

THE IMPACT OF ASYNCHRONOUS ONLINE COURSE DESIGN  
FOR PROFESSIONAL DEVELOPMENT ON  
SCIENCE-TEACHER SELF-EFFICACY

By

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Abstract: This dissertation examines how various designs of asynchronous online courses for teacher professional development may impact science-teacher self-efficacy. Mayer's studies, providing the cognitive theory of multimedia learning, targeted designs of asynchronous online learning and the point where contributions of written, auditory, and visual information on these sites could cause cognitive overload (Mayer, 2005). With increasing usage of online resources for educators to gain teaching credits, understanding how to construct these professional development offerings is critical. Teacher self-efficacy can affect how well information from these courses relays to students in their classroom. This research explored the connection between online asynchronous professional development design and teacher self-efficacy through analysis of a physics-based course in three distinct course-design offerings, while collecting content-acquisition data and self-efficacy effects before and after participation. Results from this research showed teacher self-efficacy had improved in all online treatments which included a text-only, text and audio and text, audio and animation version of the same physics content. Content knowledge was most effected by the text-only and text and audio treatments with significant growth occurring in the *remember, apply, and analyze* levels of Bloom's taxonomy. Due to the small number of participants, it cannot be said that these results are conclusive.

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## CHAPTER I

### INTRODUCTION

*Technology is just a tool. In terms of getting the kids working together and motivating them, the teacher is the most important.*

—Bill Gates

*Design is not just what it looks like or feels like, but how it works.*

—Steve Jobs

Teachers are among a group of professionals who must participate in professional development to enhance their practices. Educators avail themselves of a variety of resources to meet individual state requirements, including the following:

- school-district offices;
- third-party learning centers;
- another school, school system, state, or foreign country;
- evening or summer courses at colleges and universities;
- local, state, or national conferences; and
- online.

The schedule of the average teacher can be burdensome. In 2012, the Bill and Melinda Gates Foundation and Scholastic reported that teachers spent, on average, more

than seven hours during their regular school day, an additional two hours before or after school, working on various tasks, and one and a half hours at home preparing for the next day. This equates to 10.5 hours each day (Bill and Melinda Gates Foundation, 2012). With limited time left in the average day, educators look for more flexible ways to fulfill their professional development requirements to maintain teaching certificates. A survey regarding online learning of more than 700 educators conducted by the Department of Educational Technology found that 48% preferred online professional development formats, 31% preferred a hybrid approach, and only nine percent preferred face-to-face sessions (Rice, Dawley, Gasell, & Florez, 2008). The number of online participants is steadily increasing (Simonsen, Smaldino, Albright, & Zvacek, 2009). Participation tracking started at 11.7% in 2003 and increased to 32% in 2011 (Allen & Seaman, 2013). In the report, *Speak Up, 2011!*, educators offered a variety of benefits for taking these online courses (Project Tomorrow, 2012). More than 80% of survey respondents appreciated how online professional development fit their hectic schedules, and over 60% liked returning to the material repeatedly for review, as well as the ability to customize their learning (Blackboard, 2011). Despite these positive indicators, stakeholders know little about whether online professional development provides teachers with what they need to improve their teaching. This lack of knowledge suggests that such growing interest needs further study to determine the degree to which online participation in professional development actually improves teaching.

Governmental attention given to science, technology, engineering, and mathematics (STEM) education influences science educators to promote and strengthen STEM-based skills in U.S. students. In 2009, President Obama launched the Educate to

Innovate campaign to move U.S. students from the middle of the world's ranks to the top of the list in science and mathematics achievement over the next decade. Part of this emphasis includes preparing more than 100,000 new teachers with a strong background in STEM-based content knowledge and 1 million new STEM graduates over the next 10 years. (President's Council of Advisors on Science and Technology, 2014). This new focus on STEM education, particularly for education professionals, provides added pressure on academic and government organizations to meet these goals. Teachers must understand complex science concepts for which they may not have received an appropriate level of emphasis during their undergraduate years. In the classroom they not only need to understand the content they must teach, but possess a level of self-efficacy about the subject matter to convey excitement and enthusiasm about the topics to their students. The more meaningful knowledge educators possess about STEM concepts, the greater their confidence level to pass on that enthusiasm to their students (Posnanski, 2002).

Quality online professional development should contain a variety of methods of communicating the topic presented (Crow, 2010). Mayer's (2005) CTOML provides a logical construction of multimedia presentations designed to enhance learner cognition. Combining pictures with audio provides the most effective method to deepen learners' understanding of new material presented (Mayer, 2005).

Although online courses may address educators' concerns about access to professional development on their schedules, educators require researchers to specifically describe the characteristics required to develop an effective program, not only to dispel distrust among educators about the content, but also to promote the idea that time spent

on coursework is not wasted (Dede, Ketelhut, McCloskey, & Whitehouse, 2005). The CTOML addresses this concern, yet some voids exist in the model that researchers have not addressed, such as applicability to practical situations and teacher self-efficacy.

Online learning consists of a variety of presentation formats, but multimedia is a fairly typical way to pass knowledge to those who are viewing a site. How someone designs a site and integrates the use of multimedia can either enhance or hinder information being presented. There is limited information about asynchronous offerings for educators and how they may influence self-efficacy levels, thereby leading toward more effective teaching and learning. Therefore, the purpose of this study was to explore the best ways to design an online course for educator professional development using multimedia to improve K–12 science teachers' content knowledge and self-efficacy.

### **Scope of Study**

Mayer's (2005) Cognitive Theory of Multimedia Learning (CTOML) provided the foundation for this study. Mayer made significant contributions to the understanding of cognition and learning as they relate to problem solving in multimedia learning. The model states that placing connected visual and verbal materials together in the correct way is the most efficient method to achieve a deeper cognitive understanding of the material presented online. Mayer's methods focused on measuring the effectiveness of this online design by studying two elements of cognition: retention and transfer (Simonsen et al., 2009). An important component of the present study reflects these elements of Mayer's research and determines how the design of an online course impacts the level of retention of new science concepts and how they relate to science-teaching self-efficacy.

Psychologist Bandura, initiator of self-efficacy theory, stated that belief in one's ability or skill affects every facet of that person's life (Riggs & Enochs, 1990). Educators participating in a professional development course who walk away from the experience with greater self-efficacy about the content are more likely to pass that learning to their students (Tschannen-Moran & Hoy, 2001). Bandura's (1993) self-efficacy theory provides an additional framework that can help determine the best methods to design online instruction when the goal is to impart educational concepts to students successfully in educators' classrooms. Educators need asynchronous professional development coursework that uses research-based practices in its use of multimedia. This study concentrates on how designing an asynchronous course that not only increases content knowledge for educators, but also increases feelings of educator self-efficacy to increase the likelihood they will pass on the information to students.

The National Aeronautics and Space Administration's (NASA's) Digital Learning Network™ (DLN) began in 2003 as an interactive, distance learning opportunity for students to participate in synchronous modules focused on STEM content tied with NASA missions and research. NASA trains DLN educators at 10 DLN studios across the country. Over the years, the service has evolved from synchronous STEM-based module presentations featuring NASA research to webcasts that feature ongoing missions and virtual visits that highlight NASA subject-matter experts speaking with students about their careers and educational preparation. Now, NASA (2013) has added asynchronous modules that focus on the connection between stock-car racing and aerospace science . To increase its outreach and meet the organizational changes that NASA's Office of Education has made for its programs to meet the President's STEM focus, it is the DLN's



goal to offer asynchronous professional development courses for teachers in STEM content through the use of a learning-management system (LMS) housed at the Georgia Institute of Technology's Global Learning Center. The DLN seeks to develop all new aspects of its offerings grounded in research or research-based practices.

The importance of this study lies in the rapid expansion of technology advancements that coincide with the equally large asynchronous course offerings that appear on the online landscape. In addition, mandates from the federal government to produce 100,000 STEM education specialists to meet the needs of the United States over the coming years cannot be completed in today's society solely in face-to-face classrooms. NASA's DLN is a vehicle to meet this need.

To accomplish these goals efficiently, course designers must construct these courses using research-based practices. Other federal and academic organizations could then use the findings of this study to replicate the concept for their asynchronous course designs to be grounded in best practices. Technology is a tool for learning. It facilitates the process for the learning to occur. Whether the learning takes place in a face-to-face setting or virtually, students must pick the correct tools to accomplish their goals. Several components of the Georgia Institute of Technology Modular Object-Oriented Dynamic Learning Environment (Moodle) Rooms Learning Management System (LMS) make it an excellent environment to house this test study. The Moodle platform is a widely-accepted open-source program allowing others to build an LMS. The course-building software is intuitive and simple to use.

Facilitators of this course had available a variety of tools that Moodlerooms offers to promote smooth communication with participants at all times during their course

participation. Chat rooms, where participants may post questions and discussions with others in the course, a help section that provides tools for participants to work through navigation issues, and e-mail access to the course designers, assisted those taking the course to dissipate any stress that could accompany potential impediments online course participants face (Palloff & Pratt, 2007).

### **Research Questions**

This study addressed the following four research questions:

1. Will educators who use static text and animation with audio gain more content knowledge than those who use static text with static pictures or use static text and animation only?
2. Will educators who use static text and animation with audio achieve a greater increase in self-efficacy than those who use static text with static pictures or static text and animation only?
3. Will educators' improved content knowledge correlate to higher self-efficacy?
4. How do participants perceive the effect of an online professional development session on their confidence level to teach STEM?

### **Barriers**

All education professionals require professional development to renew their credentials. With the busy schedule of classroom teachers and the increasing demands made on them, being available for quality professional development is difficult at best. As a result, online courses are becoming increasingly popular in education, as well as many other professions. The demand for these courses has burgeoned with rapid changes in the quality of technology and their availability. However, the stakeholders who would

be targeted for these courses have limited information about their proper construction. Knowing more about theories that could impact effective course design could better inform instructional designers about how and why they should structure these courses, making them more viable options for education professionals to use as their license renewal option. Because the focus of this study remained on NASA physics-based content, it does not apply to all content online. Participants in the study were middle school educators (Grades 5–8).

### **Assumptions**

The following assumptions can be made about this study and its participants. Education systems require teachers to participate in professional development courses to renew their teaching certificates. Awarding a course completion certificate will encourage those that volunteer for the study to complete its requirements and participation will be mutually beneficial for both educator participant and the researcher.

The course material is fully an online course offering. To participate in this study, participants needed to be comfortable in the online-learning environment and be willing to navigate through the chosen LMS successfully.

Finally, in order to fully complete the requirements of the study, educator participants had to answer questions in the instrument and content tests honestly and to the best of their ability. By doing so, data they contributed would be considered valid.

### **Definition of Terms**

*Asynchronous learning.* This distance learning format provides participants the chance to maintain some control over their learning in comparison to a traditional classroom setting. Control is rooted in the student’s ability to contribute to the class when

they desire, on their own schedule, as well as access information literally at their fingertips.

*Cognitive-load theory.* Developed by Sweller and Chandler (1991), cognitive-load theory states that memory requires mental effort and the more one processes the more of a chance they have to experience overload and prevent transfer to long-term memory.

*Cognitive theory of multimedia learning.* Developed by Mayer (2005), the Cognitive Theory of Multimedia Learning states that people learn more deeply from words and pictures than words alone.

*Dual-coding theory.* Developed by Paivio (2006), dual-coding theory is the idea that the formation of mental images helps learning.

*Long-term memory.* The final stage of memory, in which information passes and then remains indefinitely.

*Personal Science Teaching Efficacy.* One of the subscales of the STEBI, the Personal Science Teaching Efficacy addresses how teachers feel about answering students' questions, explaining experiments, and monitoring experiments.

*Professional development.* Learning experiences that relate to credentials of a profession.

*Science Teaching Efficacy Belief Instrument (STEBI-A).* Researchers commonly use the STEBI-A to measure science-teaching self-efficacy and outcome efficacy for in-service educators.

*Science Teaching Outcome Expectancy.* One of the subscales of the STEBI, the Science Teaching Outcome Expectancy addresses how teachers refer to expected outcomes in science teaching in general.

*Self-efficacy.* An individual's beliefs in the ability to carry out what is necessary to achieve a certain goal reflects self-efficacy. An individual's ability to control behavior and motivation is key in this idea.

