subject. Stop the subject if an error is made and return subject to last correct circle. The clock keeps running during corrections, but the subject should not be penalized if the examiner takes too long to explain the error. If the subject misses a circle, remind subject to touch all circles, but do not stop the subject. Stop the clock when End is reached.
4. Write time in seconds on the form and. Write subject number and date on the form.
5. Using the Trail Making Part B SAMPLE, demonstrate the test to the subject. "This time the page has both letters and numbers. Begin at number 1 and draw a line to the letter A, then to the number 2, then to the letter B and so on until you reach End without lifting the stylus from the tablet. You should draw the lines as fast as you can. Like this." (demonstrate on the Sample).
6. Give subject stylus and Trail Making Part B. "Now it is your turn. Do you have any questions? Ready. Begin."
7. Time the subject, correcting errors along the way. Stop the clock when End is reached. Write time in seconds on the form. Write subject number and date on the form.
8. Enter Trail Making times on the Data Collection Form.

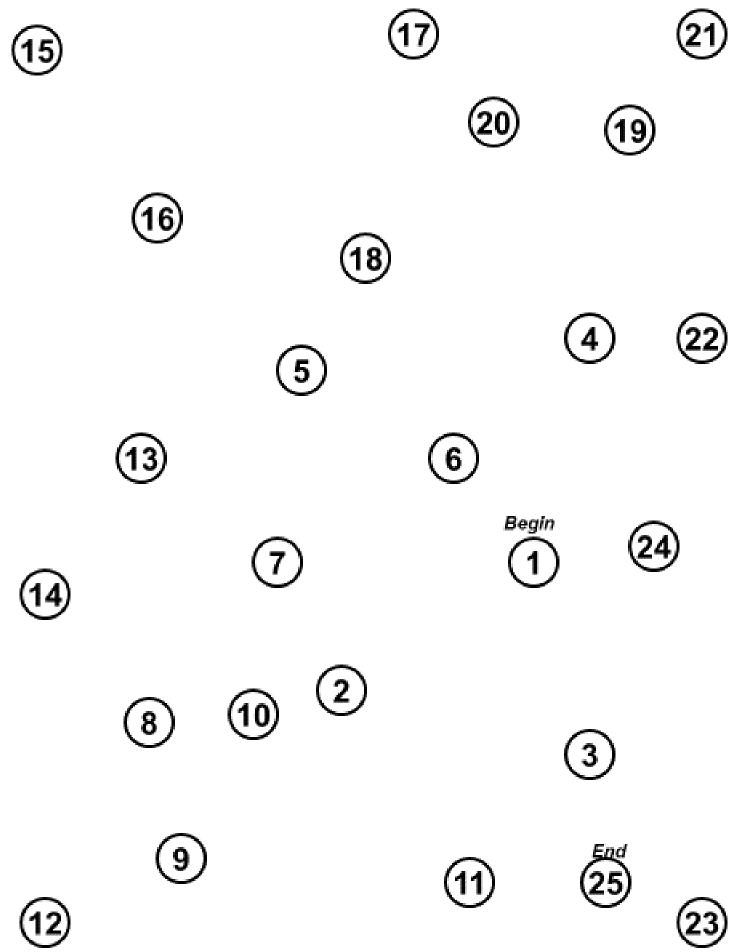
Scoring

	Average	Deficient	Rule of Thumb
Trail A	29 seconds	> 78 seconds	Most in 90 seconds
Trail B	75 seconds	> 273 seconds	Most in 180 seconds

