THE IMPACT OF SECONDARY TEACHERS' MOTIVATIONAL BELIEFS ON THEIR INTENT TO ACCEPT BRAIN-BASED TEACHING

by

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List of Abbreviations

Behavioral Intent........BI
Brain-Based Teaching........BBT
Mind, Brain, and Education........MBE
Perceived Usefulness........PU
Perceived Ease of Use........PEU
Social Cognitive Theory........SCT
Technology Acceptance Model........TAM

Abstract

THE IMPACT OF SECONDARY TEACHERS' MOTIVATIONAL BELIEFS ON THEIR INTENT TO ACCEPT BRAIN-BASED TEACHING

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Limited information exists in the Mind, Brain, and Education (MBE) field regarding teachers' intent to accept brain-based teaching (BBT). The purpose of this study was to investigate the role of motivational beliefs on secondary teachers' intent to accept BBT through the lens of Social Cognitive Theory and the Technology Acceptance Model. The study also evaluated the validity of a newly adapted BBT Acceptance Intent scale. The BBT Acceptance Intent scale was evaluated favorably and used as the dependent variable in the regression models. A sequential regression assessed the degree of variance in BBT Acceptance Intent based on secondary teachers' (N = 182) motivational beliefs controlling for knowledge, prior experience with BBT, and years teaching. The full model predicted 53% of the variance in BBT Acceptance Intent and revealed previous BBT experience, BBT subjective task value, and BBT perceived ease of use were the most significant predictors. Implications for researchers and educators are discussed in

order to optimize professional development and accelerate MBE application in the context of emerging educational innovations.

Chapter One

The potential for modern cognitive neuroscience to inform scientific understanding of human learning, cognition, and motivation has been established over the past three decades. Initiatives such as *The Decade of the Brain* (Jones & Mendell, 1999), the *How People Learn: Brain, Mind, Experience and School* initiative (National Research Council, 2000), the Economic Social Research Council's Teaching & Learning Research Programme Seminar Series entitled *Collaborative Frameworks in Neuroscience and Education* (Howard-Jones, 2010), and The White House's *Brain Research through Advancing Innovative Neurotechnologies* (BRAIN) *Initiative* (2013) have all moved Mind Brain and Education to the forefront of global educational discourse, research, and practice.

Mind, Brain, and Education (MBE) is defined as research and practice at the intersection of neuroscience, education, and psychology (Tokuhama-Espinosa, 2011). MBE uses cognitive neuroscience and psychology research to inform best practices in the classroom beyond what is known from behavioral and observational research on learning, cognition, and motivation (Petitto, 2003). That is, MBE aims to corroborate behavioral research about classroom learning and teaching with cognitive neuroscience and psychological evidence of the underlying structure and function of the human nervous system. MBE shows promise as an innovative, applied, and transdisciplinary research field (Samuels, 2009).

Although MBE is a driving force for the education community toward evidence-based practice, the integration of disciplines has presented challenges. One obstacle has been establishing an effective link between cognitive neuroscience research and education practice, particularly relating to the creation of a bridge and effective communication (Ansari & Coch, 2006). In particular, the prevalence of misleading neuroscams (Fischer, 2010) and neuromyths (Organisation for Economic Co-operation and Development [OECD], 2007) contribute to the difficulty in establishing an effective communicative bridge. Neuroscams often market training materials by falsely claiming that they are developed using brain-based evidence; these materials often support neuromyths that have been shown to be incorrect or misleading (e.g., left-right brain thinking). As such, teachers face the added challenge of differentiating legitimate science from scam or myth.

Consequently, the main focus of the present study is not MBE itself, but rather the intended acceptance of MBE by teachers. For the purposes of the present study, MBE is termed brain-based teaching (BBT) when applied to teachers' professional practice. BBT is defined as teaching methods and lesson designs that are informed by the latest scientific research about the brain.

The bridge between research and practice cannot be sufficiently built unless teachers are a focus of inquiry. Preliminary descriptive research has shown that teachers (1) are engaged and excited about the prospects of BBT to inform their pedagogy but that transmission of information is a challenge (Pickering & Howard-Jones, 2007; Serpati & Loughan, 2012); (2) tend to have limited knowledge and often subscribe to neuromyths (Dekker, Lee, Howard-Jones, & Jolles, 2012); and (3) often obtain formal pre-service or in-service training from disreputable sources (Teaching and Learning Research Programme, 2007; Dubinsky, Roehrig, & Varma, 2013). Thus, more research is needed on teachers' perspectives—their knowledge of BBT, their beliefs about the use of BBT in practice, and the role that previous experience plays in molding these perspectives.

The existing literature on teacher beliefs and their impact on pedagogical decisions serves as a vehicle for identifying factors that may impact BBT's practical utility (Ajzen & Fishbein, 1980; Pajares, 1992). Analogous areas of research explore teacher acceptance of technological innovations and implementation of project-based learning in the context of teachers' sense of self-efficacy, outcome expectancies, and subjective task value beliefs about educational innovations (Bourgonjon, Grove, Smet, Van Looy, Soetaert, & Valcke, 2013; English, 2013). Utilizing the Social Cognitive Theory (SCT) of motivation (Bandura, 1986) and the Technology Acceptance Model (TAM; Davis, 1989), the purpose of the present study is to understand the impact of teacher knowledge, motivational beliefs, and experience on their intent to accept BBT.

Background of the Problem

In 2016, approximately 50.4 million students were enrolled in kindergarten through grade 12 in the United States public educational system. This number is expected to rise to over 58 million students by 2021. Further, it is estimated that approximately 3.1 million full-time teachers are employed within the public and private education sector in the United States and that the country is expected to spend close to $584.4 billion for public education alone (National Center for Education Statistics, 2016).

Investments in education are crucial because education is essential in promoting a country's economic growth (Global Partnership for Education, 2011). The current public education system seeks to do this by providing students with the academic skills (e.g., mathematics, writing, science) necessary to succeed, as well as critical 21st century practices such as critical thinking and problem solving, effective communication, and ethical responsibility. However, optimizing student acquisition of knowledge and skills is an ongoing area of inquiry in teacher education and professional development communities (e.g., Paas, van Merriënboer, & van Gog, 2012).

Knowledge about learning processes, as explored in the field of psychology, has paved the way for the empirical investigation of teachers' impact on student learning. Stanley Hall and John Dewey's research in the early 20th century highlighted the importance of understanding teachers' knowledge of pedagogy and its impact on learners (Berliner, 2006). The impact of teachers' beliefs and behaviors on student learning hypothesized by Hall and Dewey has since been established empirically (Woolfolk-Hoy, Davis, & Pape, 2006).

Exploration of the brain's plasticity also informs research on teacher-student learning dynamics. William James' work was seminal in introducing that the brain is not a static organ (Berliner, 2006). James' hypothesis that the brain evolves throughout childhood and into adulthood, has since been empirically validated in the neuroscience and psychology literature. This phenomenon is referred to as neuroplasticity, defined as adaptive changes in the structure or function of nerve cells (neurons) or groups of neurons in response to the environment, behavior, or injury (Society for Neuroscience, 2006). This discovery provided empirical evidence that experience and the environment shape the structure and function of the human brain. These scientific advances have served as a catalyst for the union between neuroscience and education research.

Some of the first works unifying neuroscience and education research were published in the early 1990s. In *Making Connections: Teaching and the Human Brain*, Caine and Caine (1991) summarized neuroscience for an education professional audience and introduced the term brain-based learning. This work coincided with *The Decade of the Brain*, designated by U.S. President George H. W. Bush to help spread awareness of the societal implications of neuroscience research (i.e., "brain science"). By 1999, the flurry of attention on brain science engaged the interest of the general public through the release of intriguing findings coupled with innovative brain scanning images shared on mainstream media outlets (Jones & Mendell, 1999).

During the *Decade of the Brain*, more attention turned to the translation of cognitive neuroscience findings in applied settings. In considering the history of cognitive psychology, education, and neuroscience, some doubted whether neuroscience findings could extend to the field of education in a short timeframe. Bruer (1997), a vocal critic, suggested that the recently forged bridge between cognitive psychology and neuroscience was difficult to extend to educational practice. Bruer argued that the research was constrained by methodological limitations, specifically the ability to perform experiments on humans. He stated the connection between cognitive psychology and neuroscience was still in its infancy. Lastly, Bruer stated that neuroscience evidence indicating the important role of complex environments on synaptic development formed the final piece of the neuroscience-education partnership. These were all ground breaking neuroscience findings, but they had little relationship to human cognition.

In particular, Bruer (1997) highlighted key neuroscientific discoveries, in addition to neuroplasticity that helped form the foundation of MBE. These include exuberant synaptogenesis and synaptic pruning (i.e., process of rapid synaptic development in early infancy), followed by pruning of these synapses through childhood and adolescence to create a mature and optimal network of neural systems in the brain. Synaptogenenis explored in animal models, primarily rhesus monkeys, led to investigation of sensitive periods of development in humans, such as language acquisition. Despite Bruer's concerns, the budding field of MBE continued to develop and more advanced technologies addressed Bruer's methodological concerns.

In 2005, Stern discussed the challenges of MBE. She warned of the over-interpretation of neuroscience research and the hasty packaging of this information for eager education professionals. She stated, "neuroscience alone cannot provide the specific knowledge required to design powerful learning environments" (p. 745). However, Stern also highlighted the strengths of the field to provide information on the ability and constraints of the learning brain, and to answer the question of why some learning environments work and others fail.

In 2007, the *Mind, Brain, and Education* journal was established. The founding editors detailed the development and optimization of new technologies for imaging the human brain, addressing one of Bruer's (1997) major concerns (Fisher, Daniel, Immordino-Yang, Stern, Battro, & Koizumi, 2007). In light of these new brain imaging technologies, the need for a reciprocal transfer of knowledge between research and practice to connect the mind, biology, and education became apparent: *Mind, Brain, and Education* serves to provide that link.

Development of MBE in the United States is part of an international movement to understand how to enhance teaching and learning in the classroom, based on the most advanced cognitive neuroscience technology and research (Fischer et al., 2007). The growth of MBE has been fueled by the educational climate of the United States and the world, particularly by the increased focus on international comparisons of student performance (Fischer et al., 2007). In the United States, the No Child Left Behind Act of 2001 mandated integrating the science of learning into schools. Further, the National Research Council (2000) stated that the success of schools and students within those schools is ultimately predicated on teachers' understanding of student learning, cognition, and motivation from both behavioral and neurological perspectives. Hardiman, Rinne, Gregory, and Yarmolinskaya (2012) suggest that initiatives such as No Child Left Behind and Race to the Top have, intentionally or not, shifted the focus to standardized test scores rather than authentic learning. Promisingly, MBE shifts the focus toward understanding how students learn and optimal pedagogy.

Considering the full establishment of MBE, researchers and practitioners have been actively engaged in research-to-practice partnerships. There are currently graduate programs in MBE, annual conferences centered on MBE, and various programs and platforms aimed at disseminating MBE-related information (e.g., The Dana Foundation's Neuroeducation webpage). The United States has maintained a commitment to MBE research with a 2014 investment of 40 million dollars to support research on the structure and function of the human brain through the *Brain Research through Advancing Innovative Neurotechnologies* (BRAIN) initiative (The White House Office of the Press Secretary, 2013).

Still, some scholars and practitioners argue against the validity and relevancy of MBE for influencing educational practice. It is challenging to design studies that are ecologically valid (Bruer, 1997) and translate the findings into usable BBT techniques. Further, educational professionals are faced with the task of differentiating legitimate BBT from neuroscams (i.e., entrepreneurs seeking to capitalize on inaccurate brain-based products; Fischer, 2010).

The obstacles to integration of theory and practice have led to a sub-domain of MBE research aimed at understanding educators' knowledge and beliefs (e.g., Pickering & Howard-Jones, 2007; Serpati & Loughan, 2012; Dekker et al. 2012). Researchers in this sub-field, seek to understand whether teachers intend to accept BBT. Gaining a better grasp of teachers' knowledge and motivational belief structures will help position this emerging research to benefit teachers and students. To do so, the present study builds upon literature on teacher beliefs and acceptance of educational innovations.

Theoretical Framework

The present study aims to understand the impact of teachers' knowledge and beliefs on their intent to accept BBT using the SCT of motivation (Bandura, 1986) and the Technology Acceptance Model (TAM; Davis, 1989), informed by Fullan's (2001) framework of teachers' educational innovation acceptance. The application of BBT can be conceptualized as an educational innovation. The U. S. Department of Education (2004) defines an innovation as:

> ...the spark of insight that leads a scientist or inventor to investigate an issue or phenomenon. That insight is usually shaped by an observation of what appears to be true or the creative jolt of a new idea. Innovation is driven by a commitment to excellence and continuous improvement. Innovation is based on curiosity, the willingness to take risks, and experimenting to test assumptions. Innovation is based on questioning and challenging the status quo. It is also based on recognizing opportunity and taking advantage of it. (p. 1)

To understand the complexity of practitioner adoption of educational innovations derived from research, leaders in the field of education have generated theories of innovation adoption and acceptance. In the 1970s, the information technology industry pioneered innovation adoption as developers aimed to disseminate systems to often-reluctant users in various organizations (Davis, 1989). To understand facilitators and barriers to the delivery of such technological systems, researchers developed the TAM as a framework for investigating the role of user beliefs on their intent to accept the technology with which they had relatively little familiarity.

Behavioral intent to accept an innovation was also informed by the Theory of Planned Behavior (TPB) to expand upon the Theory of Reasoned Action, which aimed to explain voluntary behaviors (Ajzen & Fishbein, 1980). The TPB model highlights the importance of attitudes and beliefs around the anticipated outcomes, risks, and abilities of the individual. In many cases, beliefs such as self-efficacy, garnered from the SCT of motivation, align with this theory—highlighting the close relationship between theoretical traditions.

TPB posits that intent is the antecedent to behavior and, given the appropriate conditions to execute that behavior, the behavior would be aligned to the intent. Further, behavioral intention is influenced by the individuals' beliefs (Ajzen, 2006). The correlation between intent and behavior has been explored in a variety of contexts. Meta-analyses reveal that there is wide variability in the correlation between intent and behavior, but it is approximately .45 (Ajzen, 2011). Some fluctuation is a function of measurement error, specification of the behavioral intent, and the time-period between measurement of intent and behavior. Nonetheless, Ajzen states, "That at its core, TPB is concerned with the prediction of intentions" (p. 1115). This is because actual behavior is often impacted by factors that are outside of the individual's control, such as policy changes or access to information. In the context of technology innovations and acceptance intent, TPB has been adapted to form the TAM.

Recently, this model has been used to test the role of teacher beliefs and their impact on decisions to accept game-based learning (Bourgonjon et al., 2013). These researchers utilized SCT concepts of motivation (e.g., self-efficacy), as well as TAM definitions of beliefs (e.g., perceived usefulness and perceived ease of use), to predict users' intent to accept particular technologies. The choice to use behavioral intent as a dependent variable in the context of technological innovations is based on two arguments. First, the TAM and related TPB framework allow for interpretation and comparison of results with other research from fields in which behavioral intent to accept innovations is predicted. Secondly, researchers (e.g., Bourgonjon et al., 2013) have found that innovations are often new to most users, and thus actual implementation rather than intent to implement would be an unreasonable construct to measure. Based on results about teacher beliefs and knowledge of BBT found in initial studies (Dekker et al., 2012; Serpati & Loughan, 2012), implementation of BBT is similarly nascent to teachers in the US and Europe.

Hall and Hord (1987) proposed a theory of innovation acceptance in schools. The authors highlighted the importance of understanding the process of change and acceptance of innovations, and particularly emphasized that the personal experiences of teachers and administrators contribute to the overall success of educational innovation. Within their Concerns Based Adoption Model (CBAM; Hall & Hord, 1987), the authors detailed four initial levels of innovation use that teachers may report, including non-use (i.e., no interest, no action taken), orientation (i.e., taking the initiative to learn more about the innovation), preparation (i.e., plans to begin using the innovation), and mechanical (i.e., making changes to better organize use of the innovation). Most teachers, it is assumed, fall into the first two to three levels of use in relation to nascent BBT innovation. Thus, understanding motivational beliefs and knowledge of the innovation at the early stages of adoption can help mold future BBT initiatives, such as professional development for teachers.

Another innovation acceptance approach conceived by Fullan (2001) sheds light on the importance of the motivational belief constructs selected as independent variables in the present study. Fullan detailed three factors that impact a practitioners' acceptance of an educational innovation and their decision to act: (1) teachers' expectations for student success, (2) subjective task value, and (3) sense of self-efficacy for enacting the change. For teachers to invest in the change required to adopt an innovation, they must feel that the innovation has value, will result in successful outcomes for their students and themselves, and that they have the confidence to execute the tasks needed to adopt the innovation. Conceptual definitions of these three factors are prevalent in the extant motivational beliefs literature. For the present study, SCT of motivation is used to frame these belief constructs. According to the SCT of motivation, individuals' functioning is a product of their personal and cognitive factors, environment, and behavior (Bandura, 1986).

Bandura (1977) defines outcome expectancy as the estimate that a behavior will lead to a certain outcome. According to Fullan, a teacher's expectancies about success influence their decision to focus their energy on the novel innovation. Thus, if a teacher believes that BBT will benefit students, there is a greater likelihood of the teacher indicating an intent to accept BBT.

Wigfield and Eccles (2000) conceptualize subjective task value as a combination of *attainment* value (i.e., the importance of succeeding), *intrinsic value* (i.e., enjoyment), *utility value* (i.e., usefulness of the task), and *cost* (i.e., personal sacrifice). According to Fullan, subjective task value influences innovation adoption. Within the context of BBT, a teacher is more likely to indicate intent to accept BBT if they believe that applying BBT techniques in the classroom is important to be successful in their job; that BBT is a rewarding and enjoyable teaching approach; and if they see the potential gains to students as being higher than personal costs.

Bandura (1997) defines self-efficacy as the belief in one's capability to perform a given task. That is, if a teacher's level of self-efficacy is higher for implementation of BBT techniques, then they would be more likely to indicate intent to accept the innovation. In conjunction, expectancy of success, subjective task value and sense of self-efficacy are commonly used to predict behavior (Pajares, 1992).

Years of research on outcome expectancy, task value, and self-efficacy constructs form a social cognitive expectancy-value model of achievement motivation (Pintrich & Schunk, 2002). Extant research in the context of achievement motivation indicates that the three constructs are highly correlated and that task value may be more predictive of behavior than outcome expectancies, and that self-efficacy may be the most important predictor of achievement behaviors (Pintrich & Schunk, 2002). These three belief constructs have also been studied specifically related to teacher acceptance or implementation of educational innovations (e.g., English, 2013; Bourgonjon et al., 2013).

The TAM similarly conceptualized the prediction of behavioral intent to accept educational innovations through motivational beliefs and attitudes, particularly related to technology (Davis, 1989). The TAM defines beliefs that are related to, but are operationalized differently from, those outlined in the SCT of motivation. The TAM is applicable to educational settings due to its parsimony and predictive power found in studies of employees adopting innovative technologies (Teo, Su Luan, & Sing, 2008). Researchers have used the TAM to predict teachers' intent to accept educational technologies including three essential predictors of behavioral intent to accept innovations: perceived usefulness, perceived ease of use, and attitudes related to the technology innovation (Teo et al., 2008). The model predicts approximately 42% of the variance in behavioral intent.

Lastly, the importance of understanding the teachers' current knowledge of the innovation and their previous experience with the innovation and teaching, in general, are key factors in teacher innovation acceptance (e.g., Bourgonjon et al., 2013). Thus, BBT knowledge will be measured using the Dekker et al. (2012) scale that measures both knowledge and subscription to neuromyths. Along with teachers' BBT knowledge scores, BBT experience and years of experience teaching will be used as control variables in the present study.

The present theoretical framework investigates and integrates two widely accepted theories (SCT and TAM) to determine which has the most predictive power in relation to behavioral intent. These frameworks allow for an exploration of the relationship between teachers' beliefs, their knowledge regarding BBT to counteract neuromyths and scams, their prior experience with BBT content, and their intent to accept BBT. Results will be analyzed to determine the unique contribution of the social cognitive variables to the TAM model. The prediction of teachers' intent to accept BBT as an educational innovation will pull from theories of innovation acceptance in both educational (e.g., Fullan, 2001) and non-educational settings (e.g., Davis, 1989).