*Short-term memory.* The ability to hold a small amount of information for a short period of time.

*Working-memory theory.* Developed by Baddeley (1992), working-memory theory states that a portion of memory temporarily holds information and explains how it passes to long-term memory.

### **Summary**

The purpose of this study was to determine if educators who participated in an asynchronous professional development course with purposeful placement of various multimedia experiences ended their course with greater content knowledge of the topic, thereby increasing their content self-efficacy. Concurrent and purposeful online presentation of multimedia and written material deepens cognitive retention and transfer. Related research showed that the higher acquisition of content leads to higher levels of self-efficacy. This study examined the effect of the CTOML and its relationship with self-efficacy theory to inform the construction of a new educational offering for NASA's DLN.

## CHAPTER II

### LITERATURE REVIEW

Distance education has transformed into a variety of forms from early correspondence courses to present-day virtual connections through the Internet. Consequently, the design and delivery of online courses evolve as technology changes. The instant appeal of technology's capabilities allows the flash of this tool to overshadow the effectiveness of the delivery. Technology can be used as an effective pathway to deliver meaningful instruction.

Quality professional development should involve acquisition of the material such that the educator gains self-efficacy to carry the learning to the classroom and apply what has been learned for students' benefit. According to Mizzell (2010), "Whether participants are high, low, or average achievers, they will learn more if their teachers regularly engage in high-quality professional development" (p. 18). Effective professional development is a two-part process. The designer must plan the professional development with purpose and the educator must implement it with equal care to respond to teaching needs. Second, educators must then apply what they have learned in the classroom. One without the other reduces the value of the experience (Mizzell, 2010). Dede et al. (2005) also supported the idea of online asynchronous learning as a viable option for professional educators. Because of an increase in standards set forth by the

Elementary and Secondary Schools Education Act (1965) and the evolving core standards, teachers have a high need to be able to access professional development not offered locally. This need has influenced the growth of online teacher professional development programs (Dede et al., 2005). Not only is it advantageous for teachers to participate in these courses because of their flexibility, but school systems may access experts and resources that were previously unavailable due to financial constraints (Dede et al., 2005).

A 2015 Google search for online learning yielded 252 million results. Educators offer online learning opportunities to a variety of audiences, but how do designers properly construct these courses? In particular, educators find these courses attractive because they are adaptable to their busy schedules and provide the flexibility they need to renew teaching credentials and obtain professional development. As technology advances, an increasing number of educators choose to access online resources as a valid means to satisfy professional development requirements (Dede et al., 2005). Research about immersive technology in education shows that asynchronous environments can promote meaningful communication and thoughtful dialogue because educators have an opportunity to create meaningful answers in communication through these courses (Radda, 2011).

Asynchronous, online courses make sense for full-time professionals because teachers can access professional development sites during breaks or after school, at times that are convenient to their busy schedules (Cole & Styron, 2014). Cole and Styron (2014) gathered quantitative data using a causal comparative design that highlighted the responses of 90 K–6 and 7–12 educators in total. Participants took part in a minimum of

one online module through a free service developed by Public Broadcasting Service called Teacher Line. Participants responded to a survey instrument to determine if there were differences in attitudes related to online professional development. Overall results of this study showed that an overwhelming majority (85.5%) believed that technology enhanced professional development opportunities, and they preferred this mode of professional development over face-to-face professional development (Cole & Styron, 2014). A report in 2012 showed that 46% of teachers had taken online courses, and on a weekly basis 17% of them used online tools for professional development (Henke, 2012). As technology becomes more mature and society accepts its potential, this trend is likely to continue to grow. Encouragement from the White House committee, Educate to Innovate, to provide 100,000 more STEM educators, makes the use of online professional development seem a powerful tool to reach this goal.

Designers need greater knowledge about how to construct asynchronous online courses to increase content knowledge effectively and thereby increase teacher self-efficacy about the material. Teacher self-efficacy is likely to increase the chances that teachers will pass the information to students. The motivation to learn a concept connects to the level of self-efficacy gained from learning that topic (Betz & Hackett, 2006). This is key for constructing high-quality online educator professional development (Dede C. , Ketelhut, McCloskey, & Whitehouse, 2005). Knowing more about this connection could be useful in determining an effective balance of online materials that would inform the proper construction of online asynchronous coursework (White House 2014).



## **Theoretical Framework**

This study informs the construction of new course offerings for NASA's DLN. Pragmatism is a common approach to a mixed-methods design, because its focus is on the consequences of the research. The primary focus of the pragmatic approach is on questions asked and the multiple methods used to answer those questions (Creswell & Plano Clark, 2011). This research informs NASA's DLN about the way to properly design an asynchronous course shown to be more effective in increasing educator self-efficacy about STEM topics and depth-of-content understanding in a research-based learning environment. Research results provide instructional designers at the DLN with a comprehensive view of the proper construction methods of an asynchronous course. This real-world view fits appropriately in the pragmatic approach while theorists Paivio, Baddley, Mayer, Norman and Bandura all provide the foundations for this study.

### **Dual-Coding Theory**

Throughout history, the uses of imagery have been paramount to enhancing learning. One example is the use of art to express biblical verse during the Renaissance period (Paivio, 2006). These ideas were complex and only the elite were literate in that time period. Art conveyed the ideas in the Bible to enable nonreaders to express the stories to those around them. The effectiveness of proper combinations of visual and verbal cues that convey a concept was the primary means of educating people in the past.

Paivio's (2006) Dual-Coding Theory explains why combining visual and auditory inputs is effective in long-term learning by explaining that memory has two distinct coding systems, one for addressing language (written and auditory words) and one for nonlinguistic events (pictures). Today, Paivio's works on dual-coding theory provide a

scientific reason for why and how the combination proves effective. Dual-coding theory posits that sensory output in haptic (feeling), auditory, and visual modes condense to representational units in the memory, called logogens (how humans understand spoken or written words) and imogens (how humans understand mental images) and activate as one uses sensory outputs (Clark & Paivio, 1991). Understanding the placement of the information relies on knowing that the inputs are modality-specific. This means that what one feels (haptic) is placed in a certain “compartment” in memory along with what one hears and sees. One’s memory then uses the information in combination or singularly to come to an understanding of the concept. A study reported verbal contexts and their connection to imagery, questioning third- and fourth-grade students after reading a story with a particularly impactful climactic ending (Thompson & Paivio, 1994). Children who were able to create an image from their reading had greater recall of the story’s contents than those who did not create an image (Paivio, 2006). Dual-coding-theory revelations helped pave the way for Working-Memory Theory, established by Baddeley and Hitch (1974); their discoveries revolved around how one’s memory tries to make connections as it processes information.

### **Working-Memory Theory**

The goal of Baddeley’s (2001) Working-Memory Theory was to comprehend how information is stored and maintained in a complex series of cognitive processes.

Working-Memory Theory states that the brain simultaneously stores and processes information using three subsections: the central executive (responsible for attention control); the “slave” systems, consisting of the visuospatial sketch pad for processing images; and the phonological loop, responsible for processing speech and words

(Baddeley, 1992). Researchers apply working-memory theory by linking it to a wide range of tasks that include language comprehension and meaning. A key component in working-memory theory is that the more information is presented simultaneously, the slower one processes it in memory. Memory has two components: short-term memory and long-term memory. Short-term memory has three main components and has a limited capacity to store information. The information stored has a limited duration and can be lost when one is distracted or over the passage of time. Processing this information occurs mainly through auditory means; even the written word is transformed to an auditory unit for it to process through short-term memory (McLeod, 2009). People process long-term memory information through semantic (meaning) and visual (pictorial) means and the capacity of that area could be as short as a few minutes or as long as a lifetime (McLeod, 2010). Because the brain attempts to relate components of memory, people process short-term memory information as acoustic information, whereas people process long-term memory information as chunks of meaning. Extraneous information in abundance, while these processes are occurring, may muddle the process (Baddeley, 1996). From these theories, Mayer (2005) applied the use of multimedia resources in the Cognitive Theory of Multimedia Learning (CTOML).

### **Cognitive Theory of Multimedia Learning**

Mayer's (2005) CTOML states that providing more stimuli to online instruction (i.e., audio, visual, and multimedia), in the right combination, positively influences cognitive understanding of a topic. Mayer incorporated Paivio's (2006) dual-coding theory, Baddeley's (1992, 1996, 2001) working-memory theory, and Sweller and Chandler's (1991) Cognitive-Load Theory with their effects on multimedia learning. In

essence, the CTOML describes how people process multimedia learning in separate channels for verbal (spoken and written word) and visual (pictures and animation) information (Um, Plass, & Hayward, 2012). Learning occurs when people process multimedia elements in their proper channels as coherent parts of working memory, integrating visual and verbal representations with one another and with prior knowledge to make the necessary connections to allow transfer to long-term memory.

Cognitive-Load Theory complements the CTOML, providing an idea of the capacity of memory to learn new material. Sweller and Chandler (1991) posited that Cognitive-Load Theory comprises three kinds of cognitive load: intrinsic, describing the complexity of the information; germane, the amount of mental effort invested by the learner participating in the learning activity; and extraneous, describing the processing demands that are not directly related to the learning itself but are the end result of the design of the learning materials. In Cognitive Load Theory, emotions involved in a learning setting could be viewed as a source of extraneous cognitive load and should be limited, as they may interfere with the learning process. In contrast, other models that align with Cognitive-Load Theory show positive emotions equate to positive learning outcomes (Sweller & Chandler, 1991).

The idea that emotions provide extraneous cognitive load promotes the notion that emotions interfere with the learning process. This thought aligns with Mayer's (2005) Coherence Effect, which states that the addition of unimportant information, which may be otherwise interesting to expository texts, inhibits the learning of the main point presented (Um, et al., 2012). In studies that developed this thought, researchers used a variety of strategies to spark positive emotions about a topic. These included interesting

text and visual information, as well as music and sounds, to present the learning material (Sweller & Chandler, 1991). Their findings showed that although a learner's interest level may have increased, that level was insufficiently to adequately overcome the interference of extra processing demands of the working memory and therefore did not improve the level or depth of learning; instead learning interest was inhibited. Despite this negative outcome of the effect of extraneous cognitive load, others found that emotions can facilitate learning as well. Emotions can promote learning results in a direct way or through secondary routing, such as through interest and motivation to learn (Um et al., 2012).

Mayer's (2005) CTOML emerged from laboratory settings where researchers tested a variety of modality combinations in which they could demonstrate transfer of learning, an abstract skill defined as higher order in Bloom's taxonomy (Mayer, 2005). After designing several test situations that involved text-only instruction, text and audio instruction, and text, audio, and visual instruction presented to groups of participants in a controlled laboratory situation, Mayer deduced that multimedia presentations must be thoughtfully presented as concurrent information. The basis of this thought is rooted in the idea that a redundancy effect can determine the level of learning. When information in a variety of formats, such as pictures and words or written and audio, presents identical information, eliminating one may increase, or enhance, learning.

Mayer and Sims (1994) addressed this concern with the intentional placement of visual, auditory, and haptic cues in new learning, calling it the contiguity effect. When material has no logical connection to other material presented separately, cognitive overload results. Participants with low levels of experience in a topic presented in a

contiguous format have higher recall and transfer ability than those who participate in a multimedia course where the information is presented successively. However, for participants with high levels of experience, impact diminishes (Mayer & Sims, 1994). Likewise, participants with high or low spatial ability (how a learner manipulates figures by memory) also show variances. Multimedia learning, in which participants gain experiences in two or more ways, such as animation and narration, is truly a multimodal presentation, engaging various senses in presentation of the same information (Mayer & Sims, 1994).