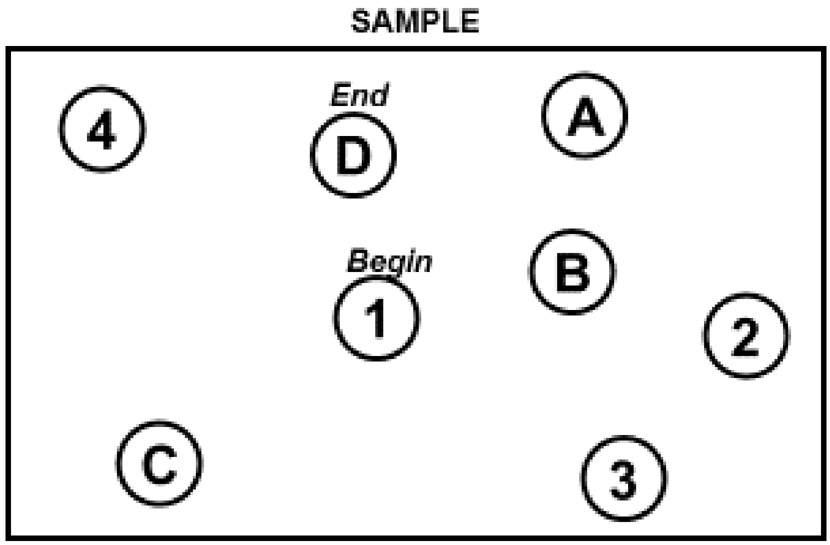
Sample: Part A



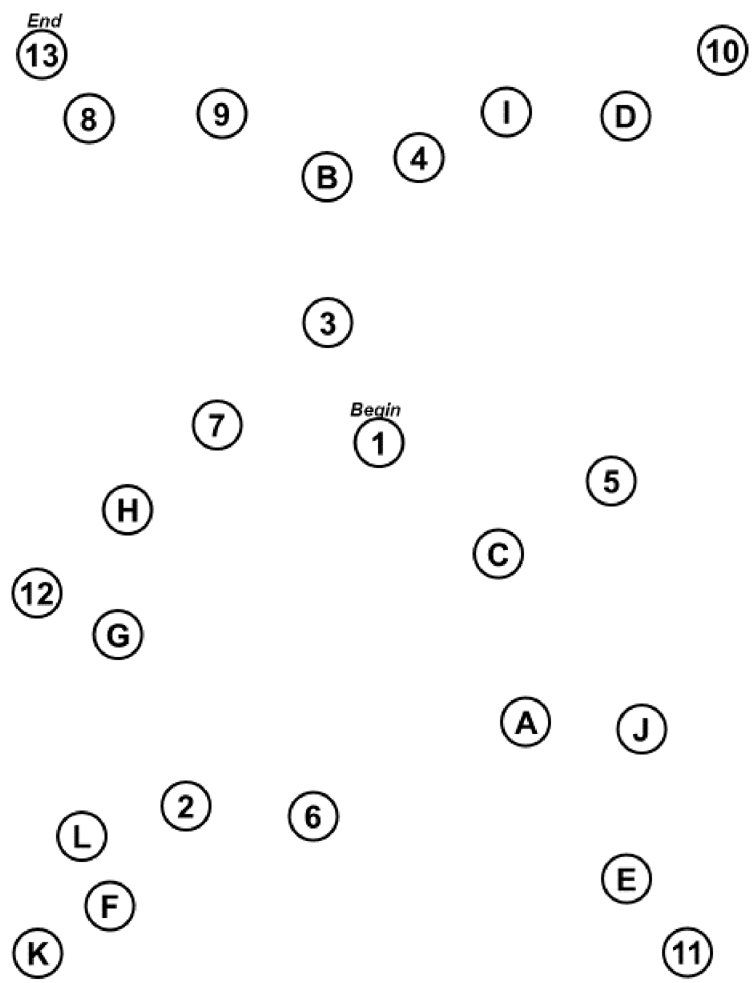
Test: Part A



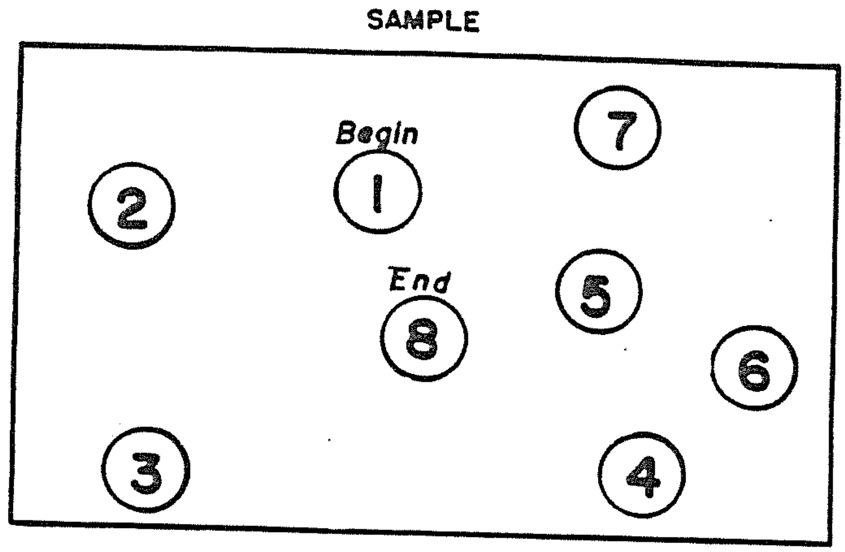
Sample: Part B



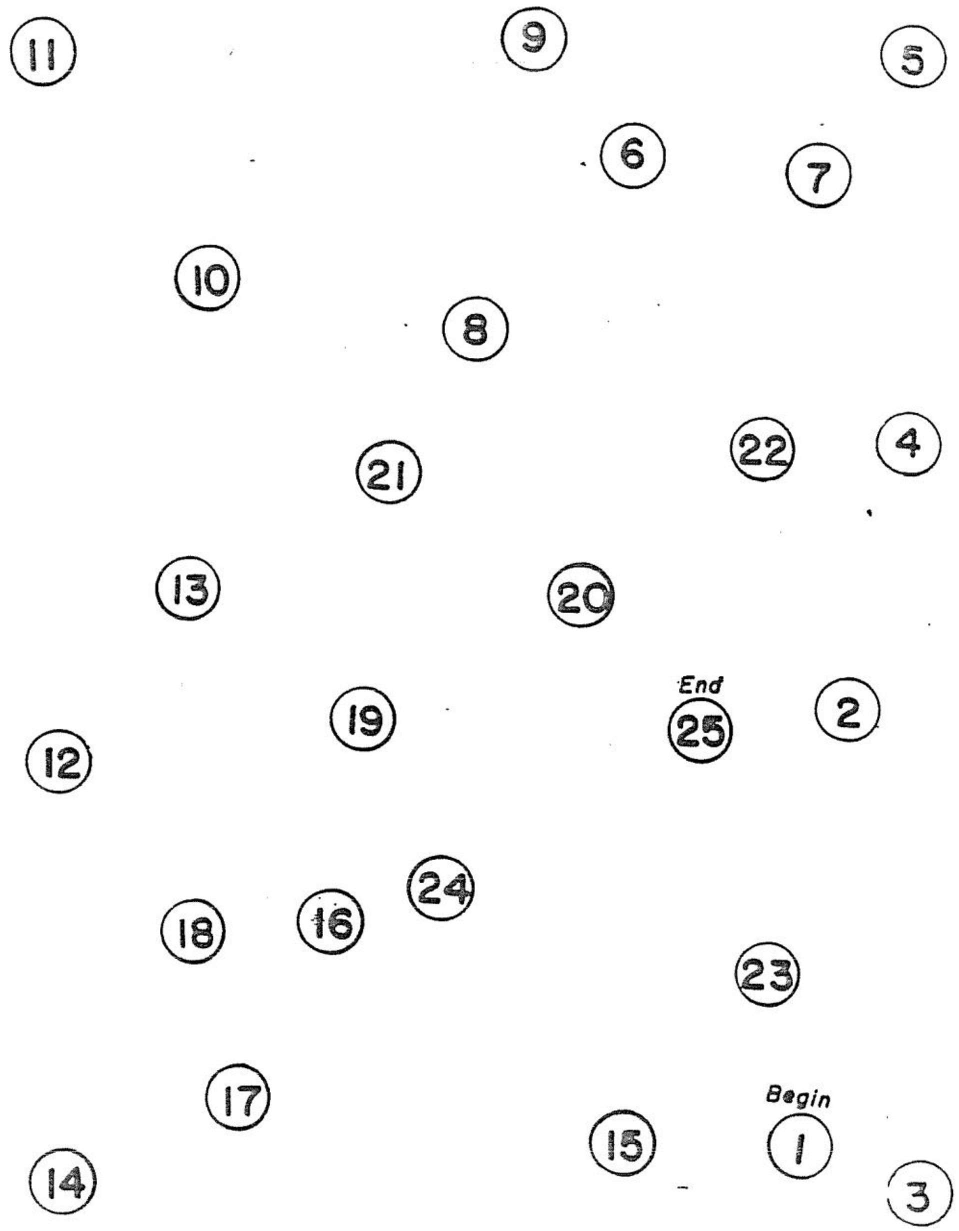
Test: Part B



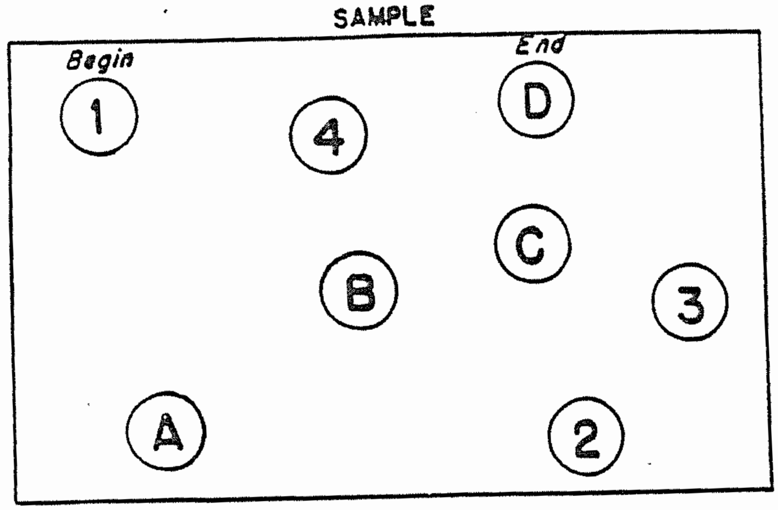
Sample: Part C



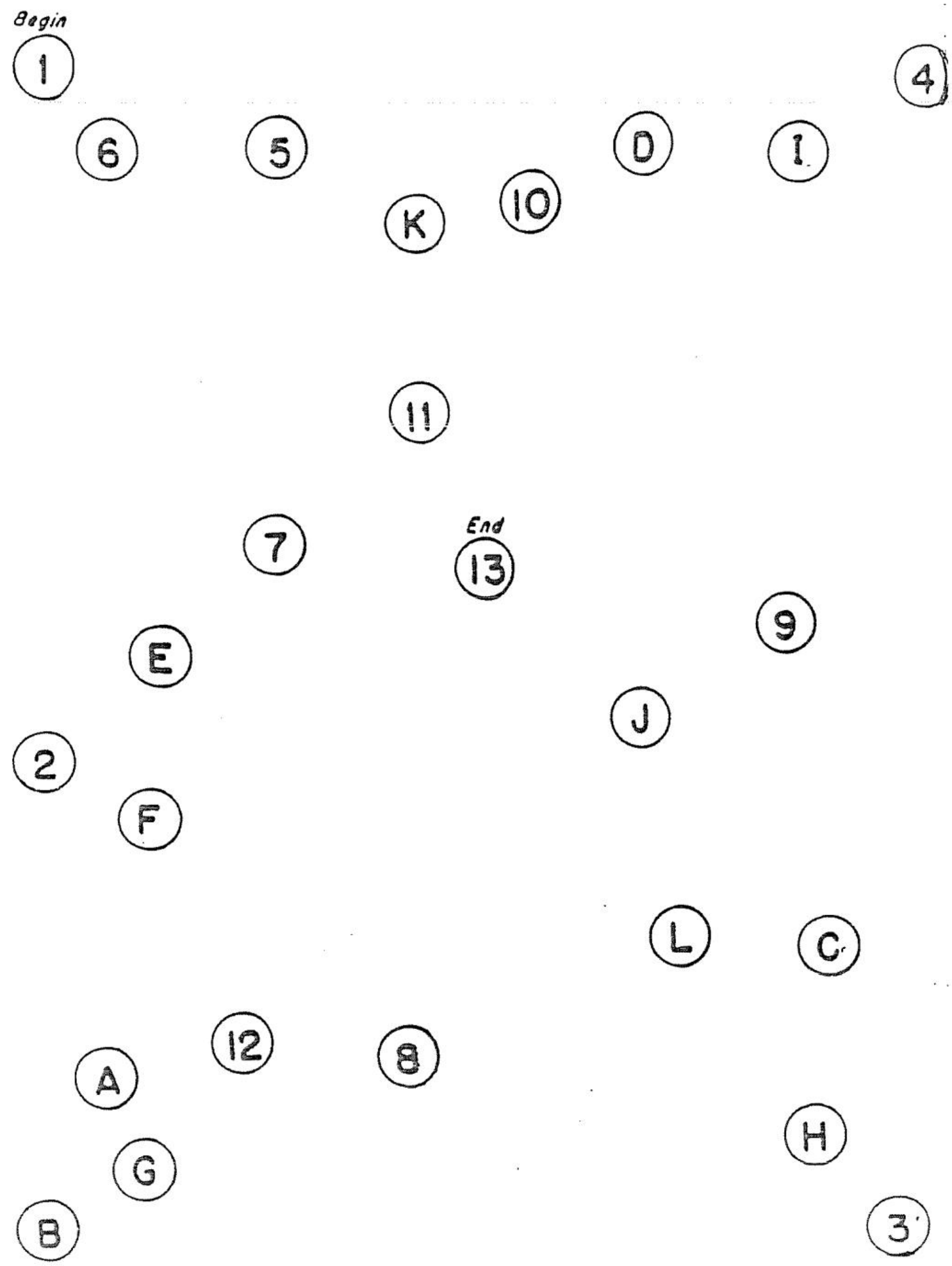
Test: Part C



Sample: Part D



Test: Part D



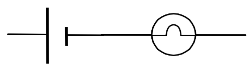
Appendix D

BEETLE Pre-Test v1.4

1) Batteries have _____ terminal(s) and light bulbs have ______ terminal(s).

   A. 1,0
   B. 2,0
   C. 2,1
   D. 2,2

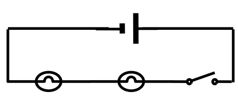
2) Which components are represented in the figure below?