Moreover, the reliability and validity of two innovation acceptance measures will be compared in order to determine the best measure of the dependent variable for the present study.

Purpose of the Study

The purpose of this study is threefold. The primary purpose of this study is to introduce a theoretically-driven framework to explore teacher beliefs and their influence on their behavioral intent to accept BBT. Established theoretical traditions can help build bridges that effectively tie research to practice. Without a strong tie to practice, MBE is not distinct from its parent disciplines: cognitive neuroscience and psychology (Tokuhama-Espinosa, 2011). Teacher knowledge and beliefs are important to understand to increase practitioners' accurate acceptance of BBT work and rejection of neuromyths and scams that pervade the education community. Neuromyths and neuroscams are barriers to knowledge transfer (Dekker et al., 2012), and teachers' enthusiasm for BBT is a facilitator of BBT innovation acceptance (Serpati & Loughan, 2012). However, little is known about the relationship between teachers' underlying motivational belief structures and their intent to accept BBT.

The second purpose of this study is to examine the predictive power of TAM beliefs (i.e., perceived usefulness, perceived ease of use, innovation attitudes) over and above SCT beliefs (i.e., self-efficacy, outcome expectancies, and subjective task values) with relation to intent to accept educational innovations (in this case, BBT). TAM and SCT of motivation help frame the investigation of teachers' role in building a strong bridge between neuroscience and education and help future researchers design and analyze research based on strong theoretical traditions.

The third purpose of this study is to explore the measurement of behavioral intent as an outcome by aggregating the TAM literature and creating a multi-item scale to use in place of a traditional two-item scale (Teo et al., 2008) and examining measurement reliability and validity. As a function of using theoretical frameworks with vast empirical support, comes measurement rigor that, until now, BBT teacher belief studies have lacked due to their descriptive goals. The present study used adapted scales from empirical studies examining teacher beliefs in various educational innovation contexts (e.g., Bourgonjon et al., 2013; Teo et al., 2008; English, 2013). The scale that performed best according to traditional psychometric principles was used as the dependent variable for the present study.

Educational Significance and Implications

In the United States, nearly $18,000 per teacher is spent annually for professional development efforts; however, teachers often find that the professional development is unhelpful or results in negligible improvements in instruction (The New Teacher Project [TNTP], 2015). In a sample of American in-service teachers, 43% reported learning about brain-based teaching strategies at least once in their careers during a professional development session (Serpati & Loughan, 2012). Meanwhile, Dekker et al. (2012) found that neuromyths are quite prevalent in the global teaching community even when teacher knowledge of BBT is high. While it is likely that many teachers are already learning about brain-based teaching strategies or will learn about them at some point in their career, they are often not learning how to distinguish between fact and myth related to the brain. Many thousands of dollars may be funding professional development that is controversial at worst, and imperfect at best. Further, it is still unclear whether teachers plan to accept BBT as part of their pedagogy.

The BBT field has the two-fold challenge of (1) developing effective professional development for teachers and (2) countering neuromyth and neuroscams that are prevalent in the community. The proposed study is anticipated to yield results that will inform implementation efforts and bridge education and neuroscience. The transdisciplinarity of this research could inform teacher education specialists, education policy makers, education administrators, as well researchers in the neuroscience and psychology fields conducting brain-based research within educational contexts.

While some BBT research is more importantly targeted toward policy makers (e.g., when to introduce second language learning; Petitto, 2003), there are day-to-day issues that are addressed through the curricular planning of individual teachers (e.g., how to influence conceptual change in physics students; Petitto & Dunbar, 2004). Often classroom teachers' transition to leadership roles in schools, districts, and states. Providing teachers with professional development and support is therefore essential (Howard-Jones, 2011) and understanding their beliefs surrounding the innovation prior to engaging in professional development is a logical step (Fullan, 2001).

Beyond understanding teachers’ intent to accept BBT as an innovation in their classroom, this work is significant for the broader educational community. There is a developed body of literature that explains how the brain acquires new information. We also know neuromyths exist and that teachers often espouse them, unknowingly. However, the ultimate goal of BBT has the individual learner in mind in order to optimize learning. The philosophy, while still debated as far as transferability, has been lauded due to its focus on the inner workings of the brain and how individuals learn. This, many would argue, is the essence of teaching. This is likely why teachers report great interest in BBT. They believe that they can help each student they encounter if they have the appropriate knowledge and resources. During a time where teacher, school, and district accountability is driven by aggregate test scores, a focus on the true form and function of learning in the human brain is a reprieve for both teachers and students alike.

Research Questions

The present study aims to address the following two research questions:

1. *Is measurement of behavioral intent to accept BBT through a multi-item approach a valid and reliable assessment of this construct?*
2. *What are the unique contributions of TAM's motivational beliefs (i.e., perceived usefulness, perceived ease of use, innovation attitudes) over and above SCT motivational beliefs (i.e., teacher self-efficacy, subjective task value, outcome expectancy) in prediction of secondary teachers' behavioral intent to accept BBT, while controlling for BBT knowledge, experience with BBT, and teaching experience?*

Definitions

Definitions of the terms central to the present study are provided below.

Mind, Brain, and Education (MBE) is an academic field that synthesizes empirical research and best-practices at the intersection of neuroscience, pedagogy, and psychology in order to develop more effective teaching methods (Tokuhama-Espinosa, 2011).

Brain-Based Teaching (BBT) refers to teaching methods and lesson designs that are informed by the latest scientific research about the brain.

Neuroscam is a non-evidence-based product that is based on false connections to neuroscience research; is often for sale; and claims to help teachers improve pedagogy (Fischer, 2010).

Neuromyth is a misconception about the structure and/or function of the brain that has persisted in popular culture, likely developed due to misunderstanding, misreading, or over-interpretation of facts about the human or mammalian nervous system (OECD, 2002).

BBT knowledge is characterized as an individual's general understanding of the brain and its role in human behavior (Dekker et al., 2012).

BBT professional development includes formal or informal teacher training activities such as reading professional publications, attending professional meetings, and viewing media related to BBT (Ganser, 2000).

Teacher self-efficacy is a teachers' confidence in their capability to influence student performance (engagement and/or learning) even among challenging students (Bandura, 1977).

Outcome expectancy is an individual's estimate that a behavior or action will lead to a certain outcome(s) (Bandura, 1977).

Subjective task value is a combination of *attainment* value (i.e., the importance of succeeding), *intrinsic value* (i.e., enjoyment), *utility value* (i.e., usefulness of the task), and *cost* (i.e., personal sacrifice; Wigfield & Eccles, 2000).

Perceived usefulness is defined as the degree to which a teacher believes that using BBT will enhance job performance (adapted from Davis, Bagozzi, & Warshaw, 1989; Teo, 2011).

Perceived ease of use refers to the degree to which a teacher believes that using BBT will be free of effort (adapted from Davis et al., 1989; Teo, 2011).

BBT attitudes refer to the way a teacher responds to and is disposed towards BBT innovations (Ajzen & Fishbein, 2005; Teo, 2011).

Behavioral intent to accept is the teachers' willingness to use BBT (Davis, 1989; Teo, 2011; Bourgonjon et al., 2013).

Chapter Two

This chapter includes a review of the extant literature from the Mind, Brain, and Education (MBE) field, teacher knowledge and beliefs surrounding brain-based teaching (BBT), and how these constructs impact teacher intentions to accept BBT as a viable strategy for improving and informing pedagogy. Further, closely related research is compiled on teacher beliefs and values regarding other educational innovations to identify research gaps and formulate a framework for the present study.

This review of literature is organized into three sections. First, I review trends within the field of MBE with a specific focus on teacher involvement. Then, the literature review focuses on teachers' knowledge, motivational beliefs, and the prediction of acceptance intent using both the Social Cognitive Theory (SCT) of motivation and the Technology Acceptance Model (TAM) frameworks. The review of the literature concludes with a section brief summary.

Brain-based Teaching Defined

Advances in the field of neuroscience have provided promising avenues for transdisciplinary collaboration among neuroscientists, psychologists, educational researchers, and teachers (Samuels, 2009). This original field for the present dissertation is MBE. Its application in practice is brain-based teaching (BBT) which is defined as research and practice at the intersection of neuroscience, pedagogy, and psychology

(Tokuhama-Espinosa, 2011) and is nested within the larger field of MBE. BBT is the result of the combined effort of researchers and practitioners to accelerate and improve human learning. Specifically, BBT uses evidence from cognitive neuroscience research to inform best practices in the classroom “in ways that could not have been done previously simply by using behavioral or observational methods alone” (Petitto, 2003, p. 74).

Public interest in cognitive neuroscience and brain-based research findings has been a driver of the MBE field. The United States Congress declared the 1990s “The Decade of the Brain” and thus, the momentum increased (Jones & Mendell, 1999). Established during the decade of newfound interest in the brain, the goal of MBE is to function as an optimum science of learning to replace the purely behavioral and cognitive approaches dominating traditional learning theory (Kelly, 2011). In many ways the cognitive neuroscience research being conducted presently is still in its infancy. Due to advances in brain imaging technology, researchers’ understanding of how humans learn based on empirical neurological evidence is increasing at an accelerated rate.

Recent noteworthy contributions to the BBT literature include work on scientific conceptual change (Petitto & Dunbar, 2004); dyslexia and literacy (Goswami, 2009; 2012); autism and information processing/executive function (Just, Cherkassky, Keller, Kana, & Minshew, 2007; Minshew & Williams, 2007); epilepsy and memory/language (Berl et al., 2005; Gaillard et al., 2007); and ADHD and cognitive control (Vaidya et al., 2005). Many of these studies focus on pedagogical challenges educators may face in the public education system. However, challenges and concerns continue to arise in the attempt to connect neuroscientific research results with pedagogy.

Research and opinions of theorists and neuroscientists are well represented in the BBT literature; however, teachers and other educational personnel (i.e., practitioners) who work daily with children are often under-represented in the BBT discussion. Although Howard-Jones (2011) and Pickering and Howard-Jones (2007) highlight the value of promoting a two-way dialogue between cognitive neuroscience research and educational practice in their research with teachers in the United Kingdom, there still exists a paucity of research in this area. Serpati and Loughan (2012) aimed to address the issue of teacher involvement in BBT research directly, and found that teacher beliefs and values regarding BBT are not adequately represented and there is no clear understanding of teacher knowledge, beliefs, and values regarding BBT.

Teachers' acceptance of BBT is instrumental in successful BBT implementation. Implementation, or use, of BBT can be understood at a variety of levels, from classroom lesson development to state or federal policy. In the context of this dissertation, implementation refers to teachers using BBT to inform decisions about day-to-day teaching methods. A stronger understanding of teacher beliefs and values regarding BBT can help MBE researchers to clarify how teachers think about BBT, including their intentions to accept BBT into their pedagogy. These investigations can help drive a concerted effort toward implementation of BBT findings on a national scale.

BBT's Strengths and Challenges

BBT rests on the assumption that a relationship exists between changes in behavioral indicators of cognition and neurological states (e.g., growth/pruning of neurons, synapses, neurological networks), and that this contributes to learning, or conceptual change (Byrnes, 2012). In his introduction to the *Contemporary Educational Psychology* special issue, Benton (2010) suggests that increased educational psychologist involvement in the field can help develop effective translational research aimed at pre-service and classroom teachers.

Empirical literature highlights the relevance of BBT research for education practitioners. For example, using functional magnetic resonance imaging (fMRI), Petitto and Dunbar (2004) presented young adults with facts that disconfirmed their naïve, implicit theories of physics. Stimuli consisted of videos that showed a large ball and a small ball falling at the same rate (Newtonian theory), and another that showed them falling at a different rate (naïve theory). Presentations of conceptually true facts based on Newtonian physics were perceived as inaccurate. Results revealed that inhibition networks within the brain were activated in the naïve observer when shown the theoretically correct videos, but were not activated within the brains of physics students who understood Newtonian physics. The findings of this study suggest that learning a new and accurate concept may be more challenging when a person espouses an inaccurate, or naïve, theory prior to receipt of the accurate information.

The implication of Petitto and Dunbar's (2004) study is that the presentation of analogous information should be used with caution in the classroom if students' inaccurate, naïve concepts persist. An alternative suggestion by the authors is that there is no clear "sensitive period" for learning basic physics concepts, and that introducing formal physics education earlier in learners' lives may prevent the inaccurate conceptual theories from being formed.

Petitto (2003) investigated early language processing of six monolingual infants utilizing near-infrared spectroscopy (NIRS). The study aimed to test the hypothesis that early language processing is not solely a perceptual phenomenon. The infants in the study were spoken to in native and non-native languages. The researchers found significant activation in Broca's Area (known for language processing) in children as young as three months old. These findings suggest that the infants differentiated language-based stimuli from visual stimuli. Due to the activation in this specific area of the brain known for phonological processing in adults, the results indicate that early language development is not simple auditory acquisition, but it involves language-based phonological processing similar to what is observed in adult participants in similar NIRS studies. The authors suggest that these results have implications for education practitioners, particularly related to diagnoses of delayed language ability.

Further, language processing, which was not fully understood through behavioral research, shows that typically developing children process phonological pieces of language early and with the same neural circuitry as adults. By further extrapolating the connection between early language processing and reading ability later in life, education professionals can instate supportive guidelines for students at a very young age rather than intervening at later stages when behavioral indicators are present in reading and writing (Petitto, 2003).

BBT researchers have also examined the role of feedback and goal orientations in learning. One study explored neural cognitive function during criterion- versus norm-referenced feedback after participation in a perceptual reasoning activity (Kim, Lee, Chung, & Bong, 2010). Functional magnetic resonance imaging (fMRI) was used to measure 22 college students' neurological responses during a simple reasoning activity presented to them while inside the fMRI scanner, with feedback provided in real-time. Results revealed that individuals who self-categorized as "low-competence" on the task and were given norm-referenced feedback were more likely to recruit brain regions known for negative affective responses (i.e., the posterior cingulated cortex). However, individuals who self-categorized as "highly competent" engaged the brain regions associated with negative affective responses only when receiving criterion-referenced feedback during their performance on the learning activity. Further, individuals who entered the task with performance, rather than mastery, goals were more likely to use brain regions known for negative emotions when receiving any type of feedback.

Kim et al. (2010) suggest that differential feedback on formative classroom assessments may help teachers tailor the assessment experience for their students. However, this would require teachers to incorporate an evaluation of students' competency beliefs and goal orientations. Additionally, more BBT research is needed to understand the implications of negative and positive affective responses on learning.

The aforementioned studies (Petitto & Dunbar, 2004; Petitto, 2003; Kim et al., 2010) highlight the potential for neurological research to impact educational practice. Petitto and Dunbar's work has clear implications for education practice and is written in language that is accessible to practitioners. Specifically, a teacher might apply the results on conceptual change to his or her instruction methods. The second example of early language processing (Petitto, 2003) and third example regarding emotional reactions to criterion and norm-referenced feedback (Kim et al., 2010) are linked to pedagogy but are complex. Thus, a deeper understanding of neuroscience may be required to interpret the results' implications for the classroom.

Howard-Jones (2011) highlights the challenges of interpretation, or what Kelly (2011) refers to as "sense-making" (p. 18), between the neuroscience field, which espouses an empirical and positivist research paradigm, and the education field, which espouses a constructivist research paradigm. Constituents of each paradigm use different lexicons, necessitating an effective bridge to facilitate communication between the two schools of inquiry. Educational psychologists are in a prime position to serve as translators (Benton, 2010).

It is acknowledged that most neuroscience research is not designed to directly impact practice; therefore we need a particular focus on contextual interpretation of neuroscience research that has the potential to build a bridge and impact education (e.g., Howard-Jones, 2011). Debate still exists about the most efficient method to build this bridge (Ansari & Coch, 2006). Some suggest that social scientists can play a pivotal role in this effort, serving as translators and interpreters to bridge the paradigmatic gaps. Increased involvement from social scientists is likely to help in sense-making and translation between the neuroscientists' findings and teachers' pedagogy (Howard-Jones, 2011). The present study aims to strengthen the understanding of the bridge between neuroscience and education by using social science to understand the practitioners' knowledge and beliefs.

Neuroscams, Neuromyths, and Teacher Knowledge of BBT

Although there is a movement toward rigorous empirically-informed teaching methods within the growing BBT field, there is also a need to counteract the prevalent, non-evidenced based practices sometimes termed "neuroscams" that pervade the field of education (Fischer, 2010). Neuroscams have gained great momentum, capitalizing on the apparent eagerness of educational practitioners who are willing adopt neuroscience principles and improve student learning but lack a thorough understanding of the research supporting such claims.

Bruer (2003) highlights many of the challenges involving the misapplication of neuroscientific results to education. For example, *Brain Gym®* has been widely adopted by educators in the United States and the United Kingdom to improve student learning through a series of exercises that are said to improve response time and attention. For example, the program includes "thinking cap" exercises that claim to facilitate short-term memory, listening ability, and abstract thinking. The thinking cap exercise involves the use of ones thumb and index finger to pull and unroll the outer part of the ear, starting from the top and moving to the bottom of the ear; repeated three times. This is intended to be a brain-training exercise; however, it has little scientific basis.

Hyatt (2009) reviewed the theoretical foundations of *Brain Gym®* and found that peer reviewed research failed to support the approach. Others who have reviewed the approach have called it pseudoscience (Teaching and Learning Research Programme, 2007). Nonetheless, the education community continues to adopt this program and other neuroscams. A clear understanding of teacher perceptions is needed to illuminate some of the misconceptions that lead educators to adopt non-rigorous forms of brain-based packaged products. These misconceptions are also termed neuromyths (Pasquinelli, 2012).

The Brain and Learning project of the Organization for Economic Co-operation and Development (OECD) published the first report on neuromyths in 2002. In 2007, the OECD published a seven-chapter report with a chapter dedicated to dispelling identified neuromyths. Primary neuromyths according to OECD include the following:

- *There is no time to lose as everything important about the brain is decided by the age of three.* Synaptogenesis (i.e., the development and pruning of neuronal synapses) is high early in life, but this does not end.
- *There are critical periods when certain matter must be taught and learnt.* "No critical periods have yet been found for humans" (p. 112). That is, research on critical periods (when only certain types of learning can take place) has only been documented in animals, such as fledglings' attachment to the mother upon hatching. In humans, the term sensitive period is more appropriate, as it indicates a time during which it is easier to learn (e.g., language acquisition early in life) but not impossible thereafter.
- *We only use 10% of our brain.* This myth likely derives from research statements generated before the advent of modern technology. However, 21st century brain imaging and brain surgery techniques have shown that 100% of the brain is active.

- *I am a ‘left-brain’ person; she is a ‘right-brain’ person.* This is one of the most commonly espoused myths, and it stems from research highlighting the distinct functions of regions in the right and left hemispheres of the brain. It is true that there are some cognitive functions, such as face recognition and language, that predominate within one hemisphere. However, current research shows that both hemispheres work in concert for all cognitive functions.
- *Men and boys have different brains from women and girls.* Although there are structural differences in brains and some differences in activation patterns, especially in language processing, there is no evidence supporting gender-specific learning processes.
- *A young child’s brain can only learn one language at a time.* This was a myth that is now better understood through research on multilingual children in the US. Although multilingual children may initially face delays in matching the language abilities of their monolingual peers, research shows that children who learn two languages concurrently actually understand language structure better than monolingual students.
- *Improve your memory.* Although individuals can utilize techniques (e.g., mnemonics) to assist their memory of content, there is still little neuroscientific understanding about how memory functions in the brain. Because memory is not clearly understood, a focus on comprehension (vs. memory enhancement) is necessary.

- *Learn while you sleep.* Although researchers have long attempted to understand the role of sleep in learning, there is no empirical evidence that individuals can learn while sleeping. There is, however, evidence that studying a task followed by sleep helps improve memory.

Discussion about the brain is popular within the media and most human service or social science domains, including those involved in the education of children. Neuromyths have been pervasive as they are derived from studies that are scientifically sound (OECD, 2007). There are cultural beliefs underpinning the persistence of neuromyths, including the fact that, in general, Western society holds the science of the brain as more legitimate than the behavioral sciences (Pasquinelli, 2012). Neuromyths are discussed here because they are the entry point into a discussion about teacher beliefs and knowledge of BBT. The science must be accurately understood for the bridge to effectively link education and neurosciences, and, to that end, teacher knowledge of BBT has been examined in the literature (e.g., Dekker et al., 2012).