Multimedia learners with a high level of spatial ability can maintain an image in their head for a longer sustained period of time and can therefore construct their own version of the contiguity effect with or without its presentation in a multimedia format (Mayer & Sims, 1994). A growing expanse of research supports the idea that when participants receive text and illustrations together in a multimedia format, deeper and more meaningful learning occurs (Mayer & Sims, 1994). Interestingly, computer-generated animation can activate the visual mode; a powerful medium for learners. Mayer and Sim's (1994) work concentrated on the placement of these cues or inputs, either concurrently or successively, and measured their effectiveness through participants' expression of a variety of ways to transfer the learned material to multiple situations. Based on the CTOML, pictures with well-integrated text worked well to deepen learning. In a second test scenario, Mayer and Sims discovered that providing pictures with audio was an improvement over the first test condition. However, by providing text, audio, and animation together, the learning condition decreased, caused by germane cognitive overload (Mayer & Sims, 1994). Mayer and Sims launched this

field by finding that the number of “channels” in memory that are accessed affect one’s ability to learn in this environment.

Instructional designers work to design multimedia learning environments that elicit positive emotional connections to improve not only learning outcomes, but feelings of self-efficacy in teaching the content. Student motivation while in the e-learning environment is a practical topic of concern for instructional designers, as new technologies and abilities to enhance online instruction consistently change. Several variables motivate student effort while participating in e-courses: perceived importance, usefulness, and the value of engaging in a task (Paas, Tuovinen, van Merriënboer, & Darabi, 2005). Participants in online learning activities must see the value of the material presented, its usefulness to their professional or personal lives, and the worth of the required effort. These elements combine to create positive affect about the material, helping teachers transition from working memory to long-term memory more efficiently, as well as making recall of that material more accessible. Um et al. (2012) stated that “the design of the materials impacts the learner’s emotions, and how these emotions may affect learning outcomes has not received sufficient attention” (p. 485).

Extensive research on this topic suggests that positive emotion toward a learning topic affects cognition in multiple ways. The earliest research shows that the more positive the emotion about a learned topic, the more improved the recall, especially when retrieving cues from long-term memory (Um et al., 2012). Therefore, instructional designers need to consider the idea that emotions affect learning during the learning process (Um et al., 2012). Mayer proposed an extension of CTOML based on the idea of combining motivational and metacognitive factors as facilitators of multimedia learning

(Um et al., 2012). The potential for emotion to impact learning is another facet to consider, especially educators must transfer their knowledge to the participants they teach. This viewpoint directly contradicts some of the earlier discussion that emotion interferes with learning. Resolving this contradiction was a strong motivator for this study.

### **Emotional Design**

Norman (2004) rooted research in how humans intrinsically connect to take information into memory through visceral, behavioral, and reflective responses. The design of physical objects elicit an emotional attachment with the people who own them. For example, automobile companies use the knowledge that people have an immediate response to the physical appearance of a .This knowledge is used to convince customers to attach to their product. At the visceral level, judgment happens quickly; the brain then signals the body's muscles to respond appropriately. The viseral level is biological and ingrained in human systems naturally, being automatic and responsive, whereas the behavioral level is a conscious response. At the behavioral level, a person analyzes a situation, changing behavior to correspond to the information being brought in, whereas the reflective level allows the brain to think about its own operations. The human brain has the capacity to integrate all three levels (Norman, 2004). Norman's studies support the idea that humans are not machines. People have feelings and emotions that impact cognitive processes: affective factors can affect learning.

Improper online design can not only inhibit learning, but can cause blocks to memory retention by causing a phenomeneon called "net rage." At the visceral level, poorly designed computer-based instruction that does not incorporate human



understanding well causes negative emotions in the participant, in addition to all of the cognitive problems that have already been explained. These negative emotions then interfere with the learning process (Hughes-Morgan, 2002). Purposeful planning of distance-learning courses must be in place for people to experience meaningful content acquisition.

Here the questions become whether optimal combinations of multimedia elements in instructional coursework affect self-efficacy levels of the professionals participating in them. Norman's (2004) research explored the impact of objects on positive and negative emotion and more relevantly, the impact of website design on whether a person would accept it. Someone participating in a poorly designed course would struggle through the system and could translate failure to understand the course content as their own failure. That feeling of failure would include low self-efficacy and could effectively prohibit not only learning of the concepts presented, but prevent transfer of that information to the educator's students.

### **Self-Efficacy Theory**

Self-Efficacy Theory, attributed to Bandura, is a personal judgment or appraisal of future performance in a particular area of expertise (Betz & Hackett, 2006). Bandura's research centered on those recovering from heart attacks; their levels of assurance that they could recover from phobias about exercise affected how they performed. From this study, Bandura discovered that people's prior experiences link closely to their behavior (Ramey-Gassert, Shroyer, & Staver, 1996). People develop a generalized expectancy about action-outcome contingencies based on life experiences, according to Self-Efficacy Theory. They develop specific beliefs concerning their own coping abilities. In other

words, the more confident someone feels about a topic area, the more likely they are to be successful in demonstrating that content. Self-efficacy and outcome, therefore, regulate behavior. Bandura hypothesized that the more positive the outcome and the greater the personal self-efficacy one possesses, the more sure that person will act toward the subject area and persist in the task at hand (Ramey-Gassert et al., 1996). Self-efficacy beliefs affect how a teacher chooses activities, the amount of effort they expend in them, and to what extent they push through any difficulties they may have in a particular topic area (Posnanski, 2002).

The importance of self-efficacy in the teaching population cannot be ignored. Teachers who lack self-efficacy in their abilities to apply content in the classroom, particularly in science education, are less likely to teach that topic (Ramey-Gassert & Shroyer, 1992). Tschannen-Moran and Hoy (2001) stated that a teacher's sense of self-efficacy relates to student outcomes and achievement as well as students' own sense of self-efficacy. Teachers with a strong sense of self-efficacy plan their lessons better, have higher aspirations as educators, and more willingly try new methods to better their students' performance (Tschannen-Moran & Hoy, 2001). Although researchers conducted many studies on teacher self-efficacy, little was published about how properly designed asynchronous online courses affect teachers' self-efficacy beliefs.

Self-efficacy must be measured accurately, defined and parsed according to the particular measure of self-efficacy a researcher intends to measure. Self-efficacy maintains strong control over a person's behavior. It influences self-thought, behavior, and motivation (Bandura, 1993).

In their research on career self-efficacy, Betz and Hackett (2006) applied self-efficacy theory to career self-development and postulated that most individuals lack self-efficacy (low self-efficacy) in their abilities; this perception of their own inadequacy could ultimately lead to restricting themselves from larger career opportunities. Perceived self-efficacy levels not only affect behavior directly, but affect outcome expectations and perception of barriers or successes in the social environment (Bandura, 2006). Self-efficacy levels

influence the courses of action people choose to pursue, the challenges and goals they set for themselves and their commitment to them, how much effort they put forth in given endeavors, the outcomes they expect their efforts to produce, how long they persevere in the face of obstacles, their resilience to adversity, the quality of their emotional life and how much stress and depression they experience in coping with taxing environmental demands, and the life choices they make and the accomplishments they realize. (Bandura, 2006, p. 309)

Self-efficacy beliefs determine subsequent performance and skills of a learned activity (Pajares, 1996). Based on Bandura's theory, people participate and engage in activities in which they feel confident and avoid those in which they do not feel this level of self-efficacy (Pajares, 1996). Researchers agreed that "those features explored in learning environment research, the perceptions of students and teachers of the environment, the social and psychological factors, will be as equally important to research in digital environments" (Clayton, 2007, p. 165). Therefore, it is reasonable to connect self-efficacy and levels of acquisition of content.

The impact of self-efficacy on self-efficacy levels has been discussed widely throughout the literature. In a study conducted by Ramey-Gassert et al. (1996) the authors highlighted the importance of science teaching self-efficacy. Through a qualitative study, the researchers used Bandura's Self-Efficacy Theory to relate to teacher's beliefs in their ability to teach science, labeling this as Personal Science Teaching Efficacy (Ramey-Gassert et al., 1996). Through the administration of the STEBI-A, a quantitative instrument that measures levels of teacher self-efficacy, researchers identified educators to be interviewed about Personal Science Teaching Efficacy and Science Teaching Outcome Expectancy. Personal Science Teachers Efficacy reflects a teacher's belief about how well they can teach a subject and Science Teaching Outcome Efficacy reflects having their students learn that content. "High Personal Science Teachers Efficacy teachers had successful preservice teacher preparation, professional development, and science-related experiences" (Ramey-Gassert et al., 1996, p. 304). The positive correlation between science-teaching self-efficacy with attitude toward science and choosing to teach science provides support for the present study's approach to investigate how the design of an asynchronous teacher science course could affect science-teaching self-efficacy.

Further evidence of the importance of strong teacher self-efficacy points to educators who experienced success and a high comfort level with science content; these educators expressed they put more effort into understanding the content and taking risks with new science material. Interestingly, teachers with a high Science Teaching Outcome Efficacy score also had a high belief in their students' success on the topic as well (Ramey-Gassert et al., 1996). It would make sense that if a teacher had a poor experience

with a professional development topic, whether they took the course in person or at a distance, they would not teach the content if they felt their students were going to fail at the material. “The degree of personal success that a teacher has experienced with science colors not only his or her attitude toward science but also the way he/she views students’ ability to achieve in science” (Ramey-Gassert et al., 1996, p. 307). The content level of science plays a pivotal role in a teacher’s science self-efficacy beliefs. Teachers with positive feelings about science content believed they had the proper tools to inspire their students to also learn the content (Posnanski, 2002). Those planning the construction of professional development courses should consider the impact on teacher self-efficacy.

Posnanski’s (2002) research affirmed this belief using three types of teacher-enhancement models to design professional development courses for educators and then measured these courses for their impact on teacher self-efficacy. An analysis of results showed that variances in the course design did affect teacher self-efficacy and may correspond to how educators teach in classrooms (Posnanski, 2002). In the summation of research, Posnanski made a powerful statement that lends credence to further study of teacher self-efficacy in relationship to professional development design. “A professional development program patterned after a research-based model could contribute to positive changes in self-efficacy beliefs and potential changes in teaching behavior” (Posnanski, 2002, p. 215). Designing an effective course is key to eliciting positive feelings for participants. Once an educator has a good experience in a professional development course, those positive feelings transfer to the classroom.

Erdem and Demirel (2007) surveyed student teachers of Grades 1–4 using a standard self-efficacy scale before and after their teacher-education program. Study

results showed the validity of the scale the researchers constructed and determined that understanding levels of self-efficacy was important for teacher-education programs. Teacher self-efficacy strongly influences the success or failure in student and classroom activities. Being able to motivate students to learn a topic and teach a concept effectively depends on the self-efficacy level the educator brings to the classroom (Erdem & Demirel, 2007). Interestingly, once self-efficacy levels were set, they were often difficult to change (Erdem & Demirel, 2007). Thus, if an educator had a bad experience learning a topic in professional development, they would be less likely to pass this learning to their students, and vice versa. “Self-efficacy beliefs provide the foundation of human motivation, well-being and personal accomplishment because unless people believe that their actions can produce the outcomes they desire, they have little incentive to act or to persevere when they face obstacles” (Erdem & Demirel, 2007, p. 576). In the realm of education, the greater the educator’s self-efficacy about newly learned material, the more likely they will transfer that knowledge to their students.

Researchers pointed to the importance of the relationship of self-efficacy and educators teaching science content. Although science education requires particular content in the elementary grades, the lack of its emphasis and weak training for elementary teachers leads to a low level of self-efficacy for science understanding (Riggs & Enochs, 1990). Low levels of self-efficacy lead to avoidance of teaching that topic. Mosley and Brown (2013) conducted a study in the same context as the current study that also focused on self-efficacy and how it effects learning in NASA’s DLN distance-learning environment. Through pre- and post-interviews of participants after completion of the DLN animation-conferencing module, “Can a Shoebox Fly,” qualitative data

showed that participants' self-efficacy levels increased, leading to more positive attitudes toward science. The researchers determined this was accomplished by creating social presence in the distance-learning experience (Mosley & Brown, 2013). They created this social presence through active interaction and participation by the presenter with fellow participants.

Researchers also turned to an instructor's use of asynchronous animation communication as part of their course design. One particular design showed an instructor explaining instructional concepts and asking participants questions while expecting participants to record and post their responses. The instructor then gave participants feedback through asynchronous animation. Participants who participated in this course design provided higher ratings of the course and instructor satisfaction than participants in a comparable face-to-face course (Borup, West, & Graham, 2012). Responses to the instructor's expression in the animation, perceived level of excitement for the content, as well as the engagement level of the presenter in the animation and audio provided, all lead to an emotional tie to that content. Sociocognitive theorists defined learning as an interactive group process where learners actively construct knowledge, then build on that new knowledge by sharing it with peers (Mosley & Brown, 2013). Results of the Mosley and Brown (2013) study suggested that distance education should incorporate social aspects of learning to affect self-efficacy.

### **Synthesis of Research Findings**

Memory contains compartments or channels that are accessible in a variety of ways (Paivio, 2006). Accessing these channels should be a methodical and planned process to keep memory from being cluttered and inefficient during the retrieval process.

Dual-Coding Theory and Working-Memory Theory support Mayer's (2005) CTOML by addressing how people compartmentalize and store information. The CTOML takes these theories one step further and uses the dimension of multimedia to view how it affects these processes. Sweller and Chandler's (1991) contribution to Cognitive-Load Theory added another dimension to Mayer's theory, addressing the emotional aspects of learning and how they can overload verbal and visual channels. This research provided insight to the connection of instruction, cognition, and technology and their relationship with multimedia learning, human-computer interaction, and solving mathematical problems.

Through 100 experimental tests, Mayer and colleagues developed a relevant theory regarding the design of online learning, based on the principles of various cognitive theories focused on how people learn (Mayer, 2005) using game-based research. Researchers must work to determine if these principles can be applied to online learning environments that are not based on games. Mayer's CTOML lays out specific groundwork for effective online learning. Purposeful placement of verbal, visual, and written cues can enhance or detract from the learning process.

The notion of feeling frustrated or excited about online content can detract or enhance the experience. Bandura (2006) stated that emotion affects behavior, self-thought, and motivation. Therefore, feelings of self-efficacy promote or discourage learning and ultimately transfer of knowledge to others in the educator–student relationship. Social presence, a feeling of intimacy in the online environment, promotes the haptic aspect of online learning and can therefore impact self-efficacy. Researchers found evidence for the influence of course design on self-efficacy frequently, as well as



its importance in increasing STEM understanding for students and educators (Dede C. , Ketelhut, McCloskey, & Whitehouse, 2005)

In summary, empirical literature supports the idea that various constructions of asynchronous online courses could affect the depth of a student's cognitive-learning transfer as well as self-efficacy. Mayer's (2005) studies addressed this concern but applied these principals to established educational settings addressing professional development. Limited literature showed application of Mayer's CTOML with educators actively practicing in the classroom. Although researchers widely cited Mayer's study as a keystone for proper usage of multimedia, practical application of the study with practicing educators who would apply new knowledge in their classrooms would enhance the literature currently available. This is important information because it could be used to help inform the development of asynchronous-learning opportunities. Likewise, in addition to what educators know about self-efficacy theory and social presence affecting relationships to online content, more investigation is needed regarding how online design impacts emotional response. Without current research continuing to apply this principle, it is difficult to determine how best to structure proper instructional design to develop quality asynchronous online coursework.

Teacher professional development requires methodical instructional planning, because it is this new knowledge that will transfer to students. As Posnanski's (2002) and Ramey-Gassert et al. (1996) showed, course design can impact the level of teacher self-efficacy and whether that material will be carried to the students they serve. The higher self-efficacy an educator feels about their learning, the more likely they will teach that information well.

Mayer's (2005) study provided the foundation for my research. Bandura's self-efficacy theory and Norman's emotional design provided the additional support needed to connect content-acquisition and content-self-efficacy levels. This research not only relied on the principles on CTOML, working-memory theory, and dual-coding theory, but also content self-efficacy as a measure of effectiveness for the construction of asynchronous online-course presentation. Feelings of self-efficacy or self-efficacy level can impact acceptance of the learned material and will more likely transfer to students upon their teachers' return to classrooms. Teachers need more online courses that will provide professional development specifically in the areas of STEM. Increasing time constraints make online learning more attractive to these educators. Online learning is one avenue to help meet the needs of educator professional development and fulfill the White House (2014) mandate to reach the goal of 1,000 new STEM educators and 100,000 new students interested in STEM fields. The importance of purposeful planning of the design of these courses, which provide the best chance not only to deepen knowledge level, but also increase teacher self-efficacy, cannot be understated.

## CHAPTER III

### METHODOLOGY

The purpose of this research study was to determine the effect that different online asynchronous course designs have on content-knowledge acquisition and self-efficacy levels of educators, based on Mayer's (2005) Cognitive Theory of Multimedia Learning (CTOML) and Bandura's (2006) Self-Efficacy Theory. In this chapter, I describe the research methods used in the study, addressing four research questions on content acquisition in asynchronous course design, self-efficacy, and their relationship. I also include the description of the design and its participants, followed by the study's procedure, measurement instrumentation used, data collection, and data analysis procedures.

This research study used a mixed-methods explanatory-sequential design that incorporated quantitative and qualitative data analysis. In the explanatory-sequential design, this researcher first collected quantitative data and in a second phase, collected qualitative data as a follow up to the quantitative results. I then connected the results to shape the questions, sampling, and data collection (Creswell, 2013). Two goals were reached when using this group-sampling procedure. Because this research used a pragmatic approach to inform best practices at NASA's Digital Learning Network, the sample population was drawn from the typical group with which the DLN works (that is,

teachers taking professional development courses). The second purpose of this type of sample choice was to enable a comparison among similar groups (Teddlie & Yu, 2007).

This mixed-method design had challenges. Multiple modes of comparison automatically add extra work to analyze the results. Coding open-ended responses was tedious and time consuming; but the benefit they provided for corroboration of the design of these courses was invaluable. To ensure each interview was fully recorded, I took notes and recorded the interview in audio and video formats. I also hired an assistant to independently transcribe and code the responses from each interviewee.

Organization and planning of the assessments and their design were important to the study's success. Assessments that were too long would not respect participants' available time which could result in answers that were not accurate. If my assessments were too short, I would not have acquired adequate data. In the end, all participants completed the full cycle of pre-tests and post-tests for the study.



DLN database of teacher participants who self-identified as middle school teachers by the national definition of Grades 5–8. This group is familiar with an online-presentation format and was presumed to be comfortable participating in an online-course design.

### **Participants**

Of the initial 90 volunteers who were solicited from the NASA DLN educator participant database and self-identified as fifth through eighth grade teachers who volunteered to participate in the study, 24 fully completed the requirements. I randomly assigned seven participants to Control Group A, seven to Group B, and 10 to Group C. Participants spanned the ages of 20 to 69 with the majority falling in the 40–49 age group.

1. Control Group A consisted of seven members, who were majority female and falling mostly in the age group of 20-49. The treatment used standard online learning format that consisted of static graphics and well-integrated textual content
2. Treatment Group B consisted of seven members who were majority female and falling mostly in the age group of 40-49. The treatment used animation only with well-integrated textual content
3. Treatment Group C consisted of ten members, who were majority female and falling mostly in the age group of 40-49. The treatment used animation with audio that explained the content with well-integrated textual content.

The focus of the asynchronous courses presented were all physics based.

I questioned a sample of the three treatment groups for interviews about feelings of self-efficacy using questions that were designed for a previous study and adjusted to fit

this one (Appendix C). I selected six participants, two from each treatment group that tested as either high or low in self-efficacy on the STEBI-A from each course design to participate in open-ended flexible interviews that specifically targeted their perceived self-efficacy levels on the physics content presented in the course. Each participant was interviewed over the phone with their responses recorded and then transcribed for later analysis. I chose physics because the education content that NASA offers centers around this science specialty (NASA, 2013). The course design consisted of three parts with each part taking approximately 5 hours to complete, for a total time investment of 15 hours for participants. Participants that fully completed the study received a certificate they could submit to their school systems for continuing education credit for their license renewals. Participants were also eligible for one of two gift cards in a drawing at the end of the study.

### **Data Analysis**

The content knowledge assessment included multiple-choice questions that evaluated participant knowledge at a variety of levels of Bloom's revised taxonomy (Krathwohl, 2002; see Appendix A). Participants in the control and treatment groups took this test prior to accessing the course and took the assessment again after completing the 4-week course. I designed pre- and post-tests of multiple choice questions to measure content knowledge of Force of Motion through the three-part asynchronous course series. Both tests included 10 questions at the base level of the taxonomy (five recall and five recognize), 10 questions at the understand level, and five application questions (Anderson, 2001).

I assured content validity by collaborating with a NASA educator who was the content planner for asynchronous learning. Science educators currently in the grade level of focus also reviewed the tests for interrater reliability. Ratings for approval included a 1 that indicated the rated question was not clear. A rating of 2 indicated that although the question may have been clear, the answers did not appear to be clear or did not appear to align with the purpose of the question. A rating of 3 indicated that the question and its answer had clarity. All questions were approved by professors at Oklahoma State University where this study was based.

I measured self-efficacy before and after the intervention using the Science Teaching Efficacy Belief Instrument-A (STEBI-A) (Riggs and Enochs, 1990; see Appendix B, 1990). The STEBIs were developed in 1990 by Riggs and Enochs specifically to measure the self-efficacy level of preservice and in-service elementary teachers that also taught science. The instruments grew from Bandura's (2006) ideas on self-efficacy theory which stated that behavior is predicted based on two elements: if the behavior has a favorable result, then it is likely to be repeated (Science Teaching Outcome Efficacy) and the belief that the action can be performed effectively (Personal Science Teaching Efficacy) (Christol & Adams, 2006). STEBI-A consists of 23 items that are rated on a 5-point Likert-like scale with the following response categories: *strongly agree*, *agree*, *uncertain*, *disagree*, and *strongly disagree*. Subscales that measure Personal Science Teaching Efficacy and Science Teaching Outcome Efficacy are embedded in the instrument. There are 13 items on the Personal Science Teaching Efficacy subscale with a scoring range between 13-65. The Science Teaching Outcome Efficacy subscale has 12 items with a scoring range between 10-50. Researchers have



shown links between student achievement and teacher self-efficacy. Although the STEBI-A considers the beliefs of a teacher regarding their competence in teaching an area of science, it also consider the teacher's belief of students' ability to learn these concepts (Riggs & Enochs, 1990).

The instrument was tested with over 300 rural and urban elementary teachers. Item analysis of both subscales revealed a Cronbach's alpha of .77 for the Science Teaching Outcome Expectancy subscale and .92 for the Personal Science Teaching Efficacy subscale (Riggs & Enochs, 1990). Researchers showed the Science Teaching Outcome Expectancy is more difficult to measure (Gibson & Dembo, 1984). The lower alpha is consistent with these findings. Results showed that the STEBI is a reliable tool for studying elementary teacher's beliefs toward science learning and teaching (Riggs & Enochs, 1990).

I used the STEBI-A to answer the first research question: "Will educators who use static text and video with audio achieve a greater increase in efficacy than those who use static text with static pictures or static text and video only?" Previous uses of this instrument showed changes in confidence levels for practicing teachers over time. Researchers use the STEBI-A as a tool to help understand teacher behavior; that understanding leads to better designs of programs that could improve science teaching (Riggs & Enochs, 1990). I compared testing groups before and after course participation in each of the three treatment groups. I used nonparametric statistics and participant interviews to determine if the treatment impacted scores on these subscales of self-efficacy. The small number of participants made it difficult to discern definitive results.

I interviewed participants using the questions below, which had been normed in a previous study targeted to gather information about feelings of science self-efficacy from elementary teachers (Hopkins, 2007).

1. What beliefs do you hold about science teaching and learning?
2. Why do you think it's important to teach science? How important do you think it is to teach science in X grade? (X represents the grade level of their class) Please cite specific examples of why science is important to teach.
3. Do you feel confident about your [physics] science content knowledge? Please explain your answer.
4. Did [your asynchronous class] help you become more (or less) comfortable in teaching physics concepts? Please cite specific examples.
5. [Are you confident in teaching physics concepts?] Did your [asynchronous course] help you gain confidence in your ability to teach [these physics concepts]? Please cite specific examples.
6. Do you see yourself using what you learned in [your asynchronous course for your students] in general and in teaching [physics content] in particular? Please cite specific examples. (Hopkins, 2007, pp. 89–90)

I took qualitative measurements using these interview questions to gather information from a small select group of study participants. I then coded the results of the interview seeking similar trends in responses. Professors at Oklahoma State University reviewed all questions and the Institutional Review Board approved the study before it commenced (Appendix C).

Prior knowledge of physics content was a potential confounding factor to this study. To eliminate this potential bias, I gave participants a content-knowledge multiple-choice qualifying test to eliminate those who may have high levels (greater than 80%) of prior Force of Motion knowledge. This test also served as the initial baseline to gather data from the remaining participants whose content knowledge level was applicable for the design.

### **Procedures**

Participants were volunteers from NASA's DLN customer base that consisted of a list of teachers who had used the DLN to schedule modules for their classrooms across all grade levels. This study narrowed solicitation of these participants to those that self-identified as fifth through eighth grade teachers. Advertisements on the homepage and targeted e-mails solicited their participation encouraging participants to join the effort by offering professional development credit hours as well as an entry into a drawing for one of two \$100 gift cards to purchase classroom supplies (see Appendix C). Participants took the STEBI-A and physics-content pre-tests. I determined level of physics knowledge by scores of the content test with only those who scored 79% and below allowed to participate in the study. Of the 24 participants that completed the pre-test, each one qualified.

I input data from the STEBI-A and content pre-test into an Excel spreadsheet while the course activation phase began. Participants were randomly assigned each to the control group (Group A), Treatment Group B, or Treatment Group C. I granted access to their particular course design once they completed the content pre-test and STEBI-A. Participants then had four weeks to complete the three-part course. The course creator

monitored course progress with e-mail reminders of timelines to ensure completion of the online content. Once participants completed the course, they completed the post-test content and STEBI-A to receive their professional development continuing-education unit certificates and to qualify for the drawing for the gift card. Once participants completed all tests, I input results to SPSS and compared them with pre-test scores. I analyzed results for growth in content as well as changes in perception of Science Teaching Outcome Efficacy and Personal Science Teaching Efficacy.

I interviewed six participants identified as having either high self-efficacy or low self-efficacy through the post-STEBI-A instrument. I recorded and transcribed all interviews and undertook thematic analysis of the transcripts to identify themes and categories relevant to the study phenomena, collapsing comments with common themes into common categories. For example, I placed course review and revelation in content in the same category. Individual interviews lasted approximately 1 hour as I asked set questions while taking notes of the answers and recording the session in audio and video formats using web or video-conferencing platforms. I then used an open-coding system and analyzed participants' answers for key words that indicated growth in efficacy levels in the presented science-content knowledge. Researchers generally use open-coding systems for interviews and seek distinct concepts throughout the responses. This process is accomplished by highlighting concepts with various colors of highlighters, then synthesizing them into a tabled format (Seidman, 2013). Interviews were transcribed, coded, and analyzed and I sought multiple trends to report in the analysis.

I analyzed the quantitative results through SPSS version 21 using Wilcoxon Signed Ranks Test and Kruskal–Wallis tests, due to the small sample size. This design

reflected an explanatory-sequential mixed-methods design in which a researcher collects and analyzes quantitative data and follows up with collection and analysis of qualitative data (Creswell & Plano Clark, 2011). The purpose of using this design was to present a clear overall picture of the effect of the various modes of the asynchronous courses on adult participants.

The quantitative part of this research provided understanding of how well participants retained the content overall, showing growth or lack thereof, for learning the physics content based on the variations of course design to simulate channel-acquisition engaging learning, aligned with Mayer's (2005) CTOML. Self-efficacy quantitative results provided a measured scale of any changes that occurred based on these designs. Quantitative results provided the objective measurements of increase or decrease in the learning and self-efficacy levels of the educators taking the courses.

Qualitative measurements (open ended-question responses conducted after participation in the courses) provided a deeper dimension of the research, informing me of the link between self-efficacy in the physics course design. I then checked for trends in participants' answers to adequately determine if the course design changed teachers' self-efficacy levels about the content presented. Having both measurements allowed me to determine if a relationship existed among the design of the course, the amount of learning that took place, and potential changes in levels of self-efficacy in the topic area.

## CHAPTER IV

### RESULTS

The purpose of this research study was to determine if different media treatments had a positive or negative effect on content knowledge acquisition and self-efficacy levels of educators who participate in these courses. This chapter presents the major findings from the content and self-efficacy assessments, interviews, and open-ended questions I asked of participants as they correspond to the following research questions:

1. Will educators who use static text and video with audio achieve a greater increase in self-efficacy than those who use static text with static pictures or static text and animation only?
2. Will educators who use static text and animation with audio gain more content knowledge than those who use static text with static pictures or use static text and animation only?
3. Will educators' improved content knowledge correlate to higher self-efficacy?
4. What themes will emerge from participants' perceptions of how an online professional development session affected their self-efficacy level in teaching STEM?

The study included only those who self-identified as middle school educators according to the national definition of Grades 5–8. All demographic data appear in Table

1. Participants started the study in September 2014 and completed the study at the end of January 2015 to allow additional participants to complete the study, given planned time off during the holiday season. I performed a Kruskal–Wallis analysis of the self-efficacy and content-knowledge pre-tests, and results showed no significance between any of the treatment groups before the intervention.

*Table 1*

*Gender, Age, and Grade Taught of Participants*

	Overall <i>n</i> = 24	Group A <i>n</i> = 7	Group B <i>n</i> = 7	Group C <i>n</i> = 10
<b>Gender</b>				
Male	3 (13%)	1 (14%)	1 (14%)	1 (10%)
Female	21 (88%)	6 (86%)	6 (86%)	9 (90%)
<b>Age groups</b>				
20–29	2 (8%)	2 (29%)	0 (0%)	0 (0%)
30–39	5 (21%)	2 (29%)	1 (14%)	2 (20%)
40–49	12 (50%)	2 (29%)	4 (57%)	6 (60%)
50–59	2 (8%)	0 (0%)	1 (14%)	1 (10%)
60–69	3 (13%)	1 (14%)	1 (14%)	1 (10%)
<b>Grade Taught</b>				
5th	8 (33%)	2 (29%)	3 (43%)	3 (30%)
6th	3 (13%)	0 (0%)	1 (14%)	2 (20%)
7th	5 (21%)	2 (29%)	1 (14%)	2 (20%)
8th	8 (33%)	3 (43%)	2 (29%)	3 (30%)

### **Self-Efficacy**

I used the Wilcoxon Signed Ranks Tests and Kruskal Wallis nonparametric tests to see if participants’ self-efficacy, as measured by the STEBI-A, increased as a result of

the intervention. As shown on Table 3, statistically significant differences arose at the .05 significance level from pre-test to post-test scores for Treatments A, B, and C on the Personal Science Teaching Efficacy subscale. For each of the three treatment groups, Wilcoxon signed ranks analysis on the Personal Science Teaching Efficacy subscale scores showed statistically significant differences between the pre-test and the post-test, indicating that Personal Science Teaching Efficacy was higher after completing the course. All three treatment groups showed a large effect size. On the Science Teaching Outcome Expectancy subscale, Wilcoxon signed ranks analysis showed no significant difference between any of the groups (see Table 2). A Kruskal-Wallis H test was conducted to determine if Personal Science Teaching Efficacy was different for three groups that were exposed to: (a) text only ( $n=7$ ); (b) text and animation ( $n=7$ ); and (c) text, animation and audio. Results showed no significant differences in Personal Science Teaching Efficacy between the three groups,  $p = .57$ . To evaluate whether differences emerged by treatment group in Personal Science Teaching Efficacy after the intervention was complete, I performed a Kruskal–Wallis analysis on Personal Science Teaching Efficacy subscale post-test scores. Results showed no significance between any of the groups (see Table 4). A Kruskal–Wallis analysis was not necessary on the Science Teaching Outcome Expectancy.



Table 2

Comparison of Pre and Post Science Teaching Efficacy Beliefs Instrument (STEBI)

Subscale	Pre-test			Post-test			Z	p	r
	Min	Max	Mdn	Min	Max	Mdn			
Treatment A (n=7)									
PSTE <sup>1</sup>	17	27	24.33	25	38	31.33	-2.375	.018*	.90**
STOE <sup>2</sup>	24	35	26.00	20	33	28.67	-.339	.734	.13
Treatment B (n=7)									
PSTE <sup>1</sup>	13	38	23.33	21	37	29.00	1.784	.074*	.67**
STOE <sup>2</sup>	21	35	28.67	24	38	28.00	-.851	3.95	.32
Treatment C (n=10)									
PSTE <sup>1</sup>	14	48	22.67	24	41	31.00	-2.247	.025*	.71**
STOE <sup>2</sup>	22	37	30.00	26	40	30.50	-1.425	.154	.45

Note <sup>1</sup>Personal Science Teaching Efficacy; <sup>2</sup>Science Teaching Outcomes Expectancy. \*The difference in the participants' responses were statistically significant, p<.05. \*\* PSTE of each treatment yielded a large effect size >.50 The range of possible scores on the PSTE is 13-65; The range of possible scores on the STOE is 10-50.

## Content Knowledge Acquisition

I addressed Question 2, Will educators who use static text and animation with audio gain more content knowledge than those who use static text with static pictures or use static text and animation only? with an overall quantitative analysis of content pre-tests and post-tests using nonparametric statistics, analysis of the test by Bloom's content level to analyze for specific differences, and qualitative interviews to check for trends of feelings of self-efficacy. Table 3 shows the overall scoring data for content pre-tests and post-tests of all three groups. For each of the three treatment groups on the content-knowledge test, I compared pre-test and post-test scores using Wilcoxon analysis to see if participants had significant knowledge gains as a result of the intervention. Wilcoxon results showed significance in all three treatment groups, as well as the group as a whole. For each of the five subscales on the content-knowledge test, I compared pre-test and post-test scores using Wilcoxon analysis to see if participants had significant knowledge gains as a result of the intervention. The Wilcoxon results for Treatment Group A showed significant gains in the lowest subscale of *remembering* and upper subscales of *applying* and *analyzing*, with no significant gains in the *understanding* subscales, as well as a significant difference in the content test overall. Treatment Group B showed significance in the *remembering*, *applying*, and *analyzing* subscales and the content test overall. Treatment Group C showed significance in the *remembering* and *applying* subscales and a significant difference between the overall pre- and post-content tests (see Table 3). When comparing pre- and post-scores of all three treatment groups as a collective, significant differences emerged in all but the *evaluate* subscale (see Table 3).

Table 3

*Gain Scores and Descriptive Statistics for Three Treatments Bloom's Subscales in*

*Content Test*

Subscale	Pre-test			Post-test			Z	p	r
	Min	Max	Mdn	Min	Max	Mdn			
Treatment A (n=7)									
Remember	1	3	2	3	5	4	-2.33	.020*	0.88
Understand	0	1	0	0	3	1	-1.51	0.13	0.57
Apply	0	3	2	1	5	4	-1.90	0.06*	0.71
Analyze	1	4	1	1	6	4	-2.23	0.03*	0.84
Evaluate	0	1	0	0	1	0	0.00	1.00	0
Total	3	12	6	5	19	12	-2.21	0.03*	0.83
Treatment B (n=7)									
Remember	0	4	1	2	5	5	-2.38	0.02*	0.90
Understand	0	3	1	0	3	2	-1.47	0.14	0.56
Apply	0	4	1	0	5	4	-2.21	0.03*	0.84
Analyze	0	3	1	1	6	3	-2.21	0.03*	0.84
Evaluate	0	0	0	0	1	0	-1.41	0.16	0.53
Total	2	14	3	5	20	13	-2.37	0.02*	0.90
Treatment C (n=10)									
Remember	0	4	2	3	4	4	-2.04	0.04*	0.65
Understand	0	1	1	0	3	1	-1.89	0.06	0.60
Apply	0	5	1	2	5	4	-2.23	0.03*	0.71
Analyze	1	4	1	1	5	2.5	-1.62	0.10	0.51
Evaluate	0	0	0	0	1	0	-1.00	0.32	0.31
Total	3	13	4.5	8	16	11	-2.38	0.018*	

Note. \*The difference in the participants' responses were statistically significant,  $p < .05$ .

To see if the different treatments resulted in different levels of content knowledge after the content interventions, I performed Kruskal–Wallis analysis on the post-test scores. No significant difference showed for any of the subscales (see Table 4).

*Table 4*

*Kruskal–Wallis Test to Determine Content Test Subscale Difference*

(n=24)	Mean	SD	Chi-Square	<i>p</i>
Bloom's Subgroup				
Total	2.1250	0.85019		
		1.56906	5.680	.058
Remembering	2.1250			
Understanding	0.7917	1.25036	.166	.920
Apply	1.8333	1.71100	.284	.868
Analyze	1.6667	1.68540	3.935	.140
Evaluate	0.1250	0.33783	2.597	.273
Total Score	6.5417	4.70873	1.981	.371

### **Is There a Correlation Between Efficacy and Content Acquisition?**

I addressed the third research question—Will educators' improved content knowledge correlate to higher self-efficacy?—using a bivariate correlation comparing post-content scores and post-STEBI-A results to determine if a connection existed between a participants' content knowledge and level of self-efficacy. Using Kendall's tau and Spearman's rho, no significance emerged between any of the three treatment groups or with the group as a collective (see Table 5).

Table 5

*Kendall's Tau and Spearman's Rho Correlation Between Efficacy and Content*

*Acquisition*

	Self-efficacy–content score correlation coefficient	Sig. (2-tailed)
Kendall's tau-b	-.183	.222
Spearman's rho	-.224	.292

*Note.*  $N = 24$ .

**Themes of Perception on How Online Professional Development Affects Self-Efficacy**

I addressed the fourth research question—What themes will emerge from participants' perceptions of how an online professional development session affected their self-efficacy level to teach STEM?—through qualitative interviews. Upon conclusion of the study, I used the STEBI-A post-test results to identify three participants who rated High Self-Efficacy on their overall self-efficacy score and three participants who rated Low Self-Efficacy.

All six participants in each of the High Self-Efficacy and Low Self-Efficacy groups reported that teaching science was important for participants in their academic preparation. Each teacher mentioned that a hands-on learning approach, integrated with learning from trial and error, was an important part of the process of learning science. Emphasis on science careers when the United States is focusing on STEM-career enhancement was also a common theme. When I asked participants what beliefs they had about science teaching, the theme of hands-on experiential learning was prevalent. “Students learn best in a hands-on approach where they can get in and test and learn from

mistakes” (High Self-Efficacy respondent). “Science = [problem-based learning] and hands-on learning. Not based on a textbook” (Low Self-Efficacy respondent)

Question 2 related to participants’ perceptions of how important it was to teach science. Some difference emerged between High Self-Efficacy and Low Self-Efficacy respondents. High Self-Efficacy educators were more career and future focused than Low Self-Efficacy educators, who were more focused on daily activities and understanding, “It is important because science is such an important part of daily decision making. In teaching science, you are teaching students how to think. This is problem solving.”(Low Self-Efficacy respondent) A member of the High Self-Efficacy group responded with more of a global perspective saying, “This is where our future lies in terms of understanding the world.”

In response to the question about their level of self-efficacy in teaching physics content specifically, the general consensus of the High Self-Efficacy group was that they were confident in their knowledge of this content, crediting their preparation as pre-service teachers for that self-efficacy level. In contrast, one of the Low Self-Efficacy teachers felt the same, but added the caveat that their comfort level was restricted to the middle school level. “At the middle school level. Yes. The content for this course was challenging for me so I was not as comfortable.” Although the course content was vetted before the study took place, indicating it was appropriate for middle-school level teachers, the course content appeared to overwhelm Low Self-Efficacy participants (see Appendix F).

Participation in the asynchronous class seemed to have helped those educators with high and low self-efficacy feel more comfortable teaching physics concepts. One

such response from a participant identified as High Self-Efficacy stated, “The class was interesting and informative but if I did not have physics background it would have been difficult.” Similarly a Low Self-Efficacy participant stated, “There were some different topics that I had not seen in a long time and going over different concepts was very helpful.” These responses aligned with results of the *Wilcoxon*, indicating the effects of the treatment groups with self-efficacy was significant at all treatments levels of self-self-efficacy for teaching this science content.

The ultimate test of any professional development course is whether the educator puts the material into practice. Here, teachers in both groups had conflicting responses that could be tied to their own self-identified feelings of self-efficacy. All High Self-Efficacy respondents could envision the implementation of the material in their classrooms: “I see myself using part of it like using physics to teach about kinetic energy and rollercoasters and dropping balls to show energy.” The specific details of the use of particular learning areas from the course content could relate this teacher’s higher level of self-efficacy in the ability to integrate the material in the classroom setting. In contrast, Low Self-Efficacy respondents did not believe they would use the course material, with some assessing that the material was too deep for their students.

Common high-frequency themes of all participants fell in two categories: an emphasis on hands-on learning and the course providing a review of their pre-service knowledge content. High Self-Efficacy teachers were unique in mentioning the importance of making science relatable, assessing that the course helped them feel more confident and reconfirming the importance of professional development in their careers. The Low Self-Efficacy group did not have any unique thematic responses (see Table 6).

Table 6

*Trends of Participation Responses to Online Experiences Through Personal Interviews*

Theme	No. of times mentioned	No. of participants that mentioned	HSE, LSE, or both
Hands-on learning	4	3	Both
Experience science and make it relatable	2	2	HSE
Understanding the world	3	3	Both
Cool factor/appreciation for science	3	2	Both
Career focused	3	3	Both
College preparation	3	3	Both
Course made me more confident	3	3	HSE
Course provided a review or revelation of content	5	4	Both
Course design encouraged self-efficacy	3	3	Both
Important to continue learning	2	2	HSE
Content above usable level	3	3	Both
Examples in the course will be used in class	2	2	Both

*Note.* HSE = High Self-Efficacy; LSE = Low Self-Efficacy.

### Summary

With few participants completing the study, results were limited. Quantitative results showed an increase in self-efficacy for all three treatment groups, whereas qualitative results were taken from such a small sample that accurate results and relationships cannot be determined. Although participants requested more interactivity in the control group, results from these tests cannot be used to support or deny Mayer's (2005) theory.



## CHAPTER V

### DISCUSSION

The purpose of this study was to discover if various designs of asynchronous online courses impacted teacher content retention and self-efficacy. NASA's DLN hosted the course, and I invited teachers who had participated in the DLN's programming to participate. A veteran educator employed through NASA's education program developed the course using NASA preapproved content developed by NASA's Classroom of the Future. Once the control course was uploaded, the content was altered to add two additional treatment groups: one that included the same text but included animations with no audio and one that had the text, animations, and added audio explanations. Middle school teachers across the nation vetted the course content, agreeing the content was appropriate to improve their content knowledge.

Study participants were 24 middle school teachers (Grades 5–8) randomly assigned to one of three treatment groups. Once a participant registered and completed the page consenting to participate, I administered a pre-content test and pre-self-efficacy test using the STEBI-A. Only at the point of completion of these tests did participants advance to the course content. Upon completion of the course content, I administered a post-content and post-STEBI-A. At the conclusion, seven participants had fully completed Course A, seven completed Course B, and 10 completed Course C. I then used

scores from the STEBI-A to identify six of the 24 participants to interview, to obtain additional information about their experiences. This study elicited responses to four research questions that lent themselves to an explanatory sequential design.

### **Research Question One**

Will educators who use static text and animation with audio achieve a greater increase in self-efficacy than those who use static text with static pictures or static text and animation only?

The first research question was addressed through Wilcoxon and Kruskal–Wallis analyses using results from the pre- and post-STEBI-A and participant interviews. Results from these analyses showed changes in self-efficacy across all three treatment groups in the Personal Science Teaching Efficacy subscale of the STEBI-A, but no significant change in the Science Teaching Outcome Efficacy. Cronbach’s alpha measurement of the Science Teaching Outcome Efficacy subscale of the STEBI-A had a lower reliability rating (.76) than the Personal Science Teaching Efficacy subscale (.91; Riggs & Enochs, 1990). Nonsignificant findings in this research on the Science Teaching Outcome Expectancy subscale could be due to its lack of sensitivity to detect differences, particularly with the low number of participants in this study.

Across the treatments, Personal Science Teaching Efficacy showed significant changes between pre- and post-STEBI-A participation. Although Science Teaching Outcome Expectancy showed no significant changes, the changes in Personal Science Teaching Efficacy showed value in asynchronous courses to increase the self-efficacy level of middle school educators regarding physics content. Although the STEBI-A showed that all three courses increased self-efficacy, responses from the qualitative

interviews showed a difference in answers between High Self-Efficacy and Low Self-Efficacy teachers. High Self-Efficacy teachers stated they would use the information in their classrooms whereas Low Self-Efficacy teachers were unsure they would use the information in their classrooms.

Interviews revealed similar responses between the treatment groups about their beliefs in the importance of teaching science, how the teaching should focus on STEM career objectives, and the way science can explain how the world functions. Additionally, participants answered that their course helped improve their level of self-efficacy about physics in general. Differences between the treatment groups did not reveal any significant responses that pointed to course design as impacting self-efficacy. From the data gathered, Wilcoxon results showed that self-efficacy increased for each of the treatment groups, indicating that no matter the design, each participant felt more confident in the content that was presented after the completion of their course. Kruskal–Wallis results showed no significance. Participant interviews showed more indications of connection between the treatment group and level of self-efficacy. Educators participating in all three treatment groups showed significant changes in their Personal Science Teaching Efficacy scores and not their Science Teaching Outcome Efficacy score. No one treatment stood out from another.

### **Research Question Two**

Will educators who use static text and animation with audio gain more content knowledge than those who use static text with static pictures or use static text and animation only?

Mayer's (2005) tests revealed that the more stimulus added in an asynchronous course, the more cognitive load for participants who experienced it. In the current study, Wilcoxon tests were used to analyze the various subsets of Bloom's taxonomy incorporated in the pre- and post-content tests, showed that Treatments A and B, the control and the course with static text and animated pictures but no sound, respectively, showed the greatest gains between pre-test and post-test results. Treatment C with the added audio fared worst in these changes. Question two was addressed with Wilcoxon and Kruskal–Wallis analyses. I performed a whole-group comparison between pre-test and post-test results. All subscales showed significant differences with the exception of the *evaluate* subscale.

The overall test showed no significant differences between pre-test and post-content test results. Subsequent analyses of pre-test and post-content-level tests looked specifically at content tests subscales, identified by their levels of Bloom's taxonomy. Review of Wilcoxon and Kruskal–Wallis scores showed the largest growth in Treatments A and B only for the *remembering, applying, and analyzing* levels presented in the tests. Treatment C showed a significant difference in the *remember and apply* levels only. No overall significant differences emerged in the test as a whole between any of the treatment groups, using Kruskal–Wallis analysis.

Mayer (2005) stated that multimedia works best when it addresses the visual and verbal processing systems, but expressed concern that words—written and spoken—can overwhelm the visual cognitive process, creating cognitive overload. Once people process new learning by sensory memory, they select words and images and proceed to

working memory. The words and pictures organize into verbal and pictorial models and then integrate with prior learning to form long-term learning (Mayer & Sims, 1994).

Participants exposed to Treatments A and B showed the greatest gains between pre-tests and post-content tests and improvement in quality of learning along the levels of Bloom's taxonomy. Treatment B's construction with static text and animation without audio mirrors Mayer's (2005) theory of accessing only the two areas of sensory memory with written words and pictures.

Educators who participated in Treatment A who had static text only and those in Treatment B who were exposed to static text with animation and no audio gained more content knowledge than those in Treatment C exposed to static text, animation and audio.

### **Research Question Three**

Will educators' improved content knowledge correlate to higher self-efficacy?

I performed a bivariate correlation that compared post-content and post-STEBI-A results showing a statistically non-significant result. No correlation between self-efficacy and content acquisition can be claimed in this study.

### **Research Question Four**

What themes will emerge from participants' perceptions of how an online professional development session affected their self-efficacy level to teach STEM?

There were a variety of themes that emerged during the interview process. A few pointed directly to the students and teaching technique such as hands-on learning and the course content being applicable for the classroom. Other themes pointed in a broader sense for the appreciation of science as a subject and how it helps students to understand

the world. There were some themes that were future-focused such as career and college preparation. Finally, finding ways to navigate effectively throughout the course was also frequently mentioned.

There were three themes that were mentioned solely by High Self-Efficacy participants that were interviewed. One of these themes; experiencing science and making it more relatable, speaks directly about how these educators feel teaching science is important. The last two were educator-centered. These themes were an indication of the impact of participating in professional development experiences by educators continuing their learning as a way to develop their skills. They also mentioned how the course they were assigned helped them to feel more confident about the content presented in order to relate the content of the course to their students.

### **Limitations**

This study had some limitations. I asked two questions at the conclusion of the post-test in the form of open-ended queries. The purpose was to ask participants to evaluate the course design. Themes drew from each of the two questions with the participants' treatment group identified in the theme response. Question 1 asked participants what they did and did not like about their particular course. The most prevalent responses came through two themes: concerns about course navigation and content being confusing in the way the course was designed (see Table 7). Control group A was the only group that mentioned they needed more interactivity in their course. All three groups addressed all other themes (see Table 7). The second question addressed participants' suggestions for course improvement. Course navigation was the most popular thematic response addressed by all three treatment groups. Control group A

repeated their desire for more interactivity, with Groups B and C wanting more quizzes and sections to break the content into smaller increments (see Table 7).

Table 7

*Trends of Participation Responses to Online Questions at Completion of Content Test*

Theme	No. of time mentioned	No. of participants that mentioned	Course assignment
<b>Question 1</b>			
Course hard to navigate	18	15	A, B, C
Pace of course	9	9	A, B, C
Course specific comments	11	9	A, B, C
Content specific comment	6	7	A, B, C
More interactivity needed	3	3	A
<b>Question 2</b>			
Course navigation	11	10	A, B, C
Suggestions for navigation improvement	2	2	B, C
No suggestions for improvement	2	2	A, C
Links broken or errors in question	3	2	A, B
Add interactivity	2	2	A
More quizzes/examples/break up content	6	6	B, C

Designed through Drupal on the Georgia Institute of Technology course site, template constraints existed. Through these comments and interactions with participants during the course trials, I discovered the template may not have been as intuitive as was needed, which could have contributed to the large numbers of participants who originally started the course but later stopped. Norman's (2013) theories regarding the emotional impact of an online site that causes frustration could have impacted the results of this study. Throughout the trial period, I had to provide step-by-step suggestions on how to navigate the course. This difficulty also could have contributed to the lower numbers of

participants who completed the study from the original 90 who volunteered initially to the final number of 24.

Another limitation was the small sample size, which may have been caused by the navigation problems listed above and also by the time of year in which the course was offered. Typically, at the beginning of the school year educators are busy with start-of-school procedural activities as well as initial assessments of students. I estimated a possible time investment of up to 15 hours to complete the course. When the majority of participants did not complete the study in full, I extended the opportunity through the holidays to allow educators to have some uninterrupted time to complete all course parts. Only three additional educators completed all requirements once I gave this extension. Because of the small sample size, the findings must be interpreted with caution.

### **Recommendations for Future Research**

It would be valuable to replicate this study with a larger sample size. A larger sample might be achieved by collecting data during the summer months when educators would have the most time to devote to the activity. In addition, researchers should initiate some consideration of a simpler design for the course navigation. Interviews of participants included elements that provided a course-navigation map and an agenda to follow. Other comments included adding more quizzes and practice items for each section, thereby breaking up the content into smaller chunks of information.

Narrowing the scope of the middle school teacher group for this physics content would also be in order. Although the national definition of middle school includes fifth grade, unanimously the fifth-grade teacher participants mentioned the material was beyond their scope of content knowledge. Future research could expand courses for



elementary teachers who receive limited amounts of science instruction in preparation for teaching as well as for high school teachers in specific science-teaching categories (e.g., biology and chemistry). Connecting these educators and their online course experiences to self-efficacy level could open opportunities for additional professional development that may not be offered through the district, or allow a district to offer more professional development opportunities away from the school system to expand the educator knowledge base.

### **Conclusions**

Due to the limited number of participants, it is difficult to draw conclusions about how different configurations of text, audio, and animation affect content acquisition and self-efficacy in online teacher professional development. Using the numbers of participants for this study, Treatments A and B (control and static text with animations) showed significant differences in measurement of content acquisition. The STEBI-A results showed that a teacher's Personal Science Teaching Efficacy was the only area across all three treatments with significant differences. Interviews with the teacher participants identified as either low self-efficacy or high self-efficacy through the STEBI-A revealed multiple common themes.

Perhaps most telling from this study is the result that all of the treatments improved Personal Science Teaching Efficacy. Prior studies concur. Dede, Ketelhut, Whitehouse, Breit, and McCloskey (2009) delved into the need for further research in this area, particularly discussing the impact of online professional development on self-efficacy. A study by Fisher, Schumaker, Culbertson, and Deshler (2010) compared achievement in teachers participating in an online professional development course and

the same content presented face to face. Much like this study, in which all three treatments resulted in changes in self-efficacy, both the face-to-face and online courses showed equal achievement levels. It would be beneficial to investigate the benefits of online professional development and its impact on teacher self-efficacy. Although the study numbers cannot point to conclusive results, the assessments provided an interesting view into the significance of considering Mayer's (2005) study results in planning asynchronous coursework, as well as how that design impacts self-efficacy.

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## APPENDICES

### A. Science Teaching Efficacy Belief Instrument

#### Science Teaching Efficacy Belief Instrument\*

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA = Strongly Agree  
 A = Agree  
 UN = Uncertain  
 D = Disagree  
 SD = Strongly Disagree

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	SA A UN D SD
2. I am continually finding better ways to teach science.	SA A UN D SD
3. Even when I try very hard, I don't teach science as well as I do most subjects.	SA A UN D SD
4. When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.	SA A UN D SD
5. I know the steps necessary to teach science concepts effectively.	SA A UN D SD
6. I am not very effective in monitoring science experiments.	SA A UN D SD
7. If students are underachieving in science, it is most likely due to ineffective science teaching.	SA A UN D SD
8. I generally teach science ineffectively.	SA A UN D SD
9. The inadequacy of a student's science background can be overcome by good teaching.	SA A UN D SD
10. The low science achievement of some students cannot generally be blamed on their teachers.	SA A UN D SD
11. When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.	SA A UN D SD
12. I understand science concepts well enough to be effective in teaching elementary science.	SA A UN D SD
13. Increased effort in science teaching produces little change in some students' science achievement.	SA A UN D SD
14. The teacher is generally responsible for the achievement of students in science.	SA A UN D SD
15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	SA A UN D SD
16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	SA A UN D SD
17. I find it difficult to explain to students why science experiments work.	SA A UN D SD
18. I am typically able to answer students' science questions.	SA A UN D SD
19. I wonder if I have the necessary skills to teach science.	SA A UN D SD
20. Effectiveness in science teaching has little influence on the achievement of students with low motivation.	SA A UN D SD
21. Given a choice, I would not invite the principal to evaluate my science teaching.	SA A UN D SD
22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.	SA A UN D SD
23. When teaching science, I usually welcome student questions.	SA A UN D SD
24. I don't know what to do to turn students on to science.	SA A UN D SD
25. Even teachers with good science teaching abilities cannot help some kids learn science.	SA A UN D SD

\*In Riggs, I., & Knochs, L. (1990). Towards the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*, 625-637.

## B. Letter of Participation Solicitation

Greetings,

We would like to invite you to participate in research that will help to establish a new offering for the NASA Digital Learning Network's educators. This online course is a joint effort between NASA's DLN and Oklahoma State University's Educational Technology Department.

The purpose of this research is to help us better understand how to properly construct an online professional development course for educators. We recognize that these courses have flooded the online learning landscape and want to provide these services to you as well. Participating in this online course will help inform us on the best way to construct these courses by measuring changes in your understanding of physics content as well as changes in how confident you feel about teaching that content (self-efficacy). *We sent this request to a selected number of customers in the DLN customer database.* The course is three parts with an estimated time investment of 5 hours for each section. You will take a pre content test and self-efficacy survey that will approximately take 45 minutes to complete. Once you have completed the course, you will take these surveys again and may be selected to participate in an interview to assist the researcher in her understanding of your content confidence levels. Your participation is valuable to the success of this study.

If you are selected as a participant for this study, upon its completion you will receive a certificate indicating you have invested 15 hours of professional development time to submit for your license renewal. In addition, all participants will be registered for a drawing for one of two \$100 Amazon gift cards.

If you have any questions regarding the questionnaire, you may contact us directly at [caryn.long@okstate.edu](mailto:caryn.long@okstate.edu). If you have questions about your rights as a research volunteer, you may contact the Oklahoma State University Institutional Review Board (IRB) at 219 Cordell North, Stillwater, OK 74078, 405-744-5700 or [irb@okstate.edu](mailto:irb@okstate.edu).

If you are interested in being considered to assist us with this research, please click this **registration link (TBD)**.

We thank you in advance for your participation and for volunteering your valuable time. We strongly urge you to participate in this very important study and to help us serve you better.

### C. Interview Questions

Interview questions:

1. What beliefs do you hold about science teaching and learning?
2. Why do you think it's important to teach science? How important do you think it is to teach science in X grade? (X represents the grade level of their student teaching class.) Please cite specific examples of why science is important to teach.
2. Do you feel confident about your physics science content knowledge? Please explain your answer.
3. Did your asynchronous class help you become more (or less) comfortable in teaching the physics concepts? Please cite specific examples.
4. Are you confident in teaching physics concepts? Did your asynchronous course help you gain confidence in your ability to teach these physics concepts? Please cite specific examples.
5. Do you see yourself using what you learned in your asynchronous course for your students in general and in teaching physics content in particular? Please cite specific examples.

Hopkins, A. (2007). *Elementary preservice teachers' science self-efficacy: Impact of an earth and atmospheric science content course on student teachers' practice*. (Order No. 3278675, Purdue University). *ProQuest Dissertations and Theses*, , 235. Retrieved from <http://search.proquest.com/docview/304841159?accountid=4117>. (304841159).

D. Pre- and Postcontent Assessment


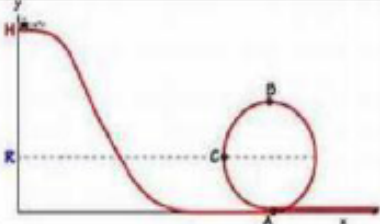


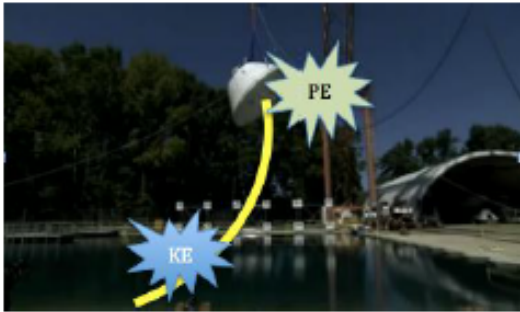
Assessment

Remembering (5)

1	<b>T</b> or F	When you jump into a pool, the water temperature goes up a little	Bloom's Taxonomy of Remembering: States whether statement of fact is correct.
2	T or <b>F</b>	A ball dropped from twice the height will create a crater in the mud twice as deep	Bloom's Taxonomy of Remembering: States whether statement of fact is correct.
3	<b>T</b> or F	$KE_1 + PE_1 = KE_2 + PE_2 = KE_3 + PE_3$	Bloom's Taxonomy of Remembering: Define the meaning of the term, kinetic energy.
4	<b>T</b> or F	Radioactivity is the source of energy for Plate Tectonics	Bloom's Taxonomy of Remembering: States whether statement of fact is correct.
5	MC: A B <b>C</b> D E	Kinetic Energy, KE, is defined as a. mv b. $\frac{1}{2} mv$ c. $\frac{1}{2} mv^2$ d. 2 mv e. $2 mv^2$	Bloom's Taxonomy of Remembering: Define kinetic energy

### Understanding (5)

<p>6</p>	<p>Group the following examples with the correct conservation law:</p> <table border="1" data-bbox="376 268 1164 548"> <thead> <tr> <th data-bbox="376 268 760 296"><i>Examples</i></th> <th data-bbox="760 268 1164 296"><i>Laws</i></th> </tr> </thead> <tbody> <tr> <td data-bbox="376 296 760 548">                     Tea cooled with ice                      Bunting a baseball                      Skateboard                      Rolling Rock                      Collision of 2 cars at a stoplight                      Ball launched with a spring                      Bohr Atom                      Insulated house                 </td> <td data-bbox="760 296 1164 548">                     Conservation of Energy                      Conservation of Momentum                      Conservation of Energy &amp; Momentum                      Conservation of Thermal Energy                 </td> </tr> </tbody> </table> <p><b>Answers:</b></p> <p>Tea cooled with ice.....Conservation of Thermal Energy                      Bunting a baseball.....Conservation of Momentum                      Skateboard.....Conservation of Energy &amp; Momentum                      Rolling Rock.....Conservation of Energy                      Collision of 2 cars at a stoplight.....Conservation of Energy &amp; Momentum                      Ball launched with a spring...Conservation of Energy                      Bohr Atom.....Conservation of Energy                      Insulated house.....Conservation of Thermal Energy</p>	<i>Examples</i>	<i>Laws</i>	Tea cooled with ice Bunting a baseball Skateboard Rolling Rock Collision of 2 cars at a stoplight Ball launched with a spring Bohr Atom Insulated house	Conservation of Energy Conservation of Momentum Conservation of Energy & Momentum Conservation of Thermal Energy	<p>Bloom's Taxonomy of Understanding:  <i>Identifies an example of each conservation law</i></p>
<i>Examples</i>	<i>Laws</i>					
Tea cooled with ice Bunting a baseball Skateboard Rolling Rock Collision of 2 cars at a stoplight Ball launched with a spring Bohr Atom Insulated house	Conservation of Energy Conservation of Momentum Conservation of Energy & Momentum Conservation of Thermal Energy					
<p>7</p>	<div style="display: flex; align-items: center;">   </div> <p>A 100 kg roller coaster, the Dragon Khan roller coaster in Universal Port Aventura Park in Spain, that does a loop-d-loop must be designed such that the coaster stays on the tracks at all times, especially when it is upside down. Using the diagram, transcribe an algebraic equation that illustrates the</p>	<p>Bloom's Taxonomy of Understanding:  <i>Translates illustration into algebraic equation</i></p>				

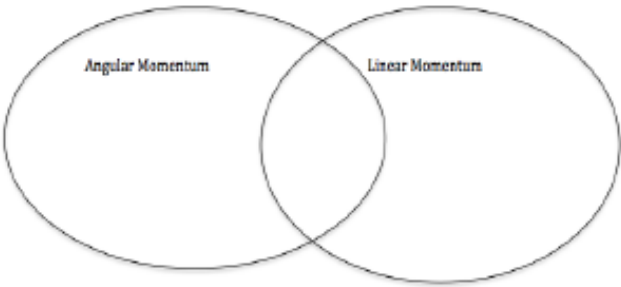
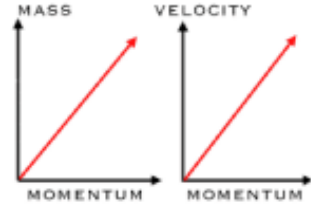
	potential and kinetic energy of the roller coaster. <b>Answer: <math>PE_H + KE_H = PE_A + KE_A = PE_B + KE_B = PE_C + KE_C</math></b>	
8	 <p>The Orion test model underwent a series of vertical drop tests at NASA Langley Research Center's Impact Research Facility. Suspended 25 feet, the 18,000 lb (8,165 kg) Orion splashed into the Hydro Impact Basin, measuring the rate at which the loads travel through the structure. Label where the KE and the PE is greatest on the diagram.</p>	Bloom's Taxonomy of Understanding: <i>Locates the optimal KE and PE on the diagram</i>
9	Which of the following is an example of a momentum problem? a. Moving at 35 km/hr in a northern direction b. <b>Throwing a piece of clay on the ground</b> c. Gravitational pull of the sun on the planets d. Raindrop creating a rainbow	Bloom's Taxonomy of Understanding: <i>Selects an example of momentum</i>
10	Which one of the following is true concerning momentum? a. Momentum is a force b. Momentum is a scalar quantity c. The SI unit of momentum is $kg \cdot m^2/s$ d. The momentum of an object is always positive e. <b>Momentum and impulse are measured in the same units</b>	Bloom's Taxonomy of Understanding: <i>Recognizing a correct statement about momentum</i>



## Applying (5)

11	Choose whether the types of energy are kinetic or potential a. Planet rotating around the sun b. Orbiting ISS c. Space Shuttle on launchpad d. Astronaut sleeping on ISS e. Space Shuttle fuel	KE KE PE PE PE	Bloom's Taxonomy of Applying: <i>Choosing the correct energy type</i>
12	NASA's Langley Research Center has been experimenting with the use of air bags to soften the landings of crew exploration vehicles (CEV) on land. What stopping time will be required in order to safely stop a 7250 kg CEV moving at 7.65 m/s with an average force of 426000 N (an average force of 6 Gs)?  <b>Answer: 0.130 seconds</b>	Bloom's Taxonomy of Applying: <i>Solving problems</i>	
13	When a large meteoroid flew across the Russian sky in February 2013 its velocity was 18.6 km/s (18,600 m/s or about 42,000 miles per hour) and its mass was 440 kilotons (440 million kg). From this scenario, find the solution for kinetic energy?  <b><math>\frac{1}{2} mv^2 = \frac{1}{2} (4.40 \times 10^8 \text{ kg}) (1.86 \times 10^4 \text{ m/s})^2 = 7.6 \times 10^{16} \text{ joules of energy}</math></b>	Bloom's Taxonomy of Applying: <i>Solving problems</i>	
14	A meteorite fragment is travelling at 900 m/s has a momentum of 4.5 kg•m/s. Calculate its mass?  <b><math>m = 4.5 \text{ kg m/s (forward)} / 900 \text{ m/s} = 5.0 \times 10^{-3} \text{ kg or } 5.0 \text{ g}</math></b>	Bloom's Taxonomy of Applying: <i>Solving problems</i>	
15	The first asteroid to be discovered is Ceres. It is the largest and most massive asteroid in our solar system's asteroid belt, having an estimated mass of $3.0 \times 10^{21} \text{ kg}$ and an orbital speed of 17900 m/s. Determine the amount of kinetic energy possessed by Ceres  <b><math>4.8 \times 10^{29} \text{ J}</math></b>	Bloom's Taxonomy of Applying: <i>Solving problems</i>	

### Analyzing (5)

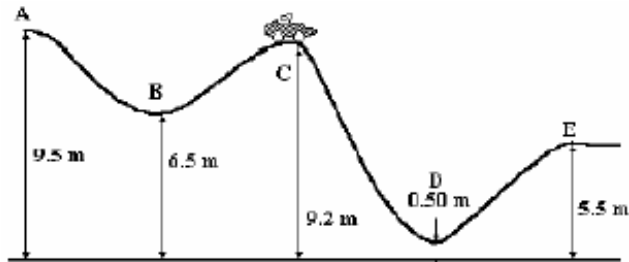
<p>16-18</p>	 <p>Angular Momentum</p> <p>Linear Momentum</p> <p>16. Linear momentum measured in <math>\text{kgm/s}</math> <math>p = mv</math> force required to change parallel to the motion</p> <p>17. Angular momentum Measured in <math>\text{kgm}^2\text{rad/s}</math> Normal to the motion Requires torque to change <math>P = mvr</math></p> <p>18. Both Are conserved Momentum - quantifies the motion of a moving body Property of moving object Vector quantity</p>	<p>Bloom's Taxonomy of Analyzing: <i>Compare Angular Momentum with Linear Momentum</i></p>
<p>19</p>	 <p>Examine the two diagrams to distinguish the correct interpretation.</p> <p>a. Momentum increases when velocity or mass increases b. Momentum increases when velocity or mass decreases</p>	<p>Bloom's Taxonomy of Analyzing: <i>Examining a diagram</i></p>
	<p>c. Momentum decreases when velocity or mass increases d. Momentum decreases when velocity or mass decreases</p> <p><b>Answer: A</b></p>	
<p>20</p>	<p>Distinguish between elastic (E) and inelastic collisions (IE) in the following examples:</p> <p>-2 meteors in the asteroid belt collide and combine to form a larger meteor</p> <p>- 2 meteors in the asteroid belt collide and ricochets. One meteors is propelled out of the asteroid belt.</p> <p><b>E</b> <b>IE</b></p>	<p>Bloom's Taxonomy of Analyzing:</p>

### Evaluating & Creating (5)

<p>21</p>	<p>Evaluate the equations to determine whether energy is conserved:</p> <p>Before:  <math>K = K_1 + K_2 = m_1 v_1^2 + m_2 v_2^2</math>  <math>2 = (4)(10)^2 + (6)(0)^2 = 200 + 0 = 200\text{J}</math></p> <p>After:  <math>K = K_1 + K_2 = m_1 v_{12}^2 + (1/2)m_2 v_{22}^2 = (4)(4)^2 + (6)(4)^2 = 32 + 48 = 80\text{J}</math></p> <p>Energy was not conserved. In this case there was a big reduction in kinetic energy after the collision, so we know that the difference in energies (120J) had to be lost either through doing work by permanently deforming one or both objects or as some sort of radiated energy such as heat or sound</p>	<p>Bloom's Taxonomy of Creating &amp; Evaluating: <i>Evaluate the equations and Select the response the most accurately defends the evaluation</i></p>
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22 -  
25

Olive Udadi is at the park with her father. The 26 kg Olive is on a swing following the path as shown. Olive has a speed of 0 m/s at position A and is a height of 3.0 m above the ground. At position B, Olive is 1.2 m above the ground. At position C (2.2 m above the ground), Olive projects from the seat and travels as a projectile along the path shown. At point F, Olive is a mere picometer above the ground. Assume negligible air resistance throughout the motion. Use this information to fill in the table.



Position	Height (m)	PE (J)	KE (J)	Time (J)	Speed (m/s)
A	3.0				
B	1.2				
C	2.2				
F	0				

Position	Height (m)	PE (J)	KE (J)	Time (J)	Speed (m/s)
A	3.0	760	0	760	0.0
B	1.2	310	460	760	5.9
C	2.2	560	200	760	4.0
F	0	0	760	760	7.7

Bloom's Taxonomy of  
Creating & Evaluating:

Created by Karen Ricks; NASA DLN Education Specialist and career high school science educator. Vetted by educators in the grade levels we intend to target for this study.

## C. IRB Approval letter

### Oklahoma State University Institutional Review Board

Date: Tuesday, August 12, 2014  
IRB Application No ED14116  
Proposal Title: Asynchronous Professional Development Online Course Design and its Impact on Science Teaching Efficacy  
Reviewed and Processed as: Exempt

**Status Recommended by Reviewer(s): Approved Protocol Expires: 8/11/2017**

Principal Investigator(s):

Caryn Smith Long	Penny Thompson
6053 John Jackson Dr	210 Willard Hall
Williamsburg, VA 23188	Stillwater, OK 74078

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The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of the research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Cordell North (phone: 405-744-5700, [dawnett.watkins@okstate.edu](mailto:dawnett.watkins@okstate.edu)).

Sincerely,

  
Tamara Mix, Interim Chair  
Institutional Review Board

## VITA

Caryn L. Smith Long

Candidate for the Degree of

Doctor of Philosophy Education

Thesis: THE IMPACT OF ASYNCHRONOUS ONLINE COURSE DESIGN FOR  
PROFESSIONAL DEVELOPMENT ON SCIENCE-TEACHER SELF-EFFICACY

Major Field: Educational Technology

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy/Education in Educational Technology at Oklahoma State University, Stillwater, Oklahoma in July, 2015.

Completed the requirements for the Master of Education in Elementary Education at University of North Carolina at Charlotte, Charlotte, NC in 1990.

Completed the requirements for the Bachelor of Arts in Education at Queens University, Charlotte, NC in 1988.

Experience:

Oklahoma State University Stillwater, OK, 09/2007 – Present Manager/Digital Learning Network Langley Research Center

Oklahoma State University Stillwater, OK, 05/2004 – 09/2007 NASA Explorer Schools Coordinator – Langley Research Center

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