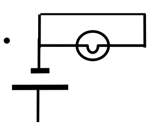
   A. A switch connected to a battery
   B. A battery connected to a light bulb
   C. A switch connected to a light bulb
   D. None of the above

3) In which of the following diagram(s) will the bulb(s) be lit?

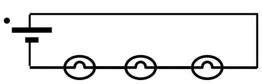
1.



2.

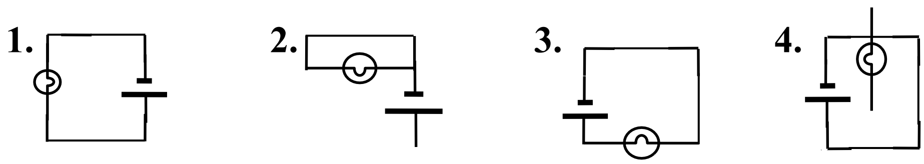


3.



   A. 1 & 3
   B. 2 & 3
   C. 3 only
   D. 1, 2, & 3
   E. None of the bulbs will be lit.

4) Which of the following diagram(s) show a short circuit?



A. 1 & 3
B. 2 & 4
C. 2 only
D. 4 only
E. None of the diagrams show a short circuit

5) Which statement best describes what happens in a short circuit?

A. The battery is damaged
B. First voltage increases; eventually the battery is damaged
C. First voltage decreases; eventually the battery is damaged
D. The battery is not damaged

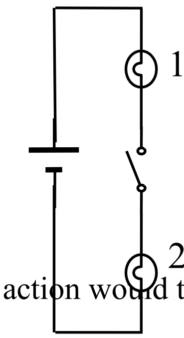
6) Which of the following would create an incomplete circuit?

A. Circuit with a closed switch
B. Circuit with an open switch
C. Circuit with a burned out bulb
D. A & C
E. B & C

7) If a light bulb is in a closed path, then that path does NOT contain:

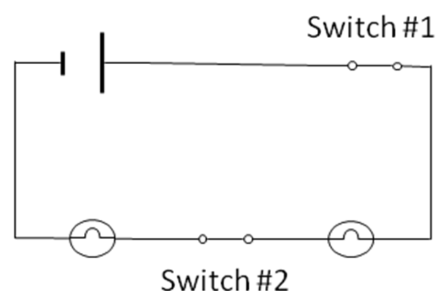
A. A battery
B. A closed switch
C. An open switch
D. None of the above

8) If you were to build the circuit exactly as it is shown in the diagram, what would the status of the bulbs be?