Dekker et al. (2012) surveyed neuroscience knowledge among 242 teachers from the UK and Netherlands utilizing a measure of 32 statements about the brain. This sample was unique because all participants had indicated interest in BBT before the survey was administered. The statements on the survey included those that were true (e.g., “The left and right hemisphere of the brain always work together”), false (e.g., “Brain development has finished by the time children reach secondary school”), or a neuromyth (e.g., “Differences in hemispheric dominance (left brain/right brain) can help explain individual differences amongst learners”). The neuromyths were generated based on OECD (2002; 2007) reports.

Results showed that teachers in the sample could correctly answer 70% of the true or false neuroscience knowledge statements, yet 49% of teachers in the sample believed the neuromyths were also true (Dekker et al., 2012). A multiple regression revealed that general knowledge scores enriched by reading popular science magazines significantly predicted an increased belief in neuromyths. These results highlight the difficulty non-experts face in differentiating between pseudoscience and empirically-supported evidence, even when they actively engage in building their BBT knowledge.

A study surveyed 283 in-service teachers, student teachers, and teacher trainers from Switzerland regarding their subscription to neuromyths built on Dekker et al.’s (2012) work (Tardif, Doudin, & Meylan, 2015). The goal was to understand teacher beliefs about neuromyths’ validation in research, whether the teachers believe neuromyths will improve pedagogy, and whether they will consider or do consider using neuromyths as part of their pedagogy. The teachers were surveyed regarding three areas of commonly understood myths: hemispheric dominance, modality dominance (i.e., visual-auditory learning styles), and executive functioning training (e.g., *Brain Gym®*).

Results indicated that there were significant differences in subscription to neuromyths between in-service and student teachers in two areas: hemispheric dominance subscription and beliefs that modality dominance is supported by brain research. Otherwise, there was no significant difference between student-teachers and in-service teachers (Tardif et al., 2015). Analysis of the group revealed that 85% of teachers agreed with the neuromyth, "some people use their left hemisphere more whereas other use their right hemisphere more", and 63% believed that a pedagogical approach based on such a distinction favors learning. Regardless of agreement with the neuromyth, only 27% reported use or intent to use this distinction in their teaching practices. Further, 96% of those surveyed agreed with the neuromyth, "some individuals are visual, others are auditory", and 85% believed that a pedagogical approach based on such a distinction favors learning. In alignment with the level of agreement, 87% of respondents reported use or intent to use this neuromyth in their teaching practices. Lastly, only 18% of respondents were familiar with *Brain Gym®*, however 88% agreed it favors learning and 65% reported use or intent to use the program with their students (Tardif et al., 2015).

Results of Tardif et al. (2015) have two implications for the present study. First, neuromyths still prevail within the teaching workforce. This could be in part due to the incoherence and dissonance regarding neural coherence between behavioral observations using multiple intelligence theories (Shearer & Karanian, 2017). It is imperative that the MBE field comes to a consensus and communicates this effectively to the teacher education community. Secondarily, Tardif et al. has shown that teachers' intent to use BBT-based information is variable. The authors found that there was a large intent to use modality dominance theories in pedagogy, yet little agreement that it would be used for hemispheric dominance. Given that there is more evidence, however controversial, in support of modality dominance highlights the possibility that teachers are willing to accept BBT, if provided with accurate, executable information.

There exists a paucity of research on teacher knowledge of BBT using consistent surveys of teachers in the United States. The present study expands on this new and valuable measure of BBT literacy by assessing a sample of typical teachers, rather than those who express existing interest in BBT, or a combination of teachers and pre-service teachers. Later in this review, I discuss the conceptual aspects of studying teacher knowledge and discuss its distinction to the closely related construct of teacher beliefs. However, I first review teacher pre-service training and professional development in relation to BBT.

Pre-Service Teacher Training and Professional Development

Teachers pursuing a traditional path toward licensure in the United States will likely complete an undergraduate degree with an emphasis on general education requirements, their area of teaching focus (e.g., mathematics), and a handful of professional teaching courses (Wilson, Floden, & Ferrini-Mundy, 2001). The majority of teachers may not register for a course dedicated to understanding how the human brain works and how new information is acquired if it is not a requirement in an already demanding curriculum. Dubinsky, Roehrig, and Varma (2013) found that only five percent of pre-service teacher training in Minnesota required a course related to the brain; and in this case it was one specific course on teaching students who had sustained brain injuries. Dubinsky et al. (2013) used this information to help propel their professional development program called BrainU. The workshops are for in-service middle and science teachers to learn how to infuse BBT into their classroom instruction, so the students *and* teachers learn about the topic of the nervous system's role in learning.

Teacher interest in BBT (e.g., Serpati & Loughan, 2012) and misunderstanding of BBT (e.g., Dekker et al., 2012) has led to the common neuromyths previously discussed, but also to the development of targeted BBT professional development programs beyond pre-service training requirements. One notable BBT professional development program is a certificate program at Johns Hopkins University School of Education. The Mind, Brain and Teaching Graduate Education Certificate is a 15-credit program designed for preschool through postsecondary educators. The program covers brain structure and function, cognitive development, learning differences, research and practical application of topics such as emotion and motivations, as well as academic skills such as mathematics and reading (Hardiman, 2010).

Similarly, Harvard's Graduate School of Education and the University of Texas at Arlington's College of Education and Health Professions maintain graduate-level programs in Mind, Brain & Education. These university-affiliated programs remain uncommon credentials for in-service teachers in the United States.

It is also possible that teachers with exposure to BBT professional development would have experienced in-service, district- or school-sponsored speaker visits to discuss brain-based teaching strategies or via reading books and other materials informally (Serpati & Loughan, 2012). Eric Jensen of *Jensen Learning®* delivers in-service professional development that asserts to connect research with practical classroom applications. For example, *Teaching with the Brain in Mind* is a 4-day workshop that aims to describe the brain principals for teachers. Topics include memory, cognition, emotion, environment, plasticity, mind-body connections, social, stress, and curriculum

(Jenson Learning Corporation, 2013). The trend for entrepreneurs to provide training in popular educational movements is common; however, such programs' scientific soundness has been questioned, and many exemplify pseudoscience (Teaching and Learning Research Programme, 2007).

On the continuum of academic (e.g., Harvard's Graduate School of Education Mind, Brain and Education graduate program) and commercial (e.g., *Jenson Learning*®) professional development, there exists a middle ground. One example of training material for educators either at the pre- or in-service level can be found through the Association for Supervision and Curriculum Development (ASCD) Free Professional Development site (ASCD, 2013). This site includes webinars and handouts from Judy Willis, a trained neurologist and middle school teacher, including topics such as *The Essential Neuroscience of Learning* and an *Ask Dr. Judy* feature with video responses to questions such as: "How can students remember next year what I teach this year?" and "What makes the adolescent and teen brain so different and what should educators do about these differences?" This open-source content provided by ASCD is unique because all educators can access this information if they are intrinsically interested in studying BBT material.

Although teachers' pre-service education and continuing professional development is not the primary focus of the present study, I have outlined the trends observed in the United States today regarding BBT training and professional development. It is evident that there is a paucity of formal training in BBT at the pre-service level, and a wider range of opportunities for post-graduate study, workshops participation, and open-source independent study that can be pursued at the in-service training level. An understanding of the various types of exposure teachers may encounter related to BBT is important to understanding the foundation of teacher knowledge and beliefs regarding BBT, with the ultimate goal of ensuring relevancy of the BBT field. In the following section, general literature on teacher beliefs is reviewed in order to support the theoretical framework of the study.

Teachers' Knowledge and Motivational Beliefs—A SCT Approach

The examination of the role of teacher beliefs has been a topic of consideration for educational researchers and those involved in teacher education and preparation programs for over a quarter of a century (Woolfolk Hoy, Davis, & Pape, 2006). Pajares (1992) defined belief as an "individual's judgment of the truth or falsity of a proposition, a judgment that can only be inferred from a collective understanding of what human beings say, intend, and do" (p. 316). Markus and Wurf (1987) state that understanding beliefs is important because beliefs shape people's behaviors. Ajzen and Fishbein (1980) highlight the close relationship between an individuals' belief and the resulting behavior in their Theory of Planned Behavior. Pajares (1992) reviewed the theoretical and conceptual concerns specifically regarding the study of beliefs within the teaching and learning domain, and he deduced that it is difficult to argue against the role of teachers' beliefs on their behavior in the classroom—they are integral to understanding teacher behaviors.

Philosophers and educational researchers have challenged the distinction between beliefs and knowledge particularly as they relate to learning and conceptual change

(Southerland, Sinatra, & Matthews, 2001). For the purposes of the present study, a psychological distinction between the two constructs is made, as knowledge of neuroscience and motivational beliefs surrounding teachers' future implementation of BBT practices are separate and distinct, both conceptually and operationally.

Given this psychological distinction, knowledge is defined as factual or objective information, whereas beliefs are defined as subjective, personal judgments often involving emotions (e.g., Southerland et al., 2001; Alexander & Dochy, 1995). Further, Parajes (1992) suggests that knowledge of a domain is distinct from feelings about that domain; and that most researchers agree that the study of beliefs provides improved insight into behavior in comparison to knowledge. For example, an individual's *knowledge* of mathematics might be objectively vast, however they might *believe* they still have much to learn, thus the belief would be more predictive of an individuals' behavior to continue mathematics study than actual level or quantity of knowledge.

There is evidence that teacher motivational beliefs impact teacher behavior (e.g., Pajares, 1992). In the following sections, extant research evaluating the significance of teachers' motivational beliefs is described in detail, grounded in Social Cognitive Theory (SCT) of motivation (Bandura, 1986). Bandura's social cognitive framework for motivational beliefs highlights the importance of what people think, believe, and feel, and how these factors impact behavior. Further, the framework hinges on the social persuasions, which can be altered by the environment. Using this framework provides a foundation for further research but also a framework for training and intervention for education innovation implementation, as highlighted by Fullan (2001).

Teacher Self-Efficacy. Highlighting the importance of teachers' self-efficacy, researchers at the Rand Corporation (Armor et al., 1976) investigated the impact of a reading program in Los Angeles elementary schools. The investigators included two items on the teacher survey that measured teacher beliefs, specifically teacher efficacy, from the perspective of external or internal control. These items included: (1) *When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance depends on his or her home environment* and (2) *If I really try hard, I can get through to even the most difficult or unmotivated students*. The results of the study revealed that teachers who successfully implemented the reading program in their urban classrooms were more likely to report increased efficacy on the two Likert-type scales.

A second study from the Rand Corporation investigated the role of teacher beliefs on implementation of innovations by surveying 1072 teachers from schools upon completion of federal funding through the Title III program. Berman and McLouglin (1977) found that teacher efficacy beliefs predicted continuation of educational innovations, teacher behavior changes, percent of project goals achieved and, most importantly, student academic performance. These two Rand studies (Armor et al., 1976; Berman et al., 1977) prompted years of research on teacher self-efficacy beliefs and their impact on teachers' behaviors in the classroom and, ultimately, student academic achievement.

Self-efficacy refers to a belief subconstruct (Pajares, 1992) in which an individual makes judgments about how well they believe they can organize and execute specific courses of action (Bandura, 1986, 1977). For the purposes of this study, self-efficacy is grounded in the SCT of learning and motivation, which conceptualizes individual agency within the context of the individuals' environment, behavior, and cognition (Bandura, 1977). Self-efficacy is a highly documented construct, specifically applied to learning, regulation, and motivation of behavior. Within the educational literature, self-efficacy has been investigated through the lens of learner and teacher. The focus of this review is teachers' self-efficacy from the SCT of learning and motivation.

Dellinger, Bobbett, Olivier, and Ellett (2008) describe teachers' self-efficacy as beliefs about their abilities to successfully perform specific teaching or learning-related tasks within the context of their classroom. Tschannen-Moran, Woolfolk Hoy, and Hoy (1998) and Pajares (1992) define teacher self-efficacy as a teacher's confidence in his or her capability to influence student performance (engagement and/or learning), even with challenging students. This definition is used in the present paper, whereas a specific operationalization of the construct is used per Bandura's guidelines of self-efficacy measurement (Bandura, 2006). Often cited broad conceptualizations of "teacher efficacy" (e.g., Gibson & Dembo, 1984) are not appropriate for the present study centered on the specific domain of BBT beliefs, as Bandura (1997) and Pajares (1997) state that teacher efficacy scales should be linked to specific domains.

Teacher self-efficacy beliefs appear to be impacted by the environment and are malleable based on experience. Bandura (1986, 1997) suggested four sources of efficacy: mastery experiences (i.e., previous personal experiences with success or failure), physiological and emotional arousal (i.e., physical symptoms such as anxiety, panic), vicarious experience (i.e., observing the experiences of others), and social persuasion (i.e., verbal encouragement). In their review of the theoretical underpinnings of teacher self-efficacy beliefs, Tschannen-Moran, Woolfolk Hoy, and Hoy (1998) emphasize that mastery experiences are the most powerful source of efficacy information. Tschannen-Moran et al. (1998) hypothesize that as teachers gain more mastery experiences, their self-efficacy beliefs increase. The malleability of self-efficacy beliefs presents a methodological challenge, particularly the measurement of self-efficacy beliefs using self-report measures.

In their study of the Teachers' Sense of Efficacy Scale (TSES) factor structure, Fives and Buehl (2009) found that teachers (N = 102) who had ten or more years of experience were more likely to report higher self-efficacy beliefs than teachers in preparation programs (N = 270) or early in their careers on the nine-point Likert-type scale. They found that the three-factor structure of the scale, including (1) efficacy for classroom management (e.g., *How much can you do to control disruptive behavior in the classroom?*), (2) instructional practices (e.g., *To what extent can you craft good questions for your students?*), and (3) student engagement (e.g., *How much can you do to motivate students who show low interest in school work?*), remained true for the practicing teachers. However, pre-service teachers, likely due to their lack of diverse teaching experiences, revealed a one-factor efficacy scale. The authors found that years of teaching experience impacts general teacher self-efficacy beliefs, but experience may also impact the psychometric measurement of the constructs.

Klassen, Tze, Betts, and Gordon (2011) found substantial variability in a review of 218 studies published between 1998 and 2009. Twenty-nine percent (*n* = 64) of studies focused on pre-service teachers and 25% (*n* = 54) utilized multiple levels of both pre- and in-service teachers. As also noted by Fives and Buehl, years of teaching experience impacts self-efficacy beliefs, which makes conceptual sense, given Bandura's (1986) theory that mastery experiences influence self-efficacy beliefs. As such, careful and consistent sampling techniques are necessary when studying beliefs from a social-cognitive perspective.

Teacher self-efficacy beliefs are also important because they are related to student success (Dellinger et al., 2008). The relationship between teacher self-efficacy and student performance has been documented empirically and there is evidence that high teacher self-efficacy beliefs are positively correlated with increased student achievement (Armor et al., 1976; Ashton & Webb, 1986; Berman & McLaughlin, 1976; Woolfolk-Hoy, & Burke-Spero, 2005). To demonstrate the relationship between teacher self-efficacy beliefs and student achievement, Ross (1992) studied a sample of 18 middle school social studies teachers representing 36 classes of students in Ontario Canada. The teachers implemented a novel history guideline mandated by the Ontario Ministry of Education with the support of instructional coaches. Teacher self-efficacy was measured using a 16-item, six-point Likert-type scale ranging from agree to disagree (e.g., "When a student does better than usual, many times it is because I exerted a little extra effort"). Assessments delivered through the Ontario Ministry of Education measured student achievement. Trained raters scored open-ended cognitive skill items developed by the researcher in previous studies to evaluate comparative thinking (e.g., compare two famous people) and decision-making.

Related to teacher self-efficacy, the results supported the researcher's hypothesis that student achievement scores would be higher in classrooms of teachers with high self-efficacy beliefs (Ross, 1992). Further, there was no relationship between teacher interaction with coaches and their self-efficacy beliefs, indicating that teachers' self-efficacy beliefs are contextualized and may be more appropriately assessed using contextualized measures (e.g., efficacy for teaching history instead of teaching in general).

Teacher self-efficacy beliefs are also integral to successful classroom instruction but malleable over time. Holzberger, Philipp, and Kunter (2013) examined the role of secondary teachers' self-efficacy on instructional quality. They demonstrated in their longitudinal analysis that teachers' self-efficacy beliefs had a significant role in predicting instructional quality, but it was bi-directional; that is, instructional quality factors such as teachers rating of classroom management and student experience of cognitive activation had a subsequent effect on teachers' self-efficacy beliefs later in time.

Research has established the power of teacher self-efficacy beliefs for both learners and teachers within an educational environment. Although the student outcomes are not a primary predictor of the present study, it is important to understand why teacher self-efficacy has been an area of inquiry for many decades of education research and its role in all facets of the educational setting. The primary area of inquiry within the present study is whether teacher self-efficacy beliefs impact teachers' intent to accept BBT. The literature suggests that teacher self-efficacy beliefs have a positive relationship with application of innovative classroom techniques (e.g., Evers, Browers, & Tomic, 2002). Thus, the impact of self-efficacy and related constructs on innovation acceptance are addressed in a later section. First, two related belief constructs from the SCT of motivation tradition—outcome expectancy and subjective task value—are reviewed.

Outcome Expectancies. Outcome expectancy is an individual's estimate that a certain behavior will produce a resulting outcome (Bandura, 1997). Bandura (1982) states that behavior would be best predicted by considering both self-efficacy and outcome beliefs. Bandura (1997) also suggests that outcomes people expect are largely dependent on their judgments of what they can accomplish. Outcome expectations are also essential to the expectancy-value theoretical tradition, which emerged from SCT of learning and motivation. A third theoretical tradition that uses outcome expectances is the Technology Acceptance Model (TAM; Davis, 1989). Within this model, outcome expectations are operationally defined differently (i.e., perceived usefulness) and are discussed later in this chapter.

Siwatu (2007) examined self-efficacy beliefs and outcome expectancies of 275 preservice teachers regarding their application of culturally responsive teaching. The author used Bandura's (1977) guidelines to develop a self-efficacy scale for executing specific teaching practices and tasks associated with teachers who adopted a culturally responsive approach (e.g., "Use my students' cultural background to help make learning meaningful"). Secondly, the author used Bandura's (1997) definition of outcome expectancy to design a scale that assessed teachers' beliefs that engaging in culturally responsive teaching will result in positive classroom and student outcomes (e.g., revising instructional material to include a better representation of the students' cultural group will foster positive self-images). Both measures were on a 0 (no confidence at all/entirely uncertain) to 100 (completely confident/entirely certain) scale.

To assess the relationship between preservice teachers' culturally responsive teaching self-efficacy and outcome expectancy beliefs, Siwatu (2007) found a .70 correlation between preservice teachers' self-efficacy and outcome expectancies related to implementing culturally responsive teaching practices. These findings highlight the close relationship, as suggested by Bandura (1997), between the two constructs. As such, the present study measures both self-efficacy beliefs and outcome expectancy beliefs.

English (2013) conducted an analysis of the facets impacting project based learning (PBL) implementation. This study is significant because it focuses on an educational innovation and it utilizes Fullan's (2001) focus on self-efficacy beliefs, outcome expectancies, and subjective task values using a SCT of motivation approach. English (2013) adapted Siwatu's (2007) outcome expectancy scale to the PBL setting. The results of a 4-model hierarchical multiple linear regression revealed that subjective task value was the only belief to significantly predict PBL implementation ($\beta = .27$, $p < .01$). Outcome expectancy and self-efficacy were not significantly related to implementation after controlling for teacher status, prior PBL experience, and perceptions of school support. This study provides evidence that task value beliefs are an important construct to include when studying the role of belief structures on teachers' acceptance of innovative educational practices.

Subjective Task Values. To complete Fullan's (2001) triadic teacher belief framework, subjective task values are also necessary to include in studies of teacher educational innovation acceptance. Teachers' subjective task value beliefs are subconstructs of the larger teacher belief construct (Pajares, 1992) within the expectancy-value theoretical tradition, which tie to the SCT of motivation. In general, expectancy-value theorists highlight the importance of individuals' subjective task value as key predictors of choices and behaviors that drive behavior. Subjective task value is a combination of attainment value (i.e., the importance of succeeding), intrinsic value (i.e., enjoyment), utility value (i.e., usefulness of the task), and cost (i.e., personal sacrifice; Wigfield & Eccles, 2000).