A. Both bulbs would be ON
B. Both bulbs would be OFF
C. #1 would be ON & #2 would be OFF
D. #1 would be OFF & #2 would be ON
E. One of the bulbs would be on, but you can't tell which one from the diagram

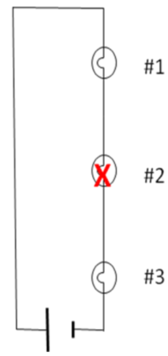
9) In this diagram, which action would turn off both light bulbs?



A. Open switch #1.
B. Open switch #2.
C. Opening either switch would turn off both light bulbs.
D. You would have to open BOTH switches to turn off both light bulbs.

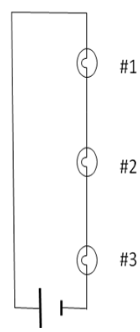
10) If light bulb #2 burns out, what will happen to the other 2 bulbs?

A. They will both stay on.
B. They will both go out.
C. Bulb #1 will stay on, but bulb #3 will go out.
D. Bulb #1 will go out, but bulb #3 will stay on.



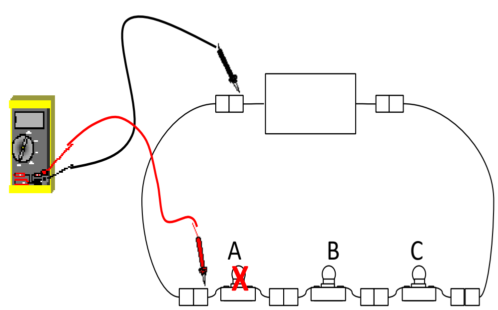
11) Which bulb(s) would have to burn out in order to make bulb #3 go out?

A. Bulb #1
B. Bulb #2
C. Either bulb # 1 or bulb #2 is sufficient
D. Both bulbs #1 and #2 are required
E. Bulb #3 will only go out if it burns out itself



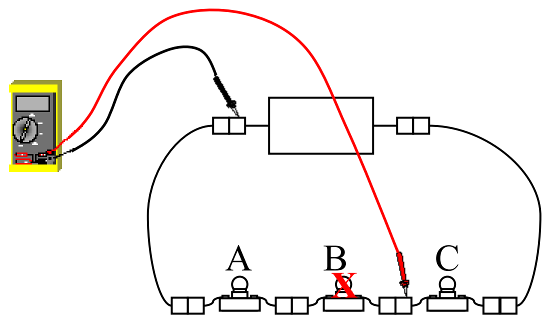
12) Bulb A (only) is burned out. Assume a 1.5 volt battery. What reading do you expect on the multimeter?

A. Can't tell because don't know which side of the battery is positive.
B. Black lead needs to be placed on the other side of bulb A.
C. 0 volts
D. 1.5 volts



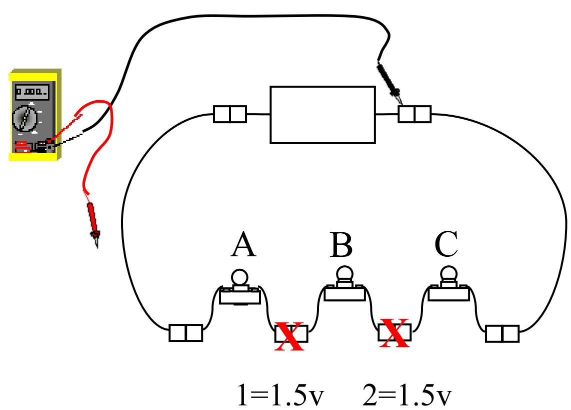
13) Bulb B (only) is burned out. Assume a 1.5 volt battery. What reading do you expect on the voltmeter?

A. Black lead needs to be placed on the other side of bulb B
B. Can't tell because don't know which side of battery is positive
C. 0 v
D. 1.5 v



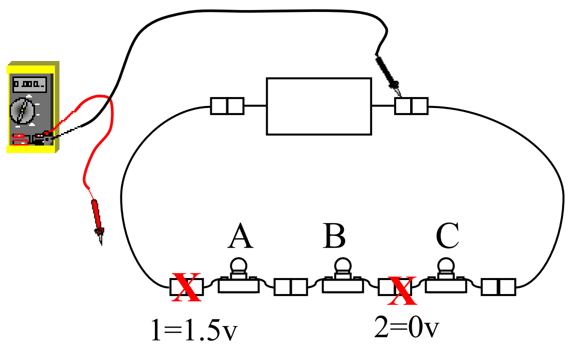
14) All of the wires are in place, but none of the light bulbs are lit. Leaving the black lead in place, a technician took a voltage reading of 1.5 at location 1 and a voltage reading of 1.5 at location 2.
What can she conclude about the light bulbs?

A. Bulb A is burned out.
B. Bulb B is burned out.
C. Bulb C is burned out.
D. None of the above.



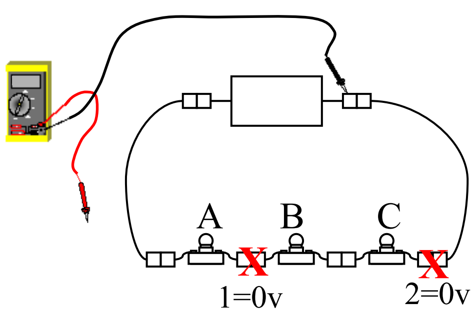
15) All of the wires are in place, but none of the light bulbs are lit. Leaving the black lead in place, a technician took a voltage reading of 1.5 at location 1 and a voltage reading of 0 at location 2.
What can she conclude about the light bulbs?

A. Bulb A is burned out.
B. Bulb B is burned out.
C. Bulb C is burned out.
D. None of the above.



16) A technician knows that exactly one of the bulbs is burned out in the circuit below, but not which one. Leaving the black lead in place, he took a voltage reading of 0 at location 1 and a voltage reading of 0 at location 2. Are any more measurements required to identify the burned out bulb?

A. The technician must measure at the terminal left of bulb A.
B. The technician must measure at the terminal between bulbs B & C.
C. The technician must measure at the both of the other terminals.
D. No more measurements are required to identify the burned out bulb.



17) Which battery produces the largest voltage, “AAA” or “D”?

A. “AAA”
B. “D”
C. The amount of voltage a battery produces depends on whether you put it in a series or a parallel circuit
D. Those 2 sizes of batteries produce the same amount of voltage

18) Which is the BEST explanation for why a multimeter, which can be used to measure voltage, has two leads?

A. Voltage is a property of batteries, so you need one lead for each battery terminal (+ and -).
B. Voltage is a measurement of the difference in electrical states at two points in a circuit, so you need one lead at each point.
C. The second lead is used for measuring current, not voltage.
D. A voltmeter only has one lead.

19) The difference in electrical states between two terminals in a circuit is referred to as:

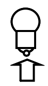
A. Current
B. Resistance
C. Voltage
D. None of the above

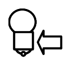
20) How does adding bulbs to a complete circuit affect the voltage of the battery?

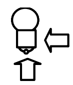
A. Voltage increases
B. Voltage decreases
C. It depends on whether the bulbs are added in series or in parallel
D. Adding bulbs would not affect the voltage of the battery

BEETLE Post-Test v1.2

1) Which of the following diagrams correctly shows the location(s) of a light bulb's terminal(s)?

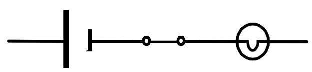
A. 

B. 

C. 

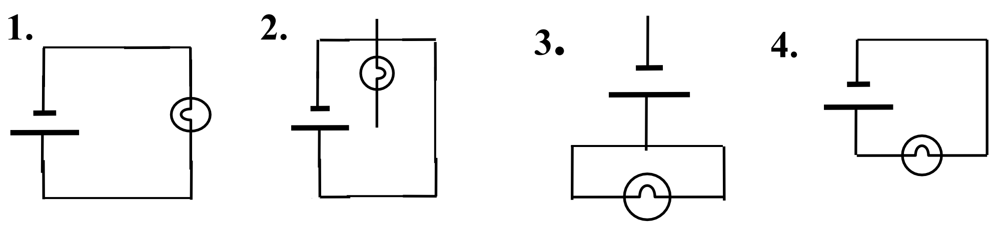
D. Light bulbs do not have any terminals.

2) Which components are represented in the figure below?



A. 1 switch, 2 light bulbs, and a battery
B. 1 battery, 2 light bulbs, and a switch
C. 1 battery, 1 open switch, and a light bulb
D. 1 battery, 1 closed switch, and a light bulb
E. None of the above

3) In which of the following diagram(s) will the bulb light?



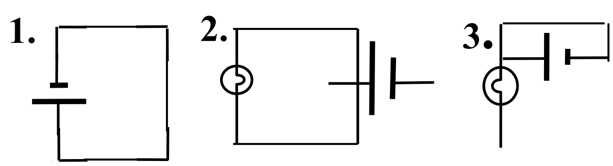
A. 1 only
B. 1 & 4
C. 1, 2 & 3
D. 1, 3 & 4
E. All of the diagrams show circuits that will light bulbs

4) If a light bulb is in a closed path, then that path must also contain:

A. A battery
B. A closed switch
C. An open switch
D. None of the above

5) Which circuit diagram(s) show a short circuit?

A. 2 only
B. 3 only
C. 1 & 3
D. 2 & 3
E. 1, 2 & 3

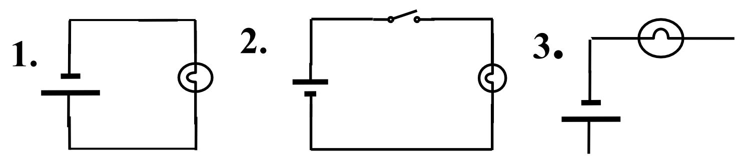


6) Select the option that best completes the following sentence: If you create a closed loop around a battery without any light bulbs in that path, you have made a(n) _______ circuit, and as a result, the battery will _______.