The first components of task value are related to what we know about individual motivation and interest. Attainment value relates directly to one's concept of identity. If one is to perceive attainment value in a task, it is because it is an important task in confirming the actualization of one's self-image. Intrinsic task value is present when an individual predicts feelings of enjoyment while engaging in the task. The second two components of task value highlighted by Wigfield and Eccles are more pragmatic judgments. The task utility is simply the importance of the task in facilitating the individual's goals as a learner or teacher. Lastly, perceived cost of the task can refer to monetary and other resources such as time and energy loss due to anxiety or physical exertion. Broadly speaking, perceived cost involves what someone gives up or sacrifices to accomplish a task.

Watt and Richardson (2007) emphasized the application of expectancy-value theory with adults, rather than children, in educational settings. The authors measure motivation constructs that predict career choices of adults who plan to be teachers using the factors influencing the choice to teach (FIT-Choice) scale. The scale assesses perceived ability, intrinsic career value, and other motivational factors toward making the decision to become a teacher. The sample included two cohorts (n = 488 and n = 652) and showed empirically that the model of subjective task value is effective with adult teachers in the context of choosing the teaching profession. Specifically, the authors found that intrinsic value and ability beliefs were the highest rated motivations for choosing a teaching career and inferred that subjective task value is of high importance to teachers.

In a study of Korean female undergraduate education majors (N = 168), Bong (2001) combined the closely related theoretical frameworks of motivation underlying self-efficacy and expectancy-value constructs. The study examined the contributions of self-efficacy beliefs and task value beliefs in predicting achievement performance and future course enrollment intentions related to a course entitled “instructional methods and technology” for preservice teachers. The self-efficacy construct was measured at five levels of specificity including self-efficacy for self-regulated learning, self-efficacy for academic achievement, course-specific self-efficacy, content-specific self-efficacy, and problem-specific self-efficacy. First, self-efficacy for self-regulated learning was measured using an 11-item, five-point Likert-type scale (e.g., “I can finish course assignments by deadlines”; “I can arrange a place where I can study without distractions”). Self-efficacy for academic achievement measured beliefs related to success in college settings and included items, such as “I’m confident I can master the courses I’m taking this semester”. Course-specific self-efficacy was a modification of the academic achievement scale, replacing the “courses I’m taking this semester” with “instructional methods and technology course” language. Content-specific self-efficacy was measured using give items asking specific questions related to the contents of the course, including domains of IT, theories of learning and instruction, etc. Lastly, problem specific self-efficacy beliefs were rated based on presenting the students with example problems and rating their confidence for solving the problems on a scale of 0 (not confident at all) to 100 (real confident).

Subjective task value was measured at the course level. There were three questions, each relating to either perceived importance, perceived usefulness, and interest in the course (e.g., “I think what I learn in instructional methods and technology is important”). Lastly, students were asked to report their future course enrollment intentions (e.g., “I’d like to take courses like instructional methods and technology again”) and student performance measures consisted of their midterm and final exam scores.

After measuring the motivational variables twice at the beginning and end of the semester, the researchers conducted a confirmatory factor analysis to determine measurement fit and a path analyses to measure relationships between constructs. All the self-efficacy measures were positively correlated with each other and correlated to the task-value factor with the exception of the problem-specific self-efficacy scale. This is likely due to the difference in specificity between the problem-specific measure and the course-level measure of task-value. The results of the analysis indicated that task value was a stronger predictor of performance scores and future enrollment intentions than self-efficacy beliefs at time 1. At time 2, self-efficacy ratings were strongly related to performance in the course and task-value ratings were strongly related to intentions to re-enroll in a similar course. This highlights the differential and complex interaction between beliefs, performance, and behavior.

The study of beliefs is a large body of research, as is the further focus on pre-service and in-service teacher beliefs. Although understanding the sources of teacher beliefs and how they impact teacher practice and student performance is important, the focus of this study is the role of teacher beliefs in their decisions to accept innovative education practices such as BBT. The next section reviews literature that examines the role of teacher beliefs on their decisions to accept innovative practices from a SCT approach.

Predicting Teachers' Intent to Accept Educational Innovations using SCT. Administrators and policy makers often introduce educational reform through innovative teaching practices. Teachers are perceived as true change-agents within schools and have background experiences that will influence their beliefs related to the innovation (Teo, 2008). Thus, understanding teachers' beliefs associated with an innovation is essential to successful implementation of any initiative (Woolfolk Hoy, Davis, & Pape, 2006).

Beliefs are one of the three change-areas Fullan (2001) highlights for educational innovations to take hold. Teacher motivational beliefs (previously reviewed) are strong predictors of teacher adoption of new and innovative practices within their classroom (Ross, 1998). In this section, I summarize three studies examining the impact of teacher beliefs on educational innovation acceptance. Since no studies have focused specifically on the context of BBT, these studies investigate innovations, including the study home program, data driven decision-making, and project-based learning.

Evers, Brouwers, and Tomic (2002) surveyed secondary teachers in the Netherlands (N = 490), with an average of 22 years of experience, who were involved with an innovation called the Study-home system introduced by the school administration. The Study-home system was designed to encourage student engagement and independent study. The researchers used regression analyses to test the hypothesis that negative attitudes toward the Study-home system and low self-efficacy for using the Study-home system predicted indicators of teaching burnout surrounding the use of the innovation.

Evers et al. developed a 13-item measure of perceived self-efficacy for this study in the Dutch language. Three domains of self-efficacy were developed based on interviews with teachers. These efficacy domains include guiding groups of students using differentiation (e.g., “If a pupil shows unmotivated behavior, I am able to find out the reason for it”), involving pupils in tasks (e.g., “If pupils experience difficulties in carrying out a task, I can make them think about finding solutions themselves”), and beliefs towards the use of innovative educational practices (e.g., “In general I can cope quite well with stress that attends the implementation of educational innovations"). These statements were scored on a six-point Likert-type scale from totally disagree to completely agree. The researchers also developed an attitude scale that measured teachers' perceived usefulness (a corollary to subjective task value) and effectiveness of the Study-home program. The five-item measure was also developed based on interviews with teachers participating in the Study-home program. The items represented bipolar statements that were evaluated by giving ten points in total to the two alternatives (e.g., "My favorite style of teaching is the teacher-centered style").

Furthermore, a confirmatory factor analysis was conducted to test how well the four-factor model fit the data (three self-efficacy factors and one attitude factor). Results indicated that the four-factor model fit the data well (χ^2 (129) = 432.23, CFI = .90, p < .001). Next, a hierarchical regression analysis was used to determine the extent to which teachers' attitudes about the usefulness and effectiveness of Study-home and their efficacy beliefs toward the three domains would explain their burnout level. Gender, age, and years of teaching experience were statistically controlled. These control variables were added in Step 1 followed by the attitude and efficacy scores in Step 2. The results indicated that, of all the independent variables, the only significant predictor of burnout was perceived efficacy for use of innovative educational practices (β = -.60, p < .001). That is, teachers with high efficacy for using innovative educational practices were less likely to report feeling burnout in their work specifically related to the Study-home system. The results of this study reveal the importance of efficacy beliefs, but not of perceived usefulness, in preventing burnout while implementing an educational innovation.

Similarly, Dunn, Airola, Lo, and Garrison (2013) used structural equation modeling (SEM) to test a model of the degree to which teacher self-efficacy and concerns regarding data-driven decision making (DDDM) inform teachers collaboration, refocusing concerns, and their willingness to adopt the innovation. The sample included 537 K-12 teachers who had attended a seminar on DDDM. The majority of teachers had one to nine years of experience in their current role.

The researchers used the 3D-ME scale designed by Airola and Dunn (2011) to measure teachers' sense of efficacy for successfully engaging in DDDM to inform professional development initiatives. The 20-item measure uses a five-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). The measure includes four sub-scales: efficacy for data identification and access (e.g., "I am confident in my ability to access state assessment results for my students"), efficacy for data technology use (e.g., "I am confident I can use the tools provided by my district's data technology system to retrieve charts, tables or graphs for analysis"), efficacy for interpretation, evaluation, and application (e.g., "I am confident in my ability to understand assessment reports"), and DDDM anxiety (e.g., "I am intimidated by statistics"). The measure was validated using exploratory and confirmatory factor analysis on a separate sample of teachers, and oblique rotation resulted in a four-factor solution. Discriminant validity was also established by negative to low correlations coefficients ($r < .28$, $p < .001$) between the 3D-ME scales and TSES (Tschannen-Moran & Woolfolk-Hoy, 2001). Internal consistency reliability of the scale was also acceptable ($\alpha > .84$).

The second measure used was the Stages of Concern Questionnaire (SoCQ), which identifies the intensity of teachers' concerns regarding the educational innovation and has been used with acceptable reliability and validity for 25 years. The 31-item measure includes subscales for each of seven stages of concern theorized by Hall and Hord (1987); however Dunn et al. (2013) used only the final two subscales: collaboration concerns (e.g., "I would like to help other faculty in their use of the innovation") and refocusing concerns (e.g., "I would like to determine how to supplement, enhance, or replace the innovation").

The results indicated that the model fit the data (CFI = .934, SRMR = .058, RMSEA = .054 and 90% CI = .049 to .058). Chi-square was significant (χ^2 (397) = 934.079, $p < .001$); however, it is suspected that the chi-square estimate overestimated the lack of fit due to the large sample size ($N = 537$). The results indicate that teachers who were more confident in their ability to engage in DDDM were more likely to be concerned with this innovation and engage with colleagues to infuse DDDM into their classrooms. This study highlights the importance of efficacy beliefs for encouraging the use of innovations within a classroom and a schools' network of teachers.

An additional line of research is related to the implementation of project-based learning (PBL) as an educational innovation. English (2013) studied 343 teachers' beliefs regarding PBL implementation. Independent variables included teacher self-efficacy, outcome expectancy, and subjective task value; intent to implement PBL and extent of PBL implementation were the dependent variables. The sample consisted of teachers from PBL training through New Tech (NT) Network and the teachers participating in non-NT PBL professional development. In both instances, the teachers had little to no prior training in PBL. Measures included a nine-item PBL self-efficacy beliefs scale, which was designed based on Bandura's (2006) guide for creating self-efficacy scales. The 100-point scale (0 = certain I cannot do, 100 = highly certain I can do) included items related to the core aspects of PBL methodology such as, "I can develop driving questions that engage my students". These items were developed based on a review of PBL training. PBL experts, two educational psychology researchers, and 24 teachers established the scale's construct validity. A factor analysis indicated one efficacy factor with Cronbach's alpha, revealing high inter-item reliability ($\alpha = .93$).

An analogous 10-item scale measuring subjective task value was developed based on the Eccles and Wigfield (1995) task value scale. The scale measures three factors (intrinsic interest value, attainment value/importance, and extrinsic utility value) aligned with the expectancy-value theory of motivation. The scale was adapted from a seven-point Likert-type scale for use within the context of PBL (e.g., "How much do you like teaching with PBL? Is the amount of effort to teach with PBL worthwhile to you? How useful are the skills that students learn through PBL?") using a 100-point scale to align with the efficacy scale format. An exploratory factor analysis revealed that the subjective task value scale consisted of two factors, and thus two items were removed to reduce the scale to one subjective task value factor. Cronbach's alpha of .93 was reported for the eight-item scale.

Lastly, the researcher developed scales to assess the intent to implement and the extent of PBL implementation (English, 2013). The one-item scale for implementation intent required respondents to choose one of six levels of intended implementation: no plans to pursue PBL-related activities, learning more, planning a project to be implemented later, implementing one project, implementing two or three projects, and fully adopting PBL as the primary methodology. The implementation extent scale required respondents to choose one of six descriptors for their current level or activity: no PBL-related activity, learning more, planned a project to be implemented later, implemented one project, implemented two or three projects, or fully adopted PBL as the primary methodology. English's (2013) mixed-methods study consisted of an extensive analysis of many PBL implementation facets over time and between the NT and non-NT groups of teachers (NT status). The results of a four-model hierarchical multiple linear regression revealed that subjective task value was the only belief to significantly predict PBL implementation ($\beta = .27$, $p < .01$). Outcome expectancy and self-efficacy were not significantly related to implementation after controlling NT status, prior PBL experience, and perceptions of school support. Further, it was found that PBL experience ($\beta = .21$, $p < .001$) and perceptions of school support structure ($\beta = .39$, $p < .001$) were also significantly related to implementation. Lastly, being from a NT school predicted 24% of the variance in PBL implementation ($\beta = .21$, $p < .001$). This study provides evidence that task value beliefs are an important construct to include when studying the role of belief structures on teachers' acceptance of innovative educational practices.

The aforementioned studies are examples of empirical, quantitative studies using teacher self-efficacy, outcome expectancies, and subjective task value belief measures grounded in SCT and in the context of educational innovation adoption. There also exists research using teacher belief measures to predict outcomes related to educational innovations outside of the traditional SCT framework. Next, I review a second theoretical tradition that uses beliefs to predict the adoption and acceptance of technology-based educational innovations—the TAM.

The Technology Acceptance Model (TAM)

Behavioral intent to accept an innovation is informed by the Theory of Planned Behavior (TPB; Ajzen & Fishbein, 1980) and the TAM (Davis, 1989). The TPB was initially developed to expand upon the Theory of Reasoned Action—both of which aim to explain voluntary behaviors. The model highlights the importance of attitudes and beliefs with respect to the anticipated outcomes, risks, and abilities of an individual. In some cases, beliefs such as self-efficacy, garnered from the SCT of motivation, have been integrated into this theory (e.g., Montaño & Kasprzyk, 2008), highlighting the close relationship between the theoretical traditions under investigation in the present study. The TPB and TAM are particularly relevant to the present study as they highlight the importance of behavioral intent.

Behavioral intent. Within the TPB, motivational beliefs and attitudes influence the intent to execute behavior. TPB suggests that intent is the antecedent to behavior, and, given the appropriate conditions to execute that behavior, the behavior would be aligned with the intent and influenced by the individuals' beliefs (Ajzen, 2006). The correlation between intent and behavior has been explored in a variety of different contexts. Meta-analyses reveal that there is variability in the correlation between intent and behavior, but it is approximately .45 (Ajzen, 2011). Some explanations for the fluctuating correlation include the effects of measurement error, specification of the behavior intent, and the time-period between measurement of intent and behavior. Nonetheless, Ajzen (2011) states, “That at its core, TPB is concerned with the prediction of intentions” (p. 1115). This is because actual behavior is often impacted by factors that are outside of the individual’s control, such as policy changes or access to information. In the context of technology innovations in the workplace, TPB has been adapted to form the TAM (Davis, 1989).

The use of behavioral intent as a dependent variable in the context of innovation acceptance is based on two arguments. First, the TAM allows for interpretation and comparison of results with other research from a variety of fields in which acceptance or behavioral intent is predicted. Secondly, researchers have found that innovations are often very new to most users (e.g., teachers), and thus actual implementation behaviors would be an unreasonable construct to measure (Bourgonjon et al., 2013; Teo, 2011). Based on the results of teacher beliefs and knowledge of BBT found in initial studies (Dekker et al., 2012; Serpati & Loughan, 2012), BBT is similarly novel to teachers in the US and Europe.

However, comparison of results across studies using the TPB, TAM, and related theories of acceptance is complicated due to the variability in the measurement of behavioral intent as a latent construct. Table 1 summarizes an interdisciplinary sample of behavioral intent measures in the relevant literature. This sample of studies is not meant to be exhaustive, but rather illustrative of the variability in the measurement of behavioral intent within the literature investigating both teacher and non-teacher populations. Given this sample of studies, scales include a range from one to three items with five- or seven-point Likert-type response options that address likelihood, agreement, and/or frequency estimations.

There are several problematic conclusions that could be gleaned from this sample of behavioral intent measures. First, the measurement of behavioral intent with one or two items is problematic due to the latent nature of the construct. Latent variables are often complex and difficult to measure with one or two items (Eisinga, Grotenhuis, & Pelzer, 2013).

Secondly, the variability in item and scale construction may indicate fine degrees of the latent construct that are unaccounted for in some studies (e.g., frequency estimations of intent) but are omitted in other studies that use a broader specification of intent (e.g., “I intend to use the technology”). Potentially omitting or under-specifying the measurement of a latent construct may introduce systematic measurement error, whereas the use of multiple indicators enhances construct validity (Eisinga et al., 2013).

Lastly, the variation in Likert-type scale response formats introduces incongruence across studies claiming to measure the same behavioral intent construct. The small sample of six studies reviewed in Table 1 reveals six different approaches to Likert-type scale response formats. The common use of a seven-point scale is potentially problematic, as there is little evidence that seven points differentiate from one another (Likert, 1932), thus, a smaller five-point format would be preferable.

For the purposes of this study, a newly adapted scale is evaluated as an alternative to the two item scale used with teachers in Teo (2008). The new scale will contain four BBT specific items that address both likelihood and frequency intentions specified by a specific timeframe as suggested by Ajzen (2010). Both scales use a five-point Likert-type response.

Table 1

Measurement of Behavioral Intent in Select Research

Authors	Item N	BI Items	Scale	Reliability
Davis et al. (1989)	2	Two items measuring intent to use WriteOne program pre- and post- intervention; guidance from Ajzen and Fishbein (1980). [Wording not provided]	7-points (1 = unlikely, 7 = likely)	Time 1 $\alpha = .84$; Time 2 $\alpha = .90$
Venkatesh et al. (2003)	3	I intend to use the system in the next <n> months. I predict I would use the system in the next <n> months. I plan to use the system in the next <n> months.	7-points (1 = strongly disagree, 7 = strongly agree)	Not provided
Montaño & Kasprzyk (2008)	1	I intend to use condoms all the time with steady partners in the next three months.	5-points (1 = strongly disagree, 5 = strongly agree)	N/A
Teo et al. (2008)	2	I will use computers in the future. I plan to use computers often.	5-points (1 = strongly disagree, 5 = strongly agree)	$\alpha = .73$
Ajzen (2010)	1	I intend to exercise for at least 20 minutes, three times per week for the next three months.	7-points (1 = likely, 7 = unlikely)	N/A
Bourgonjon et al. (2013)	3	Assuming [the technology] would be available on my job, I predict that I will use it on a regular basis in the future.	7-points (1 = unlikely, 7 = very likely)	$\alpha > 0.91$

Predicting Teachers' Intent to Accept Educational Innovations using TAM. Developed by the information technology field, the TAM uses the TPB in the context of technology acceptance intent. Researchers using the TAM (Davis, 1989; Teo, 2011; Bourgonjon et al., 2013) utilize the concepts from both TPB and theories of motivation to predict users' intent to accept particular technologies.

In TAM studies of teachers, perceived usefulness (PU), perceived ease of use (PEU) and computer attitudes (CA) are key predictors of behavioral intent (BI) to accept educational innovations. Teo (2011) provided operational definitions of each of these constructs for the purposes of his research with teachers' technology acceptance adapted from Davis (1989) and Fishbein and Ajzen (1975). PU is defined as the degree to which a teacher believes that using technology would enhance his or her job performance; PEU is defined as the degree to which a teacher believes that using technology would be free of effort; CA is defined as the extent to which a teacher possesses positive feelings about using technology; and BI is defined as the degree to which a teacher is willing to use the technology.

PU and PEU are hypothesized to be key determinants of user technology innovation acceptance. Davis (1989) stated that increased PU and PEU lead to positive CA and an increased likelihood of intent to accept technology innovations. Two studies using the TAM, and specifically BI to accept innovations, in the context of teachers' beliefs are reviewed next.

In the first study, Teo (2011) designed a teacher-oriented TAM using SEM to predict 592 Singaporean primary and secondary teachers' intent to use technology in the classroom. Technology was broadly defined. Using a survey data collection tool, the author found that perceived usefulness, perceived ease of use, facilitating conditions, and attitude toward use as significant predictors of BI to accept. BI was measured with three seven-point Likert-type scale items (1 = strongly disagree, 7 = strongly agree) including "I intend to continue to use technology in the future; I expect that I would use technology in the future; I plan to use technology in the future". The data fit the model well (CFI = .98, SRMR = .07, RMSEA = .06) and chi square was significant

($\chi^2 = 499.24$, χ^2/□□ = 3.31).

Bourgonjon and colleagues (2013) examined the role of beliefs and their impact on teachers' decisions to accept game-based teaching. The researchers measured perceived usefulness, innovativeness, experience with video games, subjective norms (or social pressures) to use video games, and critical mass of technology adoption in order to acceptance, as measured by BI. Bourgonjon et al. constructed a survey using Likert-type scales that were previously validated to assess the independent variables. The teacher demographic variables included age, years teaching experience, grade, and subject. The dependent variable was measured using items from a previously validated scale within the TAM literature (Venkatesh, Morris, Davis & Davis, 2003), which measures users' predicted acceptance of a technology in which they have very little prior experience using.

The scale includes the statement, "Assuming [the technology] would be available on my job, I predict that I will use it on a regular basis in the future." Then, respondents are asked to rank their likelihood of using the technology in the future twice on a seven-point scale, from likely to unlikely, and from improbable to probable, which is reverse-coded. To ensure the respondents understand the technology enough to predict their likelihood of accepting it, a one-page explanation on the use of games in education was provided for the respondents to review prior to responding.

The investigators surveyed secondary teachers (*N* = 505) with an average age of 40 years old. They delivered the surveys via Web and paper-and-pencil format, and found through an independent samples t-Test that there were no significant differences between the ratings of the two delivery formats. They used SEM to test the hypothesized model that usefulness is positively related to behavioral intent, complexity negative relates to behavioral intent, and complexity negatively relates to usefulness. In this study, the data fit the model well (χ^2 (263) = 564.17, CFI = .97, RMSEA = .05). Results indicated that teacher beliefs were multifaceted, and that the perceived usefulness of the technology was the most important direct predictor of acceptance (β = .64), aligning with findings of previous research (Venkatesh et al., 2003; Davis, 1989). Further, learning opportunities around gaming significantly predicted usefulness ratings (β = .58), highlighting the important role of prior experience with the innovation.

Bourgonjon et al. studied the role of beliefs on behavioral intent to accept game-based learning as an innovative teaching approach. This approach to measuring future-oriented intentions given minimal experience with the innovation at hand reveals a fitting dependent variable for the present study. Measurement of beliefs in the context of little to no experience with an innovation such as BBT requires additional contextualization when surveying teachers. Bourgonjon et al. (2013) and other researchers using the TAM approach provide a standard for contextualizing the survey by providing an explanation of the innovation at the start of the survey. This approach is used in the present study to contextualize the study of a relatively new innovation.

The TBP and TAM studies reviewed in this section highlight the usefulness of a unique framework for investigating teachers' intent to accept BBT, a question that has not yet been posed in the extant empirical BBT literature. The present study will be the first to use behavioral intent to explore teacher acceptance of BBT as an educational innovation. Further, comparison of SCT beliefs with TAM beliefs will contribute to the extant literature by exploring which beliefs framework may best explain the variance in intent to accept innovations. Lastly, valid and reliable measurement of behavioral intent will be addressed.

Transdisciplinary Relevancy through Study of Teacher BBT Beliefs

A central issue of psychological and educational research is relevancy to real-world educational practice (Berliner, 2006). Although often discussed in the context of educational psychology, this issue also applies to the transdisciplinary BBT field. How can the budding BBT field ensure relevancy in consideration of the complex system of "neuroscams" and "neuromyths" that have developed over the past two decades? Devonshire and Dommet (2010) suggest teacher or practitioner involvement as an objective for the BBT research community to establish relevancy. When practitioners and scientists effectively collaborate with the assistance of psychologists (Dubinsky, Roehrig, & Varma, 2013), the pseudoscientific distractions may begin to diminish and the relevancy of BBT as a field may rise. However, more empirical evidence is needed to test this concept.

Further, Fullan (2001) has studied educational change and determined that there are three dimensions that must be impacted for an educational change or innovation to take hold. These include revised materials (e.g., curriculum), new behaviors (e.g., pedagogy), and altered beliefs. MBE and BBT would likely benefit from additional work surrounding a curriculum and pedagogy focus; thus, the present research aims to assess the current state of teacher beliefs. Once baseline beliefs are understood, appropriate measures can be taken to effectively disseminate BBT information. Empirical educational psychology and teacher education journals reveal that teacher knowledge, beliefs, and values are often examined to understand more about teachers' behaviors and decisions in the classroom (e.g., Pajares, 1992; Woolfolk-Hoy, Davis, & Pape, 2006). In the context of BBT, there is a small body of research regarding the role of teachers' beliefs and values.

Pickering and Howard-Jones (2007) surveyed teachers on their beliefs regarding BBT. The sample included 200 education professionals from various BBT events primarily in the United Kingdom between 2005 and 2006. Specifically, 71 teachers were recruited from an in-service training event for teachers from North West England; 79 education professionals were recruited from an Education and Brain Research conference at the University of Cambridge; 48 education professionals were surveyed from an OECD website discussion forum and represented a geographically diverse sample; and 11 teachers were interviewed in-depth.

The researchers sought to learn more about the educators' views of BBT using survey and interview methods. Survey items included two "importance" questions on a 5-point Likert-type scale: (1) "How important is an understanding of the workings of the brain in the following: design of educational programs, decisions about curriculum content, provision for individuals with special needs?" (2) "How important are the following issues in the application of neuroscience to education: A two-way dialogue between educators and neuroscientists, relevance to the "real" classroom, ethical issues in brain research?" The exploratory portion of the survey included the following open-ended questions: (1) "Please list any ideas you have heard of in which the brain is linked to education," (2) "Please indicate how potentially useful you think these ideas are," (3) "Has your institution used teaching/learning techniques based on ideas about the brain? If so, what form does this take?" and (4) "Have you or others in your institution found them to be useful? If so, how?"

The results from the survey and in-depth interviews revealed that educators (1) were enthusiastic about the role of neuroscience in education, (2) believe an understanding of the brain was important for educational program development, (3) suggest that a translation of neuroscience knowledge is essential in order to effectively serve the needs of educators, and (4) believe that communication between the two fields needs to be increasingly emphasized and that teachers should not simply be told what to do or what works—that it should be a collaborative communicative process.

Although the Pickering and Howard-Jones (2007) study provides a promising first-look at educators' beliefs regarding BBT, the nature of the sample was a study limitation. First, the majority of the survey respondents were not BBT-naïve; in other words, they were already engaged in BBT either through their own intrinsic interest in the topic (e.g., online OECD forum) or through the in-service training. Secondly, the selection of educators was broadly defined. In the case of the OECD forum (N = 48) and the Education and Brain Research conference group (N = 79), educators included a range of educational professionals including those who may not participate directly in classroom pedagogy (e.g., educational psychologists). Due to these sample limitations, it was difficult to generalize the results to "typical" teacher beliefs about BBT. Further, this initial study based primarily on teachers in the United Kingdom sparked additional research on teacher perceptions of BBT in the United States.

Serpati and Loughan (2012) expanded Pickering and Howard-Jones' (2007) work with a sample of 221 teachers licensed in the United States. Respondents were recruited using an online network sampling approach, wherein the researchers worked through their network of practicing teachers, and asked them to complete the survey and disseminate the electronic survey link to at least one other teacher they knew. The survey was also posted on a popular nationwide education listserv for K-12 teachers. The survey required respondents to answer a series of questions to determine if they were currently or recently practicing, licensed teachers in the United States. If they did not meet these criteria, they were excluded from the analysis.

Serpati and Loughan (2012) expanded the survey instrument developed by Pickering and Howard-Jones (2007) and employed a convergent mixed methods design (Creswell, 2011) to gain a more complete representation of teachers' perceptions regarding BBT. The two Likert-type perceived importance items (#1 and #3), as well as the information source item (#2), were preserved from the 2007 survey. Additionally, the free response question regarding BBT-based teaching or learning technique use (#5) was preserved. Two additional free response questions were posed for the 2012 study to gain a better understanding of teacher perspectives and, as suggested in previous research (Devonshire & Dommet, 2010; Pickering & Howard-Jones, 2007), allow teachers to pose more research questions to drive BBT research, including: (1) Do you think neuroscience (or brain-research) should be contributing to education practice? What do you think are the most important questions brain-researchers should ask to help inform your teaching practice? (2) In general, how do you feel about the potential of neuroscience to inform education?

Key demographic indicators such as age, level of education, years practicing, and experiences working with children with disabilities were recorded. Of the 221 teachers, 87% were female and between 31 to 40 years of age. Three quarters of the sample had attained graduate-level education. General educators (65%) and special educators (35%) were included in the study. Results of the question regarding information sources revealed that teachers mainly consult books (64%) and in-service training (62%), followed by journals (professional, 53%; academic, 46%) and conferences (45%) to learn about the brain. The least used sources were media (25%) and commercial products (15%).

When educators were asked whether they felt that an understanding of the neurological underpinnings of learning, cognition, and behavior are important, 94%

completely agreed or somewhat agreed. Only 4% disagreed or remained neutral on the topic. The participants were also asked if they believed an understanding of the brain was important in many areas related to education. Results revealed that 92% of teachers agreed that it was important or very important in the delivery of educational programs, early screening for learning problems, and the provisions for individuals with special education needs of the cognitive nature (93%), physical nature (92%), and behavioral/emotional nature (92%). The design of educational programs was also endorsed as important by a majority of the sample (89%). Seventy-five percent felt that decisions surrounding curriculum development and 79% the role of nutrition were important.

The educators were additionally questioned about the application of neuroscience to education. Results revealed educators feel information needs to be easily assessable to teachers and other educational practitioners for success (91%). They also strongly agreed that there should be relevance to the "real" classroom (89%) and an emphasis on misinterpretation of neuroscience (87%). Still important, but less than those previously discussed, is the value of ethical issues related to the brain (76%) and a two-way dialogue between educators and neuroscientists (71%).

Qualitative analysis of the free-response data revealed four themes in teachers' responses. First, teachers generally agree that BBT has potential and is worth pursuing. Secondly, there was juxtaposition between "watering down" and "packaging" of complex neuroscience information. Some respondents called for simplicity, whereas others called for more detail and depth of information. Thirdly, misconceptions about the differences between brain-based education understanding and concepts such as differentiated instruction, multiple intelligences, cooperative learning, and Blooms taxonomy were prominent in the teacher-responses. Lastly, other than common questions about attention, memory, and motivation, teachers wanted to know what common practices they should *eliminate* and how their behaviors affect the neurobiology and neuropsychology of their students.

Although the 2012 study of teachers in the US expanded current research on teacher beliefs regarding BBT, there were limitations. First, the sampling technique resulted in a very broad and diverse group of teachers. Although this could be viewed as a strength, it is also a limitation because generally very little was known about the teachers' work environments. Additionally, because a snowball sampling technique was used, teachers were likely to self-select to take the survey because they may have already had some interest in BBT. Lastly, the study was highly descriptive in nature, that is, the measures used were not nested in research on teacher beliefs or knowledge. The present study aims to build on this work and address the limitations of the initial study (Serpati & Loughan, 2012) by targeting the sample and nesting the survey in established theoretical frameworks.

The descriptive research on teacher beliefs from these two reviewed studies showed that teachers are enthusiastic about BBT from a general perspective; however there are still issues with dissemination of information. Dekker et al. (2012) also highlighted the issues regarding teachers' understanding of BBT and subscription to neuromyths. There remains a paucity of empirical research on "typical" teacher BBT knowledge and beliefs and how that impacts whether they intend to accept BBT practice. Further, although these studies shed important light on the perceptions people hold, there is little work using operationalized constructs within the teacher knowledge and belief empirical literature. In comparison, other closely related educational innovations such as implementation of instructional innovations (Guskey, 1988), instructional technology (Ertmer, 2005), and inclusive practices for special education students (Sharma, Laoreman, & Forlin, 2012) have a large body of research surrounding the role of teacher beliefs and how that impacts acceptance of the innovation.

Summary

Educational psychologists should continue to support a dialogue between teachers and the neuroscience community to assist and direct evidence-based, neuropsychologically sound teaching practices (e.g., Benton, 2010). In many ways, the future of MBE is in the hands of practitioners. Without a strong link to educational practice, MBE will not be distinctly different from its parent disciplines of psychology and cognitive neuroscience (Tokuhama-Espinosa, 2011).

Considering the goal of MBE in providing an improved understanding of how to educate individuals within modern society, student-learning improvements would be the ideal dependent variable to assess the impact of BBT. However, more work is needed in the form of implementation and professional development for teachers and other practitioners (e.g., policy makers and education administrators) before the impact of BBT on student academic achievement can be assessed.

I propose that the first step in building an effective BBT field is to fully understand teacher knowledge and beliefs. Specifically, teacher self-efficacy beliefs, outcome expectancies, and subjective task value are of import, as these constructs are well understood in the empirical literature and highlighted by Fullan (2001) as key predictors of innovation acceptance in educational settings. I also propose to examine the predictive power of TAM variables over and above the SCT variables as they relate to teacher intent to accept BBT. Once the role knowledge and beliefs play in determining whether teachers indent to accept BBT is understood, teacher professional development and training can be optimized. To this end, the following research questions were addressed:

1. *Is measurement of behavioral intent to accept BBT through a multi-item approach a valid and reliable assessment of this construct?*
2. *What are the unique contributions of TAM's motivational beliefs (i.e., perceived usefulness, perceived ease of use, innovation attitudes) over and above SCT motivational beliefs (i.e., teacher self-efficacy, subjective task value, outcome expectancy) in prediction of secondary teachers' behavioral intent to accept BBT, while controlling for BBT knowledge, experience with BBT, and teaching experience?*

Chapter Three

The primary purpose of this study was to introduce a theoretically driven framework to explore teacher beliefs and their influence on teachers' behavioral intent to accept brain-based teaching (BBT). The approach was to examine the predictive power of Technology Acceptance Model (TAM) beliefs (i.e., perceived usefulness, perceived ease of use, innovation attitudes) over and above the Social Cognitive Theory (SCT) beliefs (i.e., self-efficacy, outcome expectancies, and subjective task values) with intent to accept BBT as the dependent variable. Lastly, this study aimed to optimize the measurement of behavioral intent by aggregating the TAM literature and evaluating the reliability and validity of a multi-item adapted scale to measure BBT Acceptance Intent as an alternative to a traditional two-item scale (Teo et al., 2008). The present chapter details the methodology used to address these purposes.

Participants

A total of 182 in-service licensed high school teachers participated in the study. Teachers were recruited from suburban, mid-Atlantic public high schools that serve grades 9 – 12. The Institutional Review Board (IRB) of the sponsoring university as well as the school districts' program evaluation leadership approved the research study (see Appendix A for IRB approval letter and informed consent).

The average age of the respondents was 38.02 years (SD = 10.94) and they averaged 10.49 years of teaching experience. Three quarters (77%) of the teachers were female. Eighteen percent reported a bachelors-level educational attainment while 82% reported a masters-level or higher.

Table 2 further details the exclusion/inclusion criteria for the study. These criteria were selected in order to ensure 1) that there was a clear understanding of the backgrounds of the teachers in the present study, and 2) that there was relative homogeneity among the experiences of teachers on a day-to-day basis. The majority of respondents were general education teachers, however 29 (16%) reported teaching primarily special education courses. Since many special education teachers work closely with smaller group of students who often exhibit neurodevelopmental disorders, this sub-population was separated to determine if their responses were significantly different from general education teachers. The result of an independent samples t-test revealed there was no significant difference in the scores on the nine variables of interest for the special education teachers compared to the general education teachers ($p > .05$). Subsequent analyses combined general education and special education teacher responses.

English/Language Arts and Mathematics teachers represented the highest percentage of respondents (22% each). Social studies (20%), Science (12%), Foreign language (8%), and Vocational Education (5.5%) were represented to a lesser extent, while Business (3%), Physical Education (3%), Visual Arts (2%), Performing Arts (2%), and Computer Science/IT (.5%) were minimally represented.

Table 2

Inclusion/Exclusion Criteria

Inclusion	Exclusion
Earned 4-year degree	Currently holding an administrative position (e.g., principal)
Provisional or professional license holder	Teacher assistant or other support activity
Current high school teacher	Information technology specialist
Subject-teacher (mathematics, language arts, sciences, social studies, second language, IB, visual and performing arts)	Reading specialist
Career and technical education teacher	Counselor
Special education teacher	

Participant setting. Participants were employees of a large suburban, mid-Atlantic public school district including 12 traditional high schools serving grades 9 – 12 and approximately 27,000 high school students. The district's student body is diverse: 32% White, 33% Hispanic/Latino of any race, 21% African American, 8% Asian, 6% two or more races, and .50% reported as other. About one third of the student population is considered economically disadvantaged.

Measures

A multi-section survey instrument was created, comprised of the scales described below. See Appendix B for the full instrument as it was presented to participants.

Previous BBT experience. The instrument included two items measuring previous BBT experience. The first addressed exposure to BBT during pre-service training (i.e., "Neuroscience or biological brain-based behavior courses were part of my teacher preparation program"). Response options included "Yes, they were required; Yes, elective and I enrolled; Yes, elective but I did not enroll; and No, courses were not part of my teacher preparation program". The second item addressed exposure to BBT through formal or informal professional development or continuing education settings (i.e., "Which of the following sources have provided you with professional development regarding the role of the brain in education?"). Response options included: In service training, conferences, academic journals, professional journals, books, commercial products, and other; respondents were allowed to check all that apply.

The two categorical previous experience items were used to provide a sum-score variable of "previous BBT experience". Each "checked" item equated to one point, with the exception of the last two options on the pre-service training item, which indicate lack of participation in pre-service training. A total of nine points including the option of listing "other" sources of continuing education were possible (M = 2.33, SD = 1.70).

BBT knowledge (Dekker et al., 2012). The BBT knowledge scale is a measure of teacher knowledge of MBE concepts developed by Dekker et al. (2012). The 32 statements on the survey are either true (e.g., "The left and right hemisphere of the brain always work together”), false (e.g., “Brain development has finished by the time children reach secondary school”), or a neuromyth (e.g., “Differences in hemispheric dominance--left brain/right brain--can help explain individual differences amongst learners”). The neuromyths were generated by OECD (2002, 2007) and used in Dekker et al.’s (2012) study of teachers’ subscription to neuromyths.

Responses included a) incorrect, b) correct, and c) I don’t know. Choosing option c) I don’t know, was marked as incorrect. Each item of the scale was dichotomously scored (0 = incorrect, 1 = correct). The original author of the scale confirmed a summed score was appropriate for the purposes of the present study focused on generating a composite of teachers’ general BBT knowledge (S. Dekker, personal communication, August 11, 2017), thus, a total summed score was generated for each response (M = 18.43, SD = 3.54) with 32 being the highest possible score.

BBT self-efficacy beliefs scale (Serpati, 2014). This scale was developed by the author to determine teachers’ confidence in their ability to interpret and integrate neuroscience research into their pedagogy. The scale was designed in alignment with Bandura’s (2006) guidance on creating self-efficacy measures. The scale includes nine items that teachers are asked to rate on a 100-point percentage scale (0 = Cannot do at all; 100 = Highly certain can do). Example items include “Locate valid and reliable resources containing information about how the human nervous system influences learning” and “Use information about the brain to accommodate students with special needs”. A subject matter expert in the field of psychology, education, and cognitive neuroscience reviewed the scale prior to administration; however one item (“Distinguish between accurate and inaccurate statements about the brain") was identified as problematic due to the possibility of double-barreled questioning and overlap with other items on the scale (Fowler, 1995). This item was removed from further analysis.

A principal-axis factor analysis with an Oblimin rotation was used to determine factor structure. The Kaiser-Meyer-Olkin measure of sampling adequacy was .90, indicating that the present data were suitable for principal axis factoring. Similarly, Bartlett's Test of Sphericity was significant ($p < .001$), indicating sufficient correlation between the variables to proceed with the analysis. The analysis revealed a single factor for the eight-item scale with an eigenvalue of 5.36 accounting for 63% of the variance. The magnitude of each item coefficient within the component matrix was good and exceeded .60 (Meyers, Gamst & Guarino, 2017). Cronbach's alpha estimate revealed high internal consistency ($\alpha = .93$). The composite mean for the eight-item scale was computed for further analyses ($M = 65.47$, $SD = 18.55$).

BBT outcome expectancy scale (Siwatu, 2007; adapted). Aligned with Bandura's (1986) definition of outcome expectancy, this scale was adapted by the author to assess teachers' outcome expectancies related to the use of BBT. The scale items were adapted based on Siwatu's (2007) Culturally Responsive Teaching Outcome Expectancy Scale and informed by English's (2013) adapted scale within the context of PBL innovations. The content of the items was based on Siwatu's (2007) content as well as BBT instructional implementation topics (Pickering & Howard-Jones, 2009; Serpati & Loughan, 2012). The 7-item scale requires teachers to indicate the probability that a behavior will lead to a specified outcome. Within the scale, there are two areas of specified outcomes: student-centered and instructionally-centered outcomes. A sample item for student-centered outcomes includes "Using brain-based teaching will help my students to be successful." An example of an instructionally centered item includes "Using brain-based teaching will improve the design of my lesson plans". In order to align with the BBT self-efficacy beliefs scale, possible responses are selected on a 100-point percentage scale (0 = Entirely uncertain; 100 = Entirely certain). Both Siwatu (2007) and English (2013) reported a one-factor structure on their culturally responsive and PBL teaching outcome expectancy scales.

With the present data, a principal-axis factor analysis with an Oblimin rotation was used to determine factor structure. The Kaiser-Meyer-Olkin measure of sampling adequacy was .90, indicating that the present data were suitable for principal axis factoring. Similarly, Bartlett's Test of Sphericity was significant ($p < .001$), indicating sufficient correlation between the variables to proceed with the analysis. The analysis revealed a single factor for the scale with an eigenvalue of 5.37 accounting for 73% of the variance. The magnitude of each item coefficient within the component matrix was good and exceeded .60 (Meyers et al., 2017). Cronbach's alpha estimate revealed high internal consistency ($\alpha = .95$). The composite mean for the scale was computed for further analyses ($M = 71.05$, $SD = 18.20$).

BBT subjective task value scale (Eccles & Wigfield, 1995; adapted). An adapted scale based on Eccles and Wigfield (1995) was used to measure BBT intrinsic interest value, attainment/importance value, and extrinsic utility value. The seven-item scale includes items assessing intrinsic interest value ("In general, I find brain-based teaching very boring/very interesting"), attainment value ("Is the amount of effort it will take to effectively integrate brain-based teaching worthwhile to you? Not very worthwhile/very worthwhile"), and extrinsic utility value ("How useful is brain-based teaching for meeting your professional goals as a teacher? Not very useful, very useful). Each answer format was presented as a 100-point Likert scale for consistency with the items used in other scales on this instrument (e.g., Serpati & Loughan, 2012). Higher ratings indicate a higher level of value placed on BBT. The three-factor model fit the data of adolescents' beliefs well in the initial validation study of the scale (Eccles & Wigfield, 1995).

A principal-axis factor analysis with an Oblimin rotation was used to determine factor structure. The Kaiser-Meyer-Olkin measure of sampling adequacy was .88, indicating that the present data were suitable for principal axis factoring. Similarly, Bartlett's Test of Sphericity was significant ($p < .001$), indicating sufficient correlation between the variables to proceed with the analysis. The analysis revealed a single factor for the scale with an eigenvalue of 5.18 accounting for 70% of the variance. The magnitude of each item coefficient within the component matrix was good and exceeded .60 (Meyers et al., 2017). Cronbach's alpha estimate revealed high internal consistency ($\alpha = .94$). The composite mean for the scale was computed for further analyses ($M = 74.47$, $SD = 15.68$).

The TAM Questionnaire—BBT (TAMQ-BBT; Teo et al., 2008; adapted). The TAMQ-NE will be used to measure perceived usefulness (PU), perceived ease of use (PEU), BBT attitudes (A), and behavioral intent (BI). The items were adapted based on the Technology Acceptance Model (TAM; Davis, 1989; Teo et al., 2008). Teachers responded to 14 items on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree), indicating to what degree they agree with statements about "brain-based teaching". Example items include, "using brain-based teaching will improve my work (PU scale; four items); I find it easy to translate brain-based teaching into my lessons (PEU scale; four items); Brain-based teaching make work more interesting (A scale; four items); I will use brain-based teaching in the future (BI scale; two items)".

A principal-axis factor analysis with an Oblimin rotation was used to determine factor structure of the PU, PEU, and A scales individually. The Kaiser-Meyer-Olkin measure of sampling adequacy exceeded .75, indicating that the present data were suitable for principal axis factoring. Similarly, Bartlett's Test of Sphericity was significant for all three scales ($p < .001$), indicating sufficient correlation between the variables to proceed with the analysis.

The analysis revealed a single factor for the PU scale with an eigenvalue of 3.35 accounting for 79% of the variance. The magnitude of each item coefficient within the component matrix was good and exceeded .60 (Meyers et al., 2017). Cronbach's alpha estimate revealed high internal consistency ($\alpha = .93$). The composite mean for the scale was computed for further analyses ($M = 3.90$, $SD = 0.87$).

The analysis also revealed a single factor for the PEU scale with an eigenvalue of 2.83 accounting for 62% of the variance. The magnitude of each item coefficient within the component matrix was good and exceeded .60 (Meyers et al., 2017). Cronbach's alpha estimate revealed high internal consistency ($\alpha = .86$). The composite mean for the scale was computed for further analyses (*M* = 3.07, *SD* = 0.85).

Lastly, the analysis revealed a single factor for the A scale with an eigenvalue of 3.32 accounting for 77% of the variance. The magnitude of each item coefficient within the component matrix was good and exceeded .60 (Meyers et al., 2017). Cronbach's alpha estimate revealed high internal consistency ($\alpha = .93$). The composite mean for the scale was computed for further analyses (*M* = 3.60, *SD* = 0.88).

The factor structure of the BI subscale was not calculated as it is comprised of two items. The correlation between those items was .85 (*M* = 3.68, *SD* = 0.89).

BBT Acceptance Intent scale (Venkatesh, Morris, Davis, & Davis, 2003; adapted). A secondary purpose of this study was to ensure measurement rigor of the BI construct, as it is used as the dependent variable in the present study. The purpose of the BBT Acceptance Intent scale is to measure teachers' predicted acceptance of a BBT as an innovation using four items. This scale was adapted based on the TAM (Venkatesh et al., 2003) and follows the guidance of Fishbein (2010) to specify the time period in which the behavior is likely to occur. Teachers respond to four items on a 5-point Likert scale (Not at all Likely/Infrequently to Very Likely/Frequently), indicating how likely they are to use BBT in their pedagogy/planning over the course the next year and how frequently they estimate their use. The items include: "Over the course of the next 12 months: how likely/frequently are you to use brain-based teaching to plan your lessons?; how likely/frequently are you to seek out professional resources to help you understand the brain and its role in teaching and learning?". Facture structure and reliability results are discussed in Chapter Four (Research Question 1).

Procedures

A total of 1,593 emails for high school teachers in the district were provided to the author by the district liaison. These teachers were emailed invitations from the author's university email account to participate in a 15-minute survey. The first email was sent in June 2017 upon completion of state standardized testing. Follow-up invitations to participate in the survey were sent out two days prior to the end of the school year and once during the summer vacation.

The resulting response rate to the survey was 11%. In order to address self-selection, an analysis of non-response bias was conducted by comparing the early respondents to late respondents (Groves, 2006). The results of an independent samples t-test indicated that there were no statistically significant differences on the variables of interest between respondents who completed the survey within the first 48 hours compared to those who completed after the subsequent invitations ($p > .01$).

Participant compensation. Participants had the option to enter their e-mail addresses to be awarded a $10 e-gift card to Amazon.com if they were one of the first 100 respondents to the survey. Upon conclusion of the data collection phase, the first 100 complete survey responses were extracted to generate 100 e-mail addresses for compensation. Once this occurred, all e-mail data were removed from the file for the remainder of the analysis phase.

Instructions. A clear set of instructions were designed to invite the participant to complete the survey, how to navigate the survey itself, and to establish a common understanding and definition of BBT. The instructions included the definition of BBT and two BBT examples for participants to review adapted from work by Tokuhama-Espinosa (2014). A question was presented at the end of the example to ensure the respondents read the content, and to determine its perceived usefulness (i.e., “Did this description help you understand brain-based teaching?”). The majority of respondents found the examples useful (68%), while 30% found them somewhat useful and 2% found them not useful.

Data analysis plan. Upon collection of the responses in Qualtrics, the response data were exported to IBM SPSS version 24 for analysis. The analysis plan included steps to screen the data for missingness and outlier responses. An evaluation of regression assumptions was followed by detailed analysis of each research question. The results are presented in Chapter Four.

Chapter Four

The present study aimed to optimize the measurement of behavioral intent as an outcome by aggregating the Technology Acceptance Model (TAM) literature and evaluating a multi-item adapted scale as an alternative to a traditional two-item scale (Teo et al., 2008). The study also examined the predictive power of the TAM beliefs (i.e., perceived usefulness, perceived ease of use, innovation attitudes) over and above the Social Cognitive Theory (SCT) beliefs (i.e., self-efficacy, outcome expectancies, and subjective task values) with intent to accept brain-based teaching (BBT) as the dependent variable. As a result, the following research questions were addressed:

1. *Is measurement of behavioral intent to accept BBT through a multi-item approach a valid and reliable assessment of this construct?*
2. *What are the unique contributions of TAM's motivational beliefs (i.e., perceived usefulness, perceived ease of use, innovation attitudes) over and above SCT motivational beliefs (i.e., teacher self-efficacy, subjective task value, outcome expectancy) in prediction of secondary teachers' behavioral intent to accept BBT, while controlling for BBT knowledge, experience with BBT, and teaching experience?*

This chapter describes how the data were screened and documents the results of each research question.

Data Screening

Missing data and outliers. A total of 201 teachers submitted responses to the survey. Eighteen teachers responded partially to the first half of the survey and did not include the dependent variable or demographic questionnaire items. Conducting multiple imputations for the missingness was not acceptable due to the systematic nature of these missing data, and thus the 18 partial responses were removed. The sample, therefore, was reduced to 183 full responses.

The new dataset presented instances of data missing at random (MAR; Meyers et al., 2017). A multiple imputation calculation in IBM SPSS version 24 was used to conduct five imputations of the original dataset to address the MAR data. A complete pooled dataset was then created for further analysis.

Outliers were visually assessed using guidance from Meyers et al. (2017) for the sample of 183 cases for each variable of interest. One response case presented as an outlier on multiple variables of interest and presented an irregular response pattern. As such, this case was removed and the final sample was obtained ($N = 182$).

G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) was used to estimate a post hoc power analysis for sequential multiple regression models. A sample of $N = 182$ assessing a medium effect ($F^2 = .087$; $\alpha = .05$) with nine predictors (numerator $df = 6$) revealed acceptable statistical power of .85 above the recommendation by Cohen (1988).

Statistical assumptions. Assumptions must be met in order to generate an interpretable regression model (Berry, 1993; Meyers et al., 2017). The first assumption tested was normality of the distributions of the independent and dependent variables. The

Kolmogorov-Smirnov test was calculated ($p < .001$) and revealed some indication of deviations from normality within the Technology Acceptance Model (TAM) questionnaire subscales and the BBT Acceptance Intent scale. Due to the Kolmogorov-Smirnov test's sensitivity to normality departures, further examinations of skewness and kurtosis statistics were conducted. All variables of interest revealed skewness and kurtosis statistics less than two, therefore assuming the normality of the variables (Lomax & Hahs-Vaughn, 2012).

A second focus area was linearity and collinearity of the independent variables. A scatterplot matrix of the variables of interest revealed elliptical or oval shaped cells, indicative of linear relationships between each of the variables (Meyers et al., 2017). Further, Berry (1993) states that there should not be multicollinearity among the predictor variables in regression analyses. While a perfect correlation is unlikely, a high level of multicollinearity can challenge the ability to interpret the unique effects of each independent variable. A Pearson correlation table (see Table 3) among the independent variables revealed correlations less than .80, indicating a lack of collinearity. Lastly, the variance inflation factor (VIF) for each independent variable's relationship to the others was calculated. Each value was equal to or less than 3.0, further indicating the lack of problematic multicollinearity in the present data (Cohen, Cohen, West, & Aiken, 2003).

A systematic variation in independent variables' errors violates the assumption of homoscedasticity (i.e., equal residual variance; Berry, 1993). In order to confirm homoscedasticity a plot of the residuals (i.e., ZRESID—standardized residuals) was generated for each independent variable with BBT Acceptance Intent as the dependent variable. Visual examination of the individual scatterplots revealed a consistent pattern of residuals across each line of best fit, confirming the assumption of homoscedasticity. The combined scatterplot for each independent variable's residual with BBT Acceptance Intent as the dependent variable is included in Appendix C. Since no violations of regression assumptions were identified, the research questions were examined.

Table 3

Pearson Correlations Among Independent Variables and Descriptive Results

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1. Years Teaching	1								
2. BBT Experience	.03	1							
3. Knowledge	.07	.09	1						
4. Task Value	.22**	.26**	.10	1					
5. Self-Efficacy	.17*	.27**	.13	.47**	1				
6. Out. Expect.	.16*	.37**	.12	.72**	.57**	1			
7. PU	.08	.24**	.12	.61**	.38**	.62**	1		
8. PEU	.14	.35**	.02	.46**	.49**	.52**	.58**	1	
9. Attitudes (A)	.09	.31**	.13	.58**	.43**	.57**	.75**	.70**	1
Mean	10.49	2.33	18.43	74.47	65.47	71.05	3.90	3.07	3.60
SD	8.15	1.70	3.54	15.68	18.55	18.20	0.87	0.85	0.88

Note. * $p < .05$; ** $p < .01$

Research Question 1: Is measurement of behavioral intent to accept BBT through a multi-item approach a valid and reliable assessment of this construct?

RQ1 was addressed by assessing both the quantitative and content-based features of the four-item BBT Acceptance Intent scale.

Quantitative analysis. In order to determine internal consistency reliability for the scale, Cronbach's coefficient alpha was calculated ($\alpha = .92$), indicating high reliability for the BBT Acceptance Intent scale. Secondly, the correlation between the BBT Acceptance Intent composite score and the Behavioral Intent (BI) composite score from the TAM Questionnaire was calculated for evidence of convergent validity. A significant Pearson correlation coefficient ($r = .60$, $p < .01$) revealed evidence of convergent validity for the BBT Acceptance Intent scale, as it intends to measure behavioral intent to accept BBT.

A principal-axis factor analysis with an Oblimin rotation was used to determine factor structure of the BBT Acceptance Intent scale. The Kaiser-Meyer-Olkin measure of sampling adequacy was .74, indicating that the present data were suitable for principal axis factoring. Similarly, Bartlett's Test of Sphericity was significant ($p < .001$), indicating sufficient correlation between the variables to proceed with the analysis. The analysis revealed a single factor for the scale with an eigenvalue of 3.19 accounting for 73% of the variance. The magnitude of each item coefficient within the component matrix was good and exceeded .60 (Meyers et al., 2017). Table 4 highlights the item wording, factor coefficients, and communalities. The composite mean for the scale was computed ($M = 3.69$, $SD = 0.92$).

Table 4

BBT Acceptance Intent Scale: Factor Matrix Coefficients and Communality Coefficients

		Communalities	
Item Number and Wording	Factor Matrix Coefficient	Initial	Extraction
Over the course of the next 12 months...			
How likely are you to seek out professional resources to help you understand the brain and its role in teaching and learning?	.84	.69	.71
How frequently are you to seek out professional resources to help you understand the brain and its role in teaching and learning?	.82	.67	.67
How likely are you to use brain-based teaching to plan your lessons?	.89	.78	.78
How frequently are you to use brain-based teaching to plan your lessons?	.87	.76	.76

Note. Rounding the nearest hundredth decimal point resulted in equal values for three of the four communalities.

Content analysis. The statistical analysis of the BBT Acceptance Intent scale revealed evidence of a valid and reliable measure of behavioral intent to accept BBT, therefore analysis of the content quality of the scale was necessary to further determine the psychometric suitability of the scale and to confirm its use as the dependent variable for Research Question 2. Table 5 highlights the item content of the BBT Acceptance

Intent scale against the traditionally used behavioral intent (BI) subscale in the TAM Questionnaire. There are two justifications as to why the newly adapted four-item scale may provide a valid and reliable measure of the construct. One is due to the increased level of specificity of the items on the BBT Acceptance Intent scale, and the second is due to the widely recognized strengths of multi-item scales (and thus the limitations of two-item scales). That is, latent variables are often complex and not easily measured with one or two items and potentially omitting or under-specifying the measurement of a latent construct may introduce systematic measurement error, while the use of multiple indicators enhances construct validity (Eisinga, Grotenhuis, & Pelzer, 2013). Therefore, the BBT Acceptance Intent scale was used to answer RQ2 because both item specific and multi-item scales are preferable, while it also displayed strong evidence of internal consistency, content validity, and convergent validity.

Table 5

BBT Acceptance Intent Item Content Table

Item	BBT Acceptance Intent	TAMQ-BBT BI
1	Over the course of the next 12 months, how likely are you to use brain-based teaching to plan your lessons?	I will use brain-based teaching in the future.
2	Over the course of the next 12 months, how frequently are you to use brain-based teaching to plan your lessons?	I plan to use brain-based teaching often.
3	Over the course of the next 12 months, how likely are you to seek out professional resources to help you understand the brain and its role in teaching and learning?	
4	Over the course of the next 12 months, how	

frequently are you to seek out professional resources to help you understand the brain and its role in teaching and learning?	

Research Question 2: What are the unique contributions of TAM's motivational beliefs (i.e., perceived usefulness, perceived ease of use, innovation attitudes) over and above SCT motivational beliefs (i.e., teacher self-efficacy, subjective task value, outcome expectancy) in prediction of secondary teachers' behavioral intent to accept BBT, while controlling for BBT knowledge, experience with BBT, and teaching experience?

A sequential multiple regression with three steps was used to address RQ2. Table 6 presents the sequential regression table. Control variables of interest were entered in *Model 1*, the Social Cognitive Theory (SCT) motivational belief variables were entered in *Model 2*, and the TAM belief and attitude predictors were entered in *Model 3*. BBT Acceptance Intent was used at the dependent variable. The model was statistically significant, $F(9, 170) = 21.17$, $p < .05$, and accounted for 53% of the variance in Intent to Accept BBT ($R^2 = .528$, adjusted $R^2 = .503$). Further, the SCT variables contributed the most amount of variance ($\Delta R^2 = .278$) while adding the TAM variables revealed a unique contribution of 3.7% of the variance ($\Delta R^2 = .037$).

A review of the standardized coefficients for *Model 3* reveals that Previous BBT Experience ($\beta = .21$, $t(170) = 3.68$, $p < .05$), BBT Subjective task value ($\beta = .26$, $t(170) = 3.14$, $p < .05$), and BBT Perceived Ease of Use ($\beta = .17$, $t(170) = 2.08$, $p < .05$) were the most significant variables to predict BBT Acceptance Intent. In order to further evaluate the unique contribution of each independent variable, the semi-partial R^2 values were also considered. As such, the unique contributions particularly of the three variables highlighted above provide evidence that similar results would be obtained if alternative models were tested.

Table 6

Sequential Multiple Regression Predicting BBT Acceptance Intent

Model		*b*	*SE b*	*β*	*t*	Semi-Partial r^2
Model 1	(Constant)	2.66	0.34		7.95*	
	Years Teaching	0.01	0.01	.06	0.83	.06
	Previous BBT Experience	0.24	0.04	.44	6.59*	.44
	NE Knowledge	0.02	0.02	.08	1.22	.08
Model 2	(Constant)	0.68	0.34		1.98*	
	Years Teaching	-0.01	0.01	-.06	-1.08	-.06
	Previous BBT Experience	0.14	0.03	.25	4.34*	.24
	NE Knowledge	0.01	0.01	.04	0.69	.04
	BBT Self-Efficacy	0.01	0.00	.11	1.60	.09
	BBT Subjective task value	0.02	0.01	.32	4.08*	.22
	BBT Outcome Expect	0.01	0.00	.23	2.65*	.14
Model 3	(Constant)	0.39	0.35		1.12	
	Years Teaching	-0.01	0.01	-.06	-1.10	-.06
	Previous BBT Experience	0.12	0.03	.21	3.68*	.19
	NE Knowledge	0.01	0.01	.05	0.83	.04
	BBT Self-Efficacy	0.00	0.00	.05	0.74	.04
	BBT Subjective task value	0.02	0.01	.26	3.14*	.17
	BBT Outcome Expect	0.01	0.00	.17	1.96	.10
	BBT PU	0.02	0.09	.02	.19	.01
	BBT PEU	0.18	0.09	.17	2.08*	.11
	BBT A	0.10	0.10	.10	1.00	.05

Note. * $p < .05$; Model 1: $R^2 = .21$; Model 2: $R^2 = .49$, $\Delta R^2 = .28$; Model 3: $R^2 = .53$, $\Delta R^2 = .04$

Chapter Five

The MBE field's success is dependent, in part, on its reciprocal relationship with educational practitioners. To date, little is known about teachers' beliefs regarding MBE. The present study addresses this problem by investigating teachers' intent to accept brain-based teaching (BBT) as an application of MBE and as an educational innovation in the classroom (e.g., Fullan, 2001). The study also provides a theoretically driven framework to explore teacher beliefs in the context of BBT—pulling from both the social-cognitive theory of motivation (SCT) and the Technology Acceptance Model (TAM). The study focused on two specific research questions addressing predictive power of SCT and TAM beliefs as well as the measurement of BBT Acceptance Intent.

To summarize, the new four-item BBT Acceptance Intent scale revealed suitable reliability and validity indicators and, thus, was used as the dependent variable for the present study. The results of a sequential multiple regression revealed that the model predicted 53% of the variance in BBT Acceptance Intent. Both TAM and SCT are important theoretical frameworks for understanding teachers' beliefs and their impact on BBT Acceptance Intent, however, the TAM variables predicted only 3.7% variance over and above the SCT belief variables that predicted 28% of the variance while controlling for prior experience with BBT, years teaching, and BBT knowledge.

The following sections discuss the findings of the behavioral intent to accept BBT scale analysis (RQ1), the findings of the sequential multiple regression (RQ2), and how the results align with prior research. This chapter concludes with a discussion of implications, limitations, and future research suggestions for MBE professionals.

Finding One: The Newly Adapted Four-Item Scale Measuring Intent to Accept BBT is a Valid and Reliable Measure of the Construct

The first research question was: Is measurement of behavioral intent to accept BBT through a multi-item approach a valid and reliable assessment of this construct? Common measurement guidelines indicate that a four-item scale is preferable to a two-item scale in order to fully assess a latent construct (e.g., Fowler, 1995). Further, Ajzen (2010) highlights the importance of phrasing behavioral intent scale items with language that defines the temporal bounds of the intent estimate. The newly adapted four-item scale was evaluated as an alternative to a broadly worded, two-item scale often used in the TAM literature to assess teacher innovation acceptance (Teo et al., 2008).

Internal consistency for the four-item scale was high. A significant correlation between the composite scores for the two-item behavioral intent (BI) scale and the four-item BBT Acceptance Intent scale revealed evidence of convergent validity. Lastly, a factor analysis revealed a single factor for the four-item scale, providing evidence of construct validity. The statistical results suggest that the four-item scale is consistently measuring the construct, and that the scale is demonstrating both construct and convergent validity. The evaluation of the four-item scale supported its use as the dependent variable for the present study.

Discussion. The use of behavioral intent as a dependent variable in the context of innovation acceptance is based on two arguments. First, the TAM allows for interpretation and comparison of results with other research from a variety of fields in which acceptance or behavioral intent is predicted. Secondly, innovations are often new to most users, and thus actual implementation behaviors would be an unreasonable construct to measure (Bourgonjon et al., 2013; Teo, 2011). Based on the results of initial studies investigating teacher beliefs and knowledge of BBT (Dekker et al., 2012; Serpati & Loughan, 2012), the present study confirms the emerging interest but insufficient knowledge of BBT within a sample of highly educated high school teachers.

Comparison of results across studies using the TAM to predict behavioral intent has been complicated due to the variability in measurement of the latent construct. In Chapter Two, I summarized an interdisciplinary sample of behavioral intent measures in the relevant literature (see Table 1, p. 60). This sample of studies illustrates the variability in the measurement of behavioral intent within the literature investigating both teacher and non-teacher populations. The scales in the reviewed studies consist of one to three items with five- or seven-point Likert-type response options that address likelihood, agreement, and/or frequency estimations.

The literature review established that measurement of behavioral intent with one or two items is problematic due to the latent nature of the construct. That is, latent variables are often complex and difficult to measure with one or two items (Eisinga, Grotenhuis, & Pelzer, 2013). Further, asking teachers to forecast their future behavior introduces additional complexity to the measurement of behavioral intent, particularly because people tend to be overly optimistic when forecasting into the future (Liberman & Trope, 1998).

Additionally, variability in item format reveals that fine degrees of the latent construct are accounted for in some studies (e.g., frequency estimations of intent) but are omitted in other studies using broader degrees of intent (e.g., “I intend to use the technology”). Omitting or under-specifying the measurement of a latent construct may introduce systematic measurement error, whereas the use of multiple indicators enhances construct validity (Eisinga et al., 2013).

Lastly, the variation in Likert-type scale response formats introduces incongruence across studies claiming to measure the behavioral intent construct. The small sample of six studies summarized in Chapter Two revealed six different approaches to Likert-type scale response formats. The common use of a seven-point scale is potentially problematic, as there is little evidence that seven points effectively differentiate from one another and a five-point format is preferable (Likert, 1932).

In the present study, convergent validity of the newly adapted BBT Acceptance Intent scale was correlated with a commonly used two-item scale (Teo, 2008). The new scale was specified by a timeframe as suggested by Ajzen (2010); in this case one year. A five-point Likert-type response was used. Given RQ1 findings and extant literature regarding psychometric properties of construct measurement scales reviewed, the four-item scale is preferable and suggested for future use in teacher innovation acceptance studies within the context of BBT. The format of this scale could also be adapted for alternate contexts.

Finding Two: TAM beliefs predict approximately 3.7% of the variance in BBT Acceptance Intent over and above the 28% variance predicted by SCT beliefs while controlling for BBT knowledge, experience, and teaching experience.

The second research question was: What are the unique contributions of TAM's motivational beliefs (i.e., perceived usefulness, perceived ease of use, innovation attitudes) over and above SCT motivational beliefs (i.e., teacher self-efficacy, subjective task value, outcome expectancy) in prediction of secondary teachers' behavioral intent to accept BBT, while controlling for BBT knowledge, experience with BBT, and teaching experience?

A sequential multiple regression with three steps was used to test RQ2. Control variables were entered in *Model 1*, the SCT motivational belief variables were entered in *Model 2*, and the TAM belief and attitude predictors were entered in *Model 3*. The newly adapted BBT Acceptance Intent scale mean score was the dependent variable. The model accounted for approximately 53% of the variance in BBT Acceptance Intent. The SCT variables contributed the most amount of variance (28%) while adding the TAM variables revealed a unique contribution of 3.7% of the variance. A review of the standardized coefficients revealed that Previous BBT Experience, BBT Subjective task value, and BBT Perceived Ease of Use were the most significant variables to predict BBT Acceptance Intent in *Model 3*. The following sections discuss these findings in detail.

SCT Discussion. *Model 1* and *Model 2* within the sequential multiple regression align partially with Fullan's (2001) framework of innovation acceptance. Fullan detailed three factors that impact a practitioners' acceptance of an educational innovation and their decision to act: (1) teachers' expectations for student success, (2) subjective task value, and (3) sense of self-efficacy for enacting the change. That is, in order for teachers to invest in the change required to adopt an innovation, they must feel that the innovation has value, will result in successful outcomes for their students and themselves, and that they have the confidence to execute the tasks needed to adopt the innovation. The present study revealed the importance of subjective task value and outcome expectancies in the context of BBT, operationalized by the SCT of motivation (Bandura, 1977; Wigfield & Eccles, 2000). With a large percentage of predicted variance, the three SCT variables combined in *Model 2* predicted the highest amount of BBT Acceptance Intent variance while controlling for prior experience, years teaching, and knowledge of BBT.

Nonetheless, the present study did not reveal a statistically significant contribution of BBT self-efficacy in *Model 2*. Additionally, subjective task value and outcome expectancies were statistically significant in *Model 2*; however, in *Model 3* only subjective task value was statistically significant. The descriptive results revealed a lower average response to the self-efficacy scale when compared to the subjective task value and outcome expectancy scales. It is possible that there was lower efficacy reported because teachers did not feel confident implementing BBT, however they still saw the value in BBT and therefore fluctuations in self-efficacy had no impact on acceptance intentions.

In a study of teachers' implementation of Data Driven Decision Making (DDDM), Dunn et al. (2011) found that teachers who were more confident in their ability to engage in DDDM were more likely to be concerned with this innovation and engage with colleagues to infuse DDDM into their classrooms. This study highlights the importance of efficacy beliefs for encouraging the use of innovations within a classroom, school, or district. Therefore, while the teachers' BBT self-efficacy was rather low and did not influence acceptance intent, it is possible what when actual implementation behaviors are studied self-efficacy beliefs will explain more variance.

Additionally, the scale for self-efficacy requires further validation. This scale was newly developed using Bandura's guidelines, and may require further revisions and validity studies. This is important because proper scale development seeks to establish face, content, convergent, and discriminant validity to ensure that the newly created scale is measuring what it is intended to measure (Crocker & Algina, 1986).

Assessing the specific contributions of each SCT independent variable in *Model 3*, the findings converge with findings from English (2013). In the context of Project-based learning (PBL), English found that subjective task value was the only motivational belief to significantly predict PBL implementation. Outcome expectancy and self-efficacy were not significantly related to implementation after controlling for contextual factors such as prior PBL experience and perceptions of school support.

In sum, the SCT beliefs in this study predicted a large amount of the variance in BBT Acceptance Intent. For researchers studying intent of early-stage or complex innovations such as BBT, these results shed light on the importance of subjective task values and their role in early implementation efforts for classroom innovations.

TAM Discussion. This is the first study to have assessed the predictive power of TAM beliefs over and above SCT motivational beliefs in the context of educational innovations. The results reveal SCT motivational beliefs to be more powerful in the context of BBT Acceptance Intent. This finding is significant because behavioral intent has been conceptualized largely within the TAM research tradition and is rarely used as an independent variable in studies using SCT as a theoretical framework. It is possible that TAM researchers may find SCT variables to be helpful in their work.

The finding that perceived ease of use (PEU) was the most significant TAM variable in predicting BBT Acceptance Intent diverged from previous TAM studies that showed only indirect impacts of PEU on intent to accept (Teo et al., 2008). Further, Bourgonjon et al. (2013) found that teacher beliefs were multifaceted, and that the perceived usefulness (PU) of the technology was the most important direct predictor of acceptance intent in the context of game-based teaching, which also aligned with findings of previous TAM research (Venkatesh, Morris, Davis, & Davis, 2003; Davis, 1989).

The statistical insignificance of PU in the present study is also of note because of the close relationship between SCT's subjective task value construct and TAM's PU construct. Subjective task value was statistically significant throughout *Model 2* and *Model 3*; however, PU was not statistically significant within *Model 3.* While Table 3 reveals a moderately high, statistically significant correlation between the two scales, there is evidence that they are measuring distinct constructs. Subjective task value as defined by Eccles and Wigfield (1995) contains three facets: intrinsic interest value, attainment/importance value, and extrinsic utility value. PU is measured using items that are most similar to extrinsic utility value. As such, it is possible to conclude that intrinsic interest value and attainment/importance values are more important to address in the context of emerging innovations such as BBT; however extrinsic utility values may be more important later in the innovation acceptance lifecycle.

The present study cannot be directly compared to prior TAM research utilizing path analysis and structural equation models. Nonetheless, researchers evaluating education innovations from any theoretical lens may consider a measure of PEU in order to better explain teachers' acceptance intent for various innovations. This would be particularly important for innovations that may require increased technical or specified knowledge such as BBT, given that teachers often struggle to implement new classroom initiatives, often lack proper training on the initiatives, and are restricted by inadequate resources (American Federation of Teachers, 2015).

Prior experience. The present study found that prior experience with BBT was an important predictor of BBT Acceptance Intent. Extant research supports the importance of prior experience impacting innovation acceptance in the classroom. English (2013) found that previous experience with PBL was significantly predictive of implementation. Further, prior learning opportunities involving gaming significantly predicted teachers' usefulness ratings of game-based teaching (Bourgonjon et al., 2013). Given the results of the present study and previous education innovation studies, effective BBT professional development for teachers is essential to ensure implementation efforts succeed.

MBE literacy. The results of the BBT Knowledge Scale reveal the need for further evaluation of the measurement of this construct as well as improvement of teachers' general MBE literacy. The scale developed by Dekker et al. (2012) was used in the present study. The average score for the present sample on this scale was rather low, indicating an inadequate knowledge of the concepts. However, further definition of the construct and validation of the scale may increase teachers' scores. That is, it is possible that the measurement of both correct, incorrect, and neuromyth statements is misleading as many neuromyths are derived from scientific studies and are often presented as fact in mainstream resources (Pasquinelli, 2012). Additionally, the need for further validation of the self-efficacy scale would hinge on the proper measurement of knowledge, as they are typically highly correlated constructs and were uncorrelated in the present study (Pajares, 1997). Detailed work regarding the definitions needed to further validate scales of this nature within MBE is currently underway (Tokuhama-Espinosa, 2017).

Summary. Studies that incorporate both features of SCT and TAM could shed additional light on the complex belief systems that impact innovation acceptance and application. The present study established baseline reliability and validity evidence for a newly adapted BBT Acceptance Intent scale that could be adapted for other researchers interested in intent to accept innovations. Secondly, this study provided additional insight into the complex and multidimensional role of teacher beliefs as well as prior experiences and knowledge. While controlling for the latter variables, beliefs from the TAM added 3.7% of the variance in a model that in its totality predicted 53% of the variance in BBT Acceptance Intent. As such, SCT beliefs appear to have stronger predictive power than TAM in the context of BBT Acceptance Intent. There are ample opportunities for future research that were suggested briefly in this section and are detailed further in the next. First, I discuss the present study's limitations and practical implications.

Practical Implications

Recommendations for researchers. The results of this study provide an opportunity for MBE researchers to further explore teachers' complex motivational beliefs regarding MBE and BBT. Further, a focus on general BBT and not a specific marketed product allows for the development of research-driven solutions where these results may be of use. The finding that most teachers plan to accept BBT into their teaching in the near future, however, general knowledge of MBE is low, indicates a large gap in the field for MBE researchers to address. That is, MBE researchers must continue to provide resources that improve communication between MBE professionals and education professionals while also improving general knowledge of MBE in the education community given heightened interest in MBE within the education community (see Tokuhama-Espinosa, 2017 for detailed MBE community initiatives). A practical professional development product or tool from the MBE community would be a significant contribution to the field.

The results of the study also provide further guidance for researchers in terms of using SCT and TAM motivational beliefs variables in an effort to predict intentions to accept educational innovations. While both SCT and TAM have strong theoretical traditions, the SCT variables appear to be more useful in prediction of intentions in this context. This is probable, as the innovation at hand was not directly related to a specific technology, while the TAM was developed in the context of technology use. However, the prediction of intent using the TAM and Theory of Planned Behavior tradition indicates that those theories may not include constructs that fully explain the variation in behavioral intent. More research is needed to clarify the relationship between these key motivational beliefs variables and their impact on behaviors.

The present study also revealed a need for further investigation of the measurement of behavioral intent to accept an innovation or technology. As such, this study provided a newly adapted measure of the behavioral intent construct in the context of BBT. An analysis of this new measure was conducted, yet it is important to explore in more detail the measurement of behavioral intent to accept educational innovations as it has proven to be prevalent in the interdisciplinary TAM literature. Further, since behavioral intent is used to determine the intended acceptance of rather complex innovations, it is essential to use in-depth introductions such as what was used in the present study as well as Bourgonjon et al. (2013). This allows (1) participants to understand the innovation being evaluated, (2) researchers to ensure a baseline level of participants' innovation knowledge, and (3) researchers to improve the validity of behavioral intent measurement. Promisingly, a majority of participants in the present study found the detailed instructions to be useful.

Recommendations for educators. Educators and administrators across all educational levels may specify actions based on results of this study. First, faculty in schools of education may consider the inclusion of modules in their pre-service teaching coursework that focus on the brain and how to effectively and critically evaluate resources advertised to the education community. The present study revealed rather low levels of knowledge regarding MBE concepts. Given that the teachers in the participants reported education levels primarily at or above the master's level of graduate education

(82%), both graduate and undergraduate programs may consider addressing this concept in more depth with a focus on dispelling neuromyths. This result also aligns with the results of Serpati and Loughan (2012) that found in an information-saturated climate, teachers would like to know what not to do in their classrooms. One example of this would be faculty members actively dispelling the concept that teaching based on neuromyths like hemispheric dominance is grounded in scientific research.

Secondly, if a district or school is pursuing brain-based professional development, the training must first be critically evaluated for scientific validity (e.g., Tardif et al., 2015). One way to evaluate the validity of a BBT program would be to determine if aspects of the program support or dispel the common neuromyths highlighted in OECD (2007). A second suggestion for school leaders is to engage with academic faculty experts before selecting professional development programs of this nature. If the content is considered appropriate, then a second preemptive step for administration to consider is their staff’s beliefs regarding the value and ease of use of the content. That is, if the staff devalues BBT or if they find it cumbersome to apply in the classroom, it is unlikely that the initiative will be applied and may have no positive impact on students.

For researchers and evaluators investigating the impact of such professional development initiatives, it may be useful to use the scales from the present study as a pre-screening. These pre-screening surveys should collect background information on whether teachers have had experience with BBT, as well as their current knowledge and motivational beliefs using such scales. Upon completion of a brain-based professional development activity, evaluators may administer a debriefing survey to understand how teachers' knowledge and beliefs may have changed over the course of the training and whether they intend to use what they learned at the event in their classroom. Lastly, while there is evidence that brain-based teacher professional development improves knowledge of the content; there is a paucity of scientific evidence regarding its impact on students in the classroom and actual teacher behaviors (Ansari, König, Leask, & Tokuhama-Espinosa, 2017). As such, those pursuing evaluations of these professional development programs are encouraged to follow up with teachers on their use of BBT and the resulting impacts on their students.

Limitations and Suggestions for Future Research

The present study aimed to understand how teachers' motivational beliefs, knowledge and prior experience impact their intent to accept BBT into their pedagogy. The study was the first to incorporate theories of motivation to explore BBT implementation challenges, and it yielded results that may shape effective implementation and professional development in the future. There are, however, limitations to this study.

First, there is evidence that teachers' general understanding of BBT may be low, which impacts the accuracy of the judgments made about BBT. Dekker et al. (2012) found that teachers with more general knowledge of BBT were more likely to also subscribe to the neuromyths. The results of the present study revealed very low scores on the scale—the average score was about 58% correct, indicating many teachers struggled to differentiate between accurate, false, and neuromyth statements about the brain. This indicates that there is significant misunderstanding of MBE concepts, what it is, and what it is not, and how that may impact pedagogy. Since a majority of respondents found the detailed instructions and examples prior to the survey to be helpful, there is evidence that resources devoted to improving MBE literacy in the education community would be well received.

Beyond the possibility that teachers simply struggle to differentiate between true and false statements about the brain, a related limitation involves the measurement of neuroscience knowledge in general. First, it is likely that the scale could be improved as low scores, high standard deviations, and lack of correlation between other scales in the study may also indicate misspecification of the latent construct of interest. Its utility as a measure in future studies may be improved by further measurement specification and validation. Secondly, the broad implications of using a measure that includes popular neuromyths without providing participants with feedback on their results may further perpetuate subscription of the neuromyths presented in the scale. As such, those using this measure in the future may include a feedback section for participants so they can learn how to better differentiate between fact and myth.

A second limitation to this study is the lack of agreed upon competencies that teachers must attain in order to effectively implement in BBT. Because there has not been a large-scale definition and validation of essential teacher competencies related to implementing BBT in practice, much of the present research is focused on “information-use” rather than strategic implementation. Identifying and validating the essential BBT competencies is an important next step in the development of valid and reliable MBE classroom application and the professional development that would precede such implementation efforts.

A third limitation in the present study involves survey research methodology. Surveys pose a validity-threat because respondents react to social desirability and self-select to respond to the survey (Rea & Parker, 2005). Further, the survey was administered at one point in time; thus, this temporal limitation did not provide an understanding of how these beliefs evolve over time or are influenced by environmental factors such as school initiatives. Future research should follow up to evaluate how teachers subsequently used BBT. An observational and interview approach would be ideal for follow-up in order to address the potential sources of survey error.

Lastly, the present study focuses on beliefs related to future acceptance of BBT in order to guide future implementation. The study did not directly assess BBT's impact on student learning or teacher effectiveness. While measuring behavioral intent is common within the literature reviewed, there is some evidence, despite the popular theory of planned behavior and TAM approach, that intentions do not consistently predict behavior. For example, Arts, Frambach, and Bijmolt (2011) found in their meta-analysis of consumer innovation adoption that users were more likely to report higher levels of intent to adopt when the innovation was complex, met their needs, and was low in uncertainty. However, actual behavioral adoption occurred when the innovation was less complex. Thus, there remains some uncertainly around the degree to which teachers who intend to accept or adopt BBT pedagogy would actually do so. It is intended that the results of this study will lead to subsequent research that addresses the degree to which teachers actually utilize BBT (i.e., behavior) as well as the impact BBT has on both the classroom environment and the learners within that environment.

Beyond the need for educational psychologists to further disentangle the relationship between SCT and TAM motivational beliefs variables, the present study poses additional questions for MBE researchers. It is imperative that the field focuses its efforts on communication toward the larger education audience in order to build the communicative bridge between scientists and practitioners, particularly around the MBE knowledge scores contrasted by a large interest in application. This study builds upon the work of Pickering and Howard-Jones (2007) and Serpati and Loughan (2012) and opens new avenues of research on teacher beliefs, acceptance intent, and knowledge within the context of BBT.

A second area that begs further investigation is the competencies teachers must acquire in order to apply BBT or MBE concepts in the classroom. This goes beyond knowledge toward application. Those involved in teacher professional development are urged to further define these competencies with both the MBE and teaching education community involved.

Lastly, researchers may aim to replicate this study with a larger sample in order to conduct an analysis using structural equation modeling. As seen in the TAM literature review (e.g., Bourgonjon et al., 2013, Teo et al., 2008), these advanced modeling techniques are the norm. For validation and extension of the present study, advanced modeling techniques could simultaneously address the unanswered questions regarding the relationships between variables as well as measurement challenges.

Summary

During a time where teacher, school, and district accountability is driven by aggregate test scores, a focus on the true form and function of learning in the human brain is a reprieve for both teachers and students alike. Educational psychologists should continue to support a dialogue between teachers and the neuroscience community to assist and direct evidence-based, neuropsychologically sound teaching practices (e.g., Benton, 2010). Without a strong link to educational practice, MBE is not distinctly different from its parent disciplines of psychology and cognitive neuroscience (Tokuhama-Espinosa, 2011). Continued bridging efforts would improve the relevance of MBE while also increasing understanding of MBE in the education community.

The present study moves the MBE community closer toward a theoretically sound understanding of the role of teachers experience, knowledge, and beliefs on their application of the field's vast knowledge. The present study documented the particular importance of prior experience, subjective task values, and perceived ease of use in the context of BBT acceptance intent. The study has also highlighted areas that continue to be problematic in samples of teachers both in the United States and elsewhere. That is, MBE professionals continue to be uniquely challenged by a pronounced interest but low understanding of the content.

Given that the goal of MBE is an improved understanding of how to educate individuals within modern society, student-learning improvements would be the ideal outcome to assess impact. However, more work is needed in the form of implementation and professional development for teachers and other practitioners before the impact of

MBE on student academic achievement can be assessed. This study influences an effective application of MBE and provides guidance to both MBE and education practitioners toward this goal.

Appendix A

IRB Approval Letter and Consent Form

Office of Research Development, Integrity, and Assurance

Research Hall, 4400 University Drive, MS 6D5, Fairfax, Virginia 22030
Phone: 703-993-5445; Fax: 703-993-9590

DATE:	May 10, 2017
TO:	Anastasia Kitsantas, PhD
FROM:	George Mason University IRB
Project Title:	[585100-1] THE IMPACT OF SECONDARY TEACHERS' MOTIVATIONAL BELIEFS ON THEIR INTENT TO ACCEPT BRAIN-BASED TEACHING
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	May 10, 2017
REVIEW CATEGORY:	Exemption category #2

Thank you for your submission of New Project materials for this project. The Institutional Review Board (IRB) Office has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

Please remember that all research must be conducted as described in the submitted materials.

Please note that any revision to previously approved materials must be submitted to the IRB office prior to initiation. Please use the appropriate revision forms for this procedure.

If you have any questions, please contact Katie Brooks at (703) 993-4121 or kbrook14@gmu.edu. Please include your project title and reference number in all correspondence with this committee.

Please note that all research records must be retained for a minimum of five years, or as described in your submission, after the completion of the project.

Please note that department or other approvals may also be required to conduct your research.

GMU IRB Standard Operating Procedures can be found here: http://oria.gmu.edu/1031-2/?_ga=1.12722615.1443740248.1411130601

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within George Mason University IRB's records.

THE IMPACT OF SECONDARY TEACHERS' MOTIVATIONAL BELIEFS ON THEIR INTENT TO ACCEPT BRAIN-BASED TEACHING

INFORMED CONSENT FORM

RESEARCH PROCEDURES

This research is being conducted to understand more about how in-service teachers perceive brain-based teaching. If you agree to participate, you will be asked to complete a 15-minute survey about your beliefs related to brain-based teaching.

RISKS

There are no foreseeable risks for participating in this research.

BENEFITS

There are no benefits to you as a participant other than to further research in brain-based teaching.

CONFIDENTIALITY

The data in this study will be confidential. Participant email addresses will be separated from the participant's survey responses so that the participant's identity is unknown. While it is understood that no computer transmission can be perfectly secure, reasonable efforts will be made to protect the confidentiality of your transmission.

PARTICIPATION

Your participation is voluntary, and you may withdraw from the study at any time and for any reason. If you decide not to participate or if you withdraw from the study, there is no penalty or loss of benefits to which you are otherwise entitled. There are no costs to you or any other party.

Participants must be licensed in-service high school subject teachers with at least a bachelor's degree to participate in the present study. Staff will be excluded if they currently serve in support or administrative roles.

You will receive compensation in the amount of a $10 e-gift card to Amazon.com if you are one of the first 100 respondents to complete the survey.

CONTACT

This research is being conducted by Lauren Serpati, M.Ed. at George Mason University College of Education and Human Development. She may be reached at 571-246-6595 for questions or to report a research-related problem. The faculty advisor is Anastasia Kitsantas, Ph.D. and she may be reached at 703-993-2688. You may contact the George Mason University Institutional Review Board office at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

CONSENT

I have read this form, all of my questions have been answered by the research staff, and I agree to participate in this study.

- ☐ Accept

Appendix B

Brain-Based Teaching Survey

[GMU IRB Informed Consent Form-see Appendix A]

Introduction

Survey Directions

The purpose of this survey is to understand high school teachers' knowledge and beliefs regarding **brain-based teaching.**

Brain-based teaching refers to teaching methods and lesson designs that are informed by the latest scientific research findings about the brain.

The two examples of brain-based research presented below highlight how research findings may be translated into brain-based teaching. As you complete this survey, please respond candidly about brain-based teaching in the context **of your own professional practice**.

> ***Example 1:***
>
> *Researchers presented students with facts that challenged their naïve beliefs about gravity. Videos showed a large ball and a small ball falling at the same rate (accurate), and another that showed a large ball falling at a faster rate than the small ball (naïve). The students were asked to determine which video was correct during a fMRI scan of the brain. Comparing with results from a pre-test, inhibition networks within the brain were only activated when students who believed in the naïve theory were watching the accurate videos. The result of this study indicates that introducing accurate information while an inaccurate conception is still present may inhibit learning of the new and accurate concept.*
>
> <u>Instructional Implications</u>***:*** *Instruction should be first targeted toward identifying, and then correcting naïve beliefs held by the students before new information is presented.*
>
> ***Example 2:***

Cognitive neuroscientists and psychologists have studied human memory for decades. They have found that memory is divided into varying neuronal circuits, including short-term memory (which relates to recoding information into intelligible terms), emotional memory, and active working memory (keeping ideas in mind, as well as short- and medium-term planning and linking short- and long-term memories to complete the process). All of these are distinct but related to long-term memory (which implies memory consolidation and ease of access for memory retrieval), important for learning. Memory circuits are related and sometimes overlapping but distinct.

*<u>Instructional Implications</u>**:** This means that, as teachers, we need to understand each circuit in order to devise instructional moments that take advantage of each to maximize the potential of learning.*

Did this description help you understand brain-based teaching?

a. Yes
b. Somewhat
c. No

Neuroscience Knowledge Scale [scale names will not be presented in survey]

Directions: For each of the following statements, respond either (A) Incorrect, (B) Correct, or (C) I don't know.

1. We use our brains 24 h a day (C).
2. *Children must acquire their native language before a second language is learned. If they do not do so neither language will be fully acquired. (I)*
3. Boys have bigger brains than girls (C).
4. *If pupils do not drink sufficient amounts of water (=6–8 glasses a day) their brains shrink (I).*
5. *It has been scientifically proven that fatty acid supplements (omega-3 and omega-6) have a positive effect on academic achievement (I).*
6. When a brain region is damaged other parts of the brain can take up its function (C).
7. *We only use 10% of our brain (I).*
8. The left and right hemisphere of the brain always work together (C).
9. *Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners (I).*
10. The brains of boys and girls develop at the same rate (I).
11. Brain development has finished by the time children reach secondary school (I).
12. *There are critical periods in childhood after which certain things can no longer be learned (I).*

13. Information is stored in the brain in a network of cells distributed throughout the brain. (C)
14. Learning is not due to the addition of new cells to the brain (C).
15. *Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic) (I).*
16. Learning occurs through modification of the brains' neural connections (C).
17. Academic achievement can be affected by skipping breakfast (C).
18. Normal development of the human brain involves the birth and death of brain cells (C).
19. Mental capacity is hereditary and cannot be changed by the environment or experience (I).
20. Vigorous exercise can improve mental function (C).
21. *Environments that are rich in stimulus improve the brains of pre-school children (I).*
22. *Children are less attentive after consuming sugary drinks and/or snacks (I).*
23. Circadian rhythms ("body-clock") shift during adolescence, causing pupils to be tired during the first lessons of the school day (C).
24. *Regular drinking of caffeinated drinks reduces alertness (C).*
25. *Exercises that rehearse co-ordination of motor-perception skills can improve literacy skills (I).*
26. *Extended rehearsal of some mental processes can change the shape and structure of some parts of the brain (C).*
27. *Individual learners show preferences for the mode in which they receive information (e.g., visual, auditory, kinesthetic) (C).*
28. *Learning problems associated with developmental differences in brain function cannot be remediated by education (I).*
29. Production of new connections in the brain can continue into old age (C).
30. *Short bouts of co-ordination exercises can improve integration of left and right hemispheric brain function (I).*
31. There are sensitive periods in childhood when it's easier to learn things (C).
32. When we sleep, the brain shuts down (I).

*Neuromyth assertions are presented in *italic*; C = correct; I = incorrect.

Perceived Brain-Based Teaching Value Scale

Directions: For each statement about neuroscience and brain-based teaching, respond on the 100-point scale provided.

Intrinsic Interest Value

i. In general, I find brain-based teaching (0 = very boring, 100 = very interesting)

ii. How much do you like learning about brain-based teaching? (0 = not very much, 100 = very much)

Attainment Value/Importance

iii. Is the amount of effort it will take to effectively use brain-based teaching worthwhile to you? 0 = not very worthwhile, 100 = very worthwhile)

iv. I feel that, to me, being good at brain-based teaching is (0 = not at all important, 100 = very important)

v. How important is it to you to learn as much as possible about brain-based teaching? (0 = not at all important, 100 = very important)

Extrinsic Utility Value

vi. How useful is brain-based teaching for meeting your professional goals as a teacher? (0 = not very useful, 100 = very useful)

vii. How useful is brain-based teaching in your interaction with students? (0 = not very useful, 100 = very useful)

Brain-Based Teaching Self-Efficacy Scale

Directions: Rate your **current** degree of certainty that you can perform the following activities using the scale below:

a. Locate valid and reliable resources containing information about how the human nervous system influences learning.
b. Interpret scientific information about the brain.
a. Distinguish between accurate and inaccurate statements about the brain.
b. Modify my lessons based on research about the brain.
c. Use information about the brain to mold instruction to promote your students' critical thinking.
d. Use information about how the brain interacts with technology to effectively employ technology in your classroom.
e. Use information about the brain to accommodate students with special needs.
f. Review research for new results about the human brain and learning.
g. Teach colleagues ways to use neuroscience research to improve their teaching.

Brain-Based Teaching Outcome Expectancy Scale

Directions: Rate your **current** degree of certainty of the following outcomes occurring from 0 (Not at all certain) to 100 (Highly Certain):

Student Outcomes

a. Incorporating a variety of brain-based teaching methods will help my students to be successful.
b. My students will be successful when instruction is designed using the most current knowledge of human brain functioning.
c. My students will be more motivated and engaged when instruction is designed using the most current knowledge of human brain functioning.

Instructional Outcomes

d. Using brain-based teaching will improve the design of my lesson plans.
e. Using brain-based teaching will improve the delivery of my lessons.
f. Using brain-based teaching will help me identify potential learning problems in my classroom.
g. Using brain-based teaching will improve my ability to provide accommodations to students with special education needs.

1. **TAMQ-- Brain-Based Teaching**

   (1 = Strongly Disagree, 5 = Strongly Agree)

   a. PU1: Using brain-based teaching will improve my work.
   b. PU2: Using brain-based teaching will enhance my effectiveness.
   c. PU3: Using brain-based teaching will increase my productivity.
   d. PU4: I find brain-based teaching a useful pedagogical tool.
   e. PEU1: My role in brain-based teaching is clear and understandable.
   f. PEU2: I find it easy to translate brain-based teaching into my lessons.
   g. PEU3: Implementing brain-based teaching does not require a lot of mental effort.
   h. PEU4: I find brain-based teaching easy to use.
   i. A1: Brain-based teaching makes my work more interesting.
   j. A2: Working with brain-based teaching is fun.
   k. A3: I like using brain-based teaching.
   l. A4: I look forward to the aspects of my job that require me to use brain-based teaching.
   m. BI1: I will use brain-based teaching in the future.
   n. BI2: I plan to use brain-based teaching often.

Brain-Based Teaching Acceptance Intent

Consider whether you intend to use brain-based teaching next year and answer the following questions. If you will **not** be teaching next year, please select “Not Applicable” as an answer option.

a. Over the course of the next 12 months, how likely are you to use brain-based teaching to plan your lessons? (1 = Not at all Likely, 5 = Very Likely; N/A)

b. Over the course of the next 12 months, how frequently are you to use brain-based teaching to plan your lessons? (1= Infrequently, 5 = Very Frequently; N/A)

c. Over the course of the next 12 months, how likely are you to seek out professional resources to help you understand the brain and its role in teaching and learning? (1 = Not at all Likely, 5 = Very Likely; N/A)

d. Over the course of the next 12 months, how frequently are you to seek out professional resources to help you understand the brain and its role in teaching and learning? (1= Infrequently, 5 = Very Frequently; N/A)

Demographic questionnaire

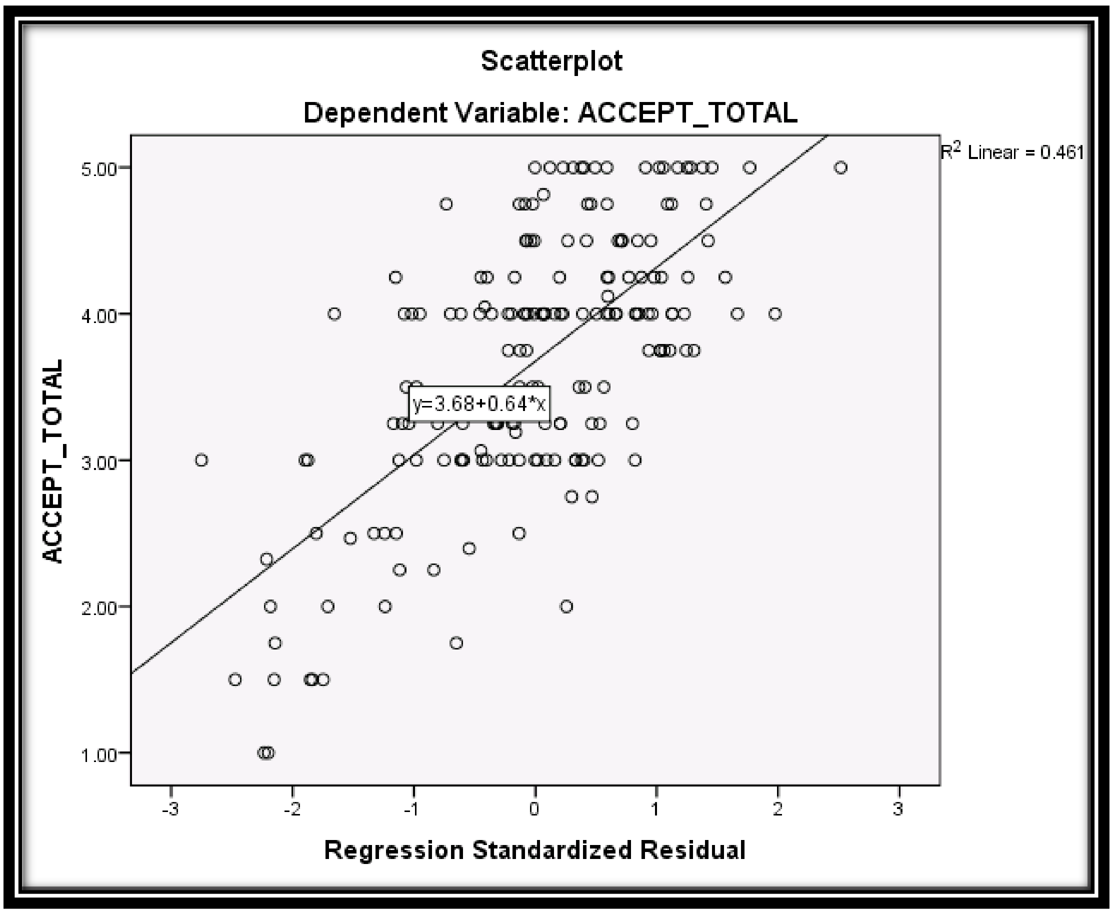
1. Gender:
    i. Free text response
2. Current Age (in years):
    i. Free numeric response (2 digit)
3. What is the highest level of education you have completed?
    i. High school/GED
    ii. Some college
    iii. 2-year college
    iv. 4-year college
    v. Graduate level certificate
    vi. Masters
    vii. Professional degree (e.g., M.D., J.D.)
    viii. Doctoral (e.g., EdD, PhD)
4. Select which item describes you best.
    i. Provisionally licensed teacher
    ii. Licensed teacher
    iii. Non-licensed teacher
5. How many years have you held your license?
    i. Free numeric response (2 digit)
6. How many years have you been a teacher?
    i. Free numeric response (2 digit)
7. What grade level(s) do you currently teach?
    i. Multiple response check box (pre-school through college)
8. I primarily teach:
    i. General Education
    ii. Special Education
9. The primary content area that I teach is:
    i. English/Language Arts
    ii. Math
    iii. Science

iv. Social Studies
v. Business
vi. Computer Science/Information Technology
vii. Foreign Language
viii. Visual Art & Design
ix. Performing Arts (Music, Theater, Dance)
x. Physical Education
xi. Vocational Education

10. Neuroscience or biological brain-based behavior courses were part of my teacher preparation program. Check all that apply.
    i. Yes, they were required.
    ii. Yes, as an elective and I enrolled.
    iii. Yes, as an elective but I did not enroll.
    iv. No, courses of this nature were not a part of my teacher preparation program.
11. Which of the following sources have provided you with professional development regarding the role of the brain in education? Check all that apply.
    i. In-service training
    ii. Conferences
    iii. Academic journals
    iv. Professional journals
    v. Books
    vi. Commercial products
    vii. Blogs/web-based resources

Appendix C

Standardized Residuals Plot



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Biography

Lauren Serpati graduated from Broad Run High School, Ashburn, Virginia, in 2004. She attended George Mason University for the entirety of her higher education career and received her Bachelor of Arts in 2008 (*magna cum laude*) and her Master of Education in Curriculum and Instruction (Learning, Motivation, & Cognition) in 2009. She was employed for five years as a Research Analyst, and later, as the Director of Education, at Global Skills X-Change in Alexandria, Virginia.