A. open; not be affected
B. short; burn out quickly
C. open; last longer
D. short; last longer
E. open; burn out quickly

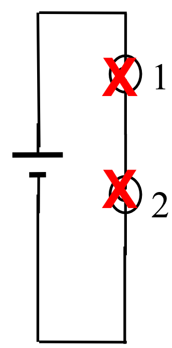
7) Which of the following circuit diagrams shows an incomplete circuit?

A. 1 & 2
B. 2 & 3
C. 3 only
D. All of the circuits are incomplete
E. None of the circuits are incomplete



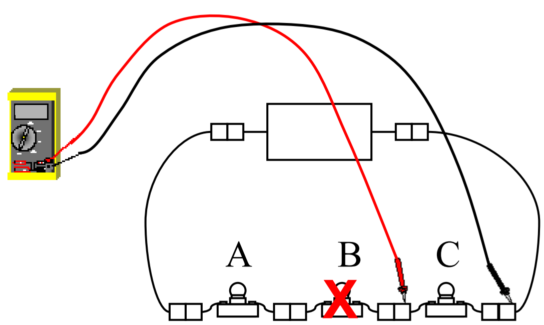
8) Bulbs 1 and 2 are both burned out. Which of the following action(s) would result in at least one of the bulbs lighting up?

A. Replace bulb 1
B. Replace bulb 2
C. Replacing either of the bulbs would work
D. None of the above



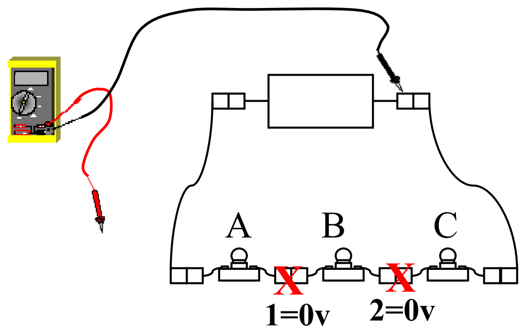
9) Bulb B (only) is burned out. Assume a 1.5 volt battery. **What reading do you expect on the voltmeter?**

A. Black lead needs to be placed on the other side of bulb B
B. Can't tell because don't know which side of battery is positive
C. 0 v
D. 1.5 v



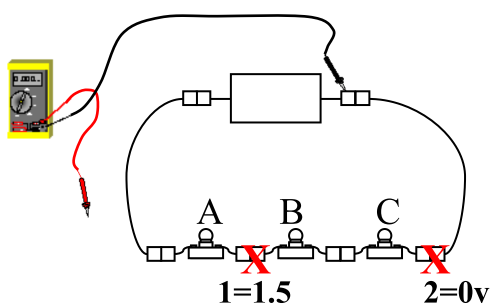
10) All of the wires are in place, but none of the light bulbs are lit. Leaving the black lead in place, a technician took a voltage reading of **0** at both locations 1 and 2. **What can she conclude about the light bulbs?**

A. Bulb A is burned out.
B. Bulb B is burned out.
C. Bulb C is burned out.
D. None of the above.



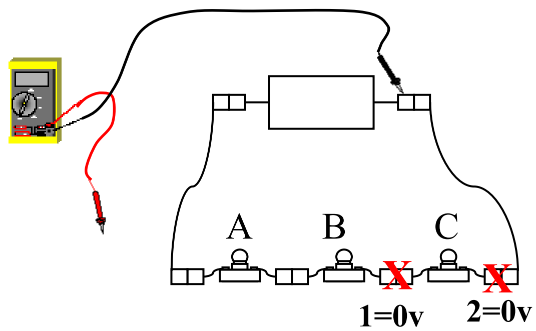
11) All of the wires are in place, but none of the light bulbs are lit. Leaving the black lead in place, a technician took a voltage reading of **1.5** at location 1 and a voltage reading of **0** at location 2. **What can she conclude about the light bulbs?**

A. It must be bulb A that is burned out
B. It must be bulb B that is burned out
C. It must be bulb C that is burned out
D. None of the above.



12) A technician knows that exactly one of the bulbs is burned out in the circuit below, but not which one. Leaving the black lead in place, he took a voltage reading of **0** at location 1 and a voltage reading of **0** at location 2. **Are any more measurements <u>required</u> to identify the burned out bulb**?

A. The technician must measure at the terminal left of bulb A.
B. The technician must measure at the terminal between bulbs A & B.
C. The technician must measure at the both of the other terminals.
D. No more measurements are required to identify the burned out bulb.

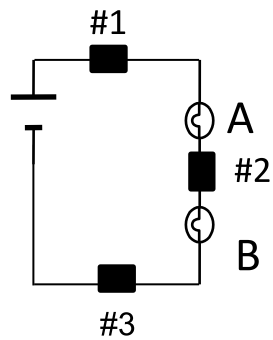


13) Which of the following is a true statement about "AA" batteries and "D" batteries?

A. "AA" batteries have a larger voltage than "D" batteries
B. "D" batteries have a larger voltage than "AA" batteries
C. The amount of voltage that either battery (AA or D) has depends on whether you put it in a series or a parallel circuit
D. "AA" and "D" batteries have the same amount of voltage regardless of the circuit that they are in

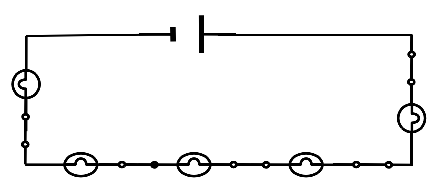
14) There are hidden switches inside of black boxes #1, 2 & 3. Bulb A is on and bulb B is off. Which of the following statements is true?

A. The switch inside black box #1 must be closed
B. The switch inside black box #2 must be open
C. Either the switch inside black box #2 or black box #3 must be open
D. (a) and (c) are both true
E. None of the above – this situation is not possible



15) Jim wants to build a circuit with 5 bulbs, where he could have any number of them in a row on at the same time (1 or 2 or 3 or 4 or all 5). Will the circuit in this diagram allow him to accomplish that goal?

A. Yes
B. No

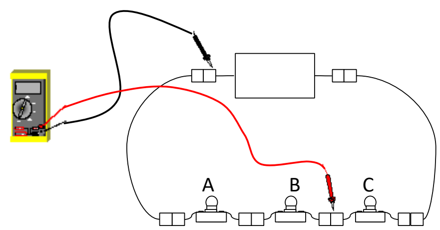


16) Which is the best explanation for why a multimeter, which can be used to measure voltage, has two leads?

A. Voltage is a property of batteries, so you need one lead for each battery terminal (+ and -).
B. Voltage is a measure of the difference between the electrical states at two points in a circuit, so you need one lead at each point.
C. The second lead is used for measuring current, not voltage.
D. A multimeter only has one lead.

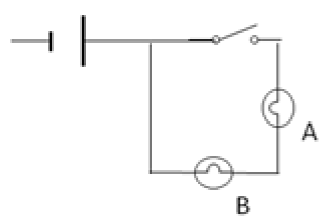
17) All of the light bulbs are out. Which is more informative in this situation: a measurement of 0 v or a measurement of 1.5 v?

A. 0 v
B. 1.5 v
C. They both provide the same amount of information
D. One measurement is not enough to tell you anything



18.) Bulb A is brand new (and works in other circuits), but is not lit in this circuit. Would closing the switch make bulb A light up?

A. Yes
B. It depends on whether or not Bulb B is burned out
C. No



19.) What is the simplest way to light a light bulb based on the following items:

Blue wire

Red wire

Green wire

Paperclip

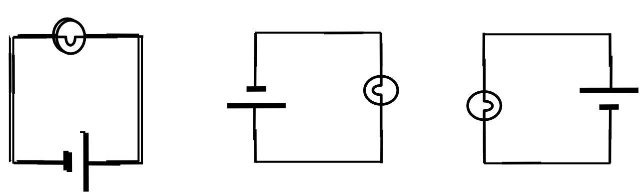
Light bulb

Battery

A. Blue wire, Red wire, Light bulb, Battery
B. Blue wire, Green wire, Light bulb, Battery
C. Any colored wire, Lightbulb, Battery
D. None of the above

20.) Which circuit should light the bulb?

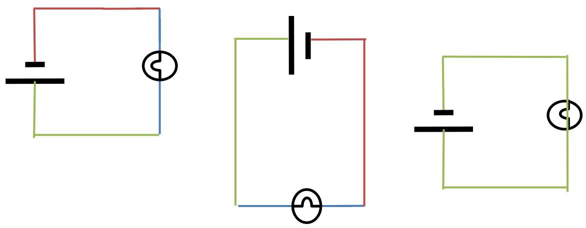
(1) (2) (3)



A. 1 and 2
B. 2
C. 2 and 3
D. 1, 2, and 3

21.) Which circuit will allow for the bulb to light? (colored lines represent the color of the wire)

(1) (2) (3)



A. 2 and 3
B. 3
C. 1 and 2
D. 1, 2, and 3

The following 3 questions are based on the items below

22.) Suppose you wanted to increase the distance between the battery And the bulb to 18 inches, but the current configuration doesn’t reach (the wires are only 12 inches) you could

A. Use the razor blade to cut the casing on the wire and split it
B. Tie one end of the black wire to the other end of the white wire
C. Connect the dime with negative terminal
D. This isn’t possible

23.) Propping up the battery with the dime and razor blade will

A. Increase the brightness of the bulb
B. Decrease the brightness of the bulb
C. Not change the brightness
D. Cause rapid swings in the voltage
E. Cause too much electrical resistance, and the bulb won’t light

24.) Suppose the terminal on the bulb connected to the white wire got loose, you should

A. Buy a new light bulb and unit
B. Use the razor blade to cut the casing of the wire to reduce the electrical resistance
C. Replace the battery
D. Use the dime to tighten the terminal connected to the white wire
E. Use the dime to loosen the terminal connected to the black wire

25.) If the casing on the wire is worn and you need to protect the wire you should

A. Just buy a new wire
B. Tighten all the terminals in the circuit
C. Tape up the wire
D. Cover the lightbulb

26.) If you need to light multiple bulbs simultaneously, it is important to use ____ to achieve maximum brightness

A. A parallel circuit
B. A series circuit
C. A complete circuit
D. A circuit without switches

Appendix E

Open-ended Post-experiment Reactions

Were the activities prior to each training module useful? Why or Why not?

Were the activities after each training module useful? Why or Why not?

Would you use these activities in other training or education classes? If yes, describe what activities you would use and why?

Please provide any comments that you have about the experiment: