DESIGN OF AN INSTRUMENT MEASURING P-12 TEACHERS' COGNITIVE LOAD AND INTENT TO ADOPT TECHNOLOGY

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Abstract: For P-12 teachers to effectively learn a technology, they must manage the cognitive load inherent to this learning task. Cognitive Load Theory (CLT) can offer insight in how P-12 teachers can manage the cognitive load of learning technology. However, technology adoption research has not used CLT to investigate how P-12 teachers manage the cognitive load of learning how to use technology or the influence of cognitive load on P-12 teachers' decisions whether to adopt technology. Hence, an instrument measuring cognitive load experienced when P-12 teachers learn about technology during professional development and their intent to adopt the technology may not be available. The purpose of this study was to design a self-report survey instrument measuring the latent constructs of P-12 teachers' cognitive load during technology professional development and their intent to adopt technology. Access to a validated instrument measuring these latent constructs may facilitate exploration of cognitive load's influence on technology adoption among P-12 teachers. Diffusion of Innovations and Cognitive Load Theory formed the theoretical foundation of this study and the instrument's design. The researcher conducted an index of item-objective congruence (IIOC) to evaluate content validity. Using data collected from P-12 teachers participating in technology professional development on the creation of interactive PowerPoint lessons, the researcher conducted exploratory factor analysis (EFA) to explore the factor model most representative of the data and to determine the instrument's internal consistency and variance explained. Results of the IIOC indicated a lack of consensus among content judges on which forms of cognitive load are being measured. Results of EFA supported a two-factor model explaining 79.759 % of the variance in the observed data. Implications of this study for future research on cognitive load and technology adoption among P-12 teachers is discussed.

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CHAPTER I

INTRODUCTION

Although P12 school district decision-makers may select new educational technologies on behalf of their districts, individual teachers may not necessarily adopt the technologies themselves. In fact, technology purchased by school districts for teachers to use in the classroom is often underused (Potter & Rockinson-Szapkiw, 2012). While there are varied reasons why technologies are underused, Rogers' (2003) Diffusion of Innovations theory (DoI) has provided a useful framework for investigating this issue (Kimmons, 2015; Hegedus et al., 2014; Martin & Quan-Haase, 2013; Richardson, 2011a; Richardson, 2011b; Adamy & Heinecke, 2005). Rogers (2003) defined adoption as the decision to fully use an innovation. Using DoI or other technology adoption frameworks, researchers have investigated factors affecting teachers' decisions to adopt or not adopt technology (Sánchez-Prieto, Olmos-Migueláñez, & García-Peñalvo, 2016, Kimmons, 2015; Hegedus et al., 2014; Martin & Quan-Haase, 2013). Technology adoption research provides evidence that the perceived difficulty or complexity of using technology can be a barrier to adoption (Aldunate & Nussbaum, 2013; Rogers, 2003; Sánchez-Prieto, Olmos-Migueláñez, & García-Peñalvo, 2017; Smith & Sivo, 2012) and that lack of effective professional development training can discourage teachers from adopting new technology (Goktas, Yildirim, & Yildirim, 2009; Rabah, 2015; Reid, 2014; Ruggiero & Mong, 2015). Teachers need effective professional development to learn how to use educational technology and integrate technology into instruction (Anthony & Clark, 2011; Bruce & Reynolds, 2009; Buckenmeyer, 2010; Coleman, Gibson, Cotten, Howell-Moroney, & Stringer, 2016; Crompton, Olszewski, & Bielefeldt, 2016), which can be an inherently complex process (Rogers, 2003). The importance of professional development training in technology adoption research suggests that whether teachers can learn a technology is influential in their decisions to adopt the technology.

According to Sweller's (2010; 2008) Cognitive Load Theory (CLT), teachers must process the cognitive load inherent to learning a technology for effective learning to occur. CLT can offer insight in how teachers process the cognitive load of learning to use a new technology, but few technology adoption studies have investigated how the cognitive load of learning a technology may influence adoption decisions (Dalinger et al., 2016). CLT research on pre-service teachers has provided some evidence indicating efforts to manage cognitive load while preservice teachers use educational technology improves their learning outcomes (Kennedy, Driver, Pullen, Ely, & Cole, 2013; Ong & Tasir, 2015; Moreno, 2007). A research study from the information systems design field suggests a connection may exist between individuals' levels of cognitive load when using a technology and their intent to adopt the technology. Dang (2011) presented police trainees in his study two web-based knowledge management systems and found the trainees exhibited significantly higher intent to adopt the system designed to minimize users' cognitive load. However, neither CLT research nor technology adoption research has attempted to explore a connection between cognitive load and intent to adopt technology in the field of P-12 education (Dalinger et al., 2016). Thus, a survey instrument measuring the latent constructs of P-12 teachers' cognitive load experienced during professional development and their intent to adopt the particular technology may not be available. This study follows the process of designing a self-report survey instrument measuring the latent constructs of P-12 teachers' cognitive load during technology professional development and their intent to adopt technology, which may facilitate future research on the potential relationship between these constructs.

This chapter will present the problem, purpose, and research questions of this study. To establish a warrant for designing an instrument that will ultimately facilitate investigation of cognitive load's influence on teachers' decisions to adopt technology, the following sections will discuss DoI and CLT before presenting the problem statement, research purpose, and research questions. A presentation of this study's theoretical framework which discusses DoI and CLT in greater detail, prospective limitations to this study, and definitions of terms will follow the research questions.

Diffusion of Innovations

Rogers (2003), who developed Diffusion of Innovations theory (DoI), argues that diffusion is the process by which an innovation is communicated throughout a system over time. Rogers (2003) described an individual's decision to adopt technology in terms of a multi-stage process called the innovation-decision. This process begins with the knowledge stage. While this section will discuss each stage of the innovation-decision process as part of the theoretical framework, the knowledge stage is of particular interest because of this study's focus on teachers' cognitive load while learning technology.

During the knowledge stage, an individual becomes aware of a new technology and acquires knowledge of how the technology functions, or how-to knowledge (Rogers, 2003). Having adequate how-to knowledge is important for individuals during the knowledge stage, especially when an innovation such as a new educational technology is inherently complex (Rogers, 2003). Based on Rogers' (2003) definitions of these terms, if school decision-makers introduce their teachers to new educational technology through professional development, teachers would be within the knowledge stage of the innovation-decision process. Whether teachers acquire sufficient how-to knowledge of the new technology during professional development may strongly influence whether they will adopt the technology. Thus, ensuring teachers receive adequate how-to knowledge about new technology should be an important consideration when decision-makers elect to adopt a new technology on behalf of their schools.

Cognitive Load Theory

Sweller's (2010) Cognitive Load Theory (CLT) offers insight into how learners, such as teachers acquiring knowledge about new educational technology, process new information. Cognitive load is load imposed on learners as their working memories manage the elements, or individual concepts, inherent to learning tasks (Sweller, 2010; Sweller, 2008; Sweller et al., 2011; Kalyuga & Liu, 2015). The more elements and interactions among elements the working memory must process for learning to occur, the higher the element interactivity, or complexity, of the learning task (Sweller, 2010; Sweller et al., 2011; Van Merriënboer & Ayres, 2005). According to CLT, learning tasks impose cognitive load on learners (Sweller, 2010; Sweller, 2008; Sweller, Sweller, Ayres, & Kalyuga, 2011; Kalyuga & Liu, 2015). Therefore, acquiring how-to knowledge about a new technology would incur cognitive load on teachers during professional development. Learning to use technology can be an inherently complex learning task (Rogers, 2003), which Sweller would describe as having high element interactivity (Sweller, 2010; Sweller et al., 2011; Van Merriënboer & Ayres, 2005). Research on technology adoption associates teachers' prior knowledge and self-efficacy in using a technology with their willingness to adopt the technology (Ertmer et al., 2012; Inan & Lowther, 2010; Li, Li, & Franklin, 2016; Teo, 2009; Velazquez, 2007). This evidence suggests teachers who do not acquire adequate how-to knowledge about a new technology during professional development will be less likely to adopt the technology. Therefore, ensuring teachers manage the cognitive load of learning a new technology during professional development may be an important consideration when districts implement new technology initiatives.

Problem Statement

P-12 teachers often choose not to adopt educational technology available to them. The perceived difficulty of technology and lack of access to effective technology professional development are factors inhibiting P-12 teachers from adopting technology. The importance of these factors suggests P-12 teachers who are successful in learning a technology are more likely to adopt the technology. For P-12 teachers to effectively learn a technology, they must manage the cognitive load inherent to learning the technology. CLT can offer insight into how P-12 teachers can manage the cognitive load of learning technology. However, technology adoption research has not used CLT to investigate how P-12 teachers manage the cognitive load of learning technology or the influence of cognitive load on P-12 teachers' decisions whether to adopt technology. Research investigating a potential relationship between P-12 teachers' cognitive load during technology professional development and their intent to adopt technology may provide insight into this issue but has yet to be conducted. Perhaps this research has not been conducted because an instrument measuring these latent constructs is not available? Establishing a tool through research-supported design processes will not only provide a means to measure P-12 teachers' cognitive load and their intent to adopt technology but may also be a means to explore the relationship between these latent constructs in future research. Access to an established tool of measurement can facilitate exploration of cognitive load's influence on technology adoption among P-12 teachers. Investigating factors related to cognitive load may lead to a better understanding of P-12 teachers' needs as they learn the technical functions and pedagogical applications of a new technology.

Research Purpose

The purpose of this study is to design an instrument measuring P-12 teachers' cognitive load experienced during technology professional development and teachers' intent to adopt technology.

Research Questions

This study seeks to answer the following questions and provide support for the accompanying hypotheses:

- Do the results of the index of item-objective congruence support the instrument's content validity?

    - Hypothesis 1: The results of the index of item-objective congruence support the instrument's content validity.
- Does the instrument demonstrate internal consistency within the context of P-12 teachers self-reporting intent to adopt technology and cognitive load after participating in a single-session technology professional development?
    - Hypothesis 2: The instrument demonstrates internal consistency.
- Does the instrument's factor structure account for most of the variability in the measured constructs?
    - Hypothesis 3: The instrument's factor structure accounts for most of the variability in the measured constructs.
- Do the instrument items demonstrate a theoretical factor structure?
    - Hypothesis 4: The instrument items demonstrate a theoretical factor structure.

Theoretical Framework

Diffusion of Innovations theory (DoI) and Cognitive Load Theory (CLT) form the foundation of this study's theoretical framework. The knowledge stage of the innovation-decision process within DoI is the framework for exploring teachers' intent to adopt technology. CLT is the framework for investigating cognitive load as a potentially inhibitory factor during the knowledge stage of the adoption-decision process among teachers who encounter new technology through professional development. This section will elaborate on these theories and provide justification for their use as the theoretical framework for this study.

Several technology adoption frameworks are available for investigating technology adoption among various populations such as Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), and DoI. Prior researchers have experienced success in applying models based on these frameworks to investigations of technology adoption (Venkatesh, Morris, Davis, &

Davis, 2003). However, the intention of each of these frameworks is to predict technology adoption of individual users. For example, the widely used TAM proposed by Davis (1986) seeks to predict individual technology adoption decisions based on factors related to users' perceptions and attitudes. TRA examines individual user intent as a function of a user's knowledge and beliefs pertinent to the anticipated outcomes of a behavior (Madden, Ellen, & Ajzen, 1992), while TPB expands on this framework to include factors related to availability of resources and opportunities for performing a behavior (Ajzen 1991; Madden et al., 1992). As this study will seek to design a survey instrument for future research investigating effects of cognitive load on members of a system, specifically teachers in school districts, and diffusion of technology throughout the system, DoI serves as the theoretical framework for technology adoption.

Diffusion of Innovations

Rogers (2003) developed DoI as a comprehensive theory explaining how an innovation diffuses throughout a population as well as why and when an individual user adopts the innovation. DoI takes into consideration attributes of innovations as well as adopters to explain innovation adoption and diffusion. Rogers (2003) defines adoption as “a decision to make full use of an innovation” (p. 21), and diffusion as “the process in which an innovation is communicated through certain channels over time among the members of a social system” (p. 5). An innovation is “an idea, practice, or object perceived as new by an individual or other unit of adoption” (Rogers, 2003, p. 36). Innovations are “communicated” throughout “social systems” through certain “channels” (Rogers, 2003, p. 11). In terms of this study, the innovation of interest is technology introduced to teachers through professional development. Professional development is the channel through which administrators communicate new technology throughout the social systems of interest in this study: schools and school districts.

The component of DoI to be investigated in this study is the knowledge stage of the innovation-decision process. Rogers (2003) proposes potential users progress through the innovation-decision process in the following stages: knowledge, persuasion, decision, implementation, and confirmation. During the knowledge stage, potential users first encounter the innovations and learn how the innovation functions as well as its potential benefits (Rogers, 2003). During the persuasion stage, potential users form a positive or negative attitude toward the innovation (Rogers, 2003). Potential users engage in behaviors leading to whether they adopt the innovation during the decision stage, and they put the innovation to use during the implementation stage (Rogers, 2003). Finally, users seek knowledge or feedback reinforcing their decision to adopt the innovation during the confirmation stage, and they may elect to reverse their decision to adopt based on this information (Rogers, 2003). In this study, teachers' experience during technology professional development is of primary concern. As professional development is a channel for communicating technology innovations throughout schools and school districts, teachers participate in the knowledge stage of the innovation-decision process during professional development training.

How users progress through the stages of the innovation-decision process depends on attributes of the innovation and the channels through which the innovation is communicated throughout a system. As discussed previously, DoI takes into consideration an innovation's attributes as factors influencing rates of adoption and diffusion. Attributes of innovations according to DoI are:

- relative advantage: perceived benefits of adopting the innovation;
- compatibility: the degree to which an innovation aligns with existing values, needs, and beliefs;
- complexity: the perceived difficulty of understanding or using the innovation;
- trialability: the degree to which users can explore and experiment with the innovation;
- observability: the visibility of the innovation among potential users (Rogers, 2003).

Rogers (2003) points out an innovation's complexity is an important concern for technology innovations, and he claims complexity can be a barrier to adoption. If teachers for example become frustrated in their efforts to learn a complex educational technology, they will be unlikely to adopt the technology. Thus, one must consider how teachers as learners and potential adopters of a technology can effectively process the complexity of the technology. To address the issue of innovation complexity as a barrier to adoption, this study turns to CLT.

Cognitive Load Theory

John Sweller (2008; 2010) developed CLT to explain the abilities and limitations of the human cognitive architecture (Sweller et al., 2011; Kalyuga & Liu, 2015). According to CLT, for one to successfully learn new information, the working memory must be able to process the cognitive load concomitant with learning the new information (Sweller, 2010; Sweller, 2008; Sweller et al., 2011; Kalyuga & Liu, 2015). Processing this load involves processing the necessary related elements, or individual concepts or units, comprising the information to be learned; and more complex information has higher element interactivity (Sweller, 2010; Sweller et al., 2011; Van Merriënboer & Ayres, 2005). In other words, the more complex the information to be learned, the more the related elements that must be processed to achieve learning (Sweller, 2010; Sweller et al., 2011; Van Merriënboer & Ayres, 2005). Thus, unfamiliar technologies may have high element interactivity for teachers who attempt to master them. Learners' prior knowledge can influence their experiences with element interactivity (Sweller, 2010; Sweller et al., 2011; Van Merriënboer & Ayres, 2005). Learners with less prior knowledge must process elements individually before they can process how the elements interact with one another to comprehend more complex concepts, while learners with more prior knowledge can manage larger chunks of information at a time (Sweller, 2010; Sweller et al., 2011; Van Merriënboer & Ayres, 2005). CLT identifies three forms of cognitive load: intrinsic load, extraneous load, and germane load (Sweller, 2010; Sweller et al., 2011; Kalyuga & Liu, 2015). Intrinsic load refers to the cognitive load inherent to the inherent complexity of the target information (Sweller, 2010; Sweller et al., 2011; Kalyuga & Liu, 2015). Extraneous load is cognitive load imposed by variables other than learning the target information and can originate from various sources such as ineffective instructional methods, improperly formatted or presented instructional materials, or environmental or contextual variables unconducive to learning (Sweller, 2010; Sweller, 2008). Unlike intrinsic and extraneous load, germane load is inherent to the learner rather than external variables and refers to the mental resources one devotes to learning information (Sweller, 2010; Sweller et al., 2011; Kalyuga & Liu, 2015). When considering teachers participating in technology professional development, teachers should learn more effectively when each teacher receives the support they need for managing the intrinsic load of learning new technology and when extraneous load is minimal.

Exploring teachers' intent to adopt technology during the knowledge stage of the innovation-decision process as defined by DoI through the lens of CLT may shed light on factors affecting teachers' decisions whether to adopt technology. These insights may then lead to developing methods of improving professional development practices and better facilitating the dissemination of technology innovations among teachers. Thus, this study pursues the design of an instrument which may facilitate future research on potential relationships between teachers' cognitive load experienced during technology professional development and their intent to adopt the technology.

Limitations

The following attributes of this study may limit the generalizability of the findings. The instrument is a subjective, self-report measure of cognitive load and intent to adopt technology which may be a source of potential error in the data. However, prior research using subjective measures of cognitive load have shown evidence of the reliability of such measures (Sweller et al., 2011). Participants in this study attended professional development offering training on the same educational technology and taught by the same instructor which may limit generalization to other technologies and professional developments. The instrument designed during this study was administered to participants immediately following professional development training. Intent to adopt technology at that time may not guarantee continued intention to adopt technology. Regardless of these potential limitations, this study serves to provide an instrument designed through research-supported processes and measuring P-12 teachers' cognitive load experienced during technology professional development and intent to adopt technology.

Definition of Terms

This section clarifies how the researcher will use certain terms throughout this study. Within the theoretical framework section of this chapter as well as chapter two, one can find definitions for terms originating from this study’s theoretical framework.

Adopters

Adopters refer to individuals who have decided to adopt a technology per Rogers’ (2003) definition of the word adoption.

Instrument

Instrument refers to the subjective, self-report survey under development during this study.

Latent Constructs

Latent constructs are variables of interest to this study which cannot be directly observed. The latent constructs of interest to this study will be users’ ability to manage intrinsic load, presence of extraneous load, and intent to adopt technology.

P-12 Teachers

P-12 teachers are individuals currently employed to provide instruction in schools serving students within the grade level range of pre-kindergarten through twelfth grade.

Scale

Scale refers to a six-point Likert-type scale used for this study’s instrument. The scale ranges from 1 = “strongly disagree” to 6 = “strongly agree.”

Users

Users refer to individuals who have not decided whether to adopt a technology.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Prior research on technology adoption reveals factors which promote or inhibit users' decisions whether to adopt technology. As Rogers (2003) pointed out in his criticisms of diffusion research in general, much research on technology adoption focuses on factors inherent to users such as attitudes, perceptions, and self-efficacy. According to Rogers (2003), exclusive focus on attributes of potential adopters appears to imply a bias in favor of the innovation itself. Research focused solely on user attributes seems to cast blame on users and does not address the possibility that attributes of an innovation may promote or inhibit adoption (Rogers, 2003). Technology adoption research in the education field has investigated the influence of factors external to users such as access to professional development and support. However, as this literature review will illustrate, research in the education field appears to have not explored how the cognitive load of learning a new technology may influence a user's decision whether to adopt the technology. Cognitive Load Theory (CLT) may provide a lens through which future research might examine this issue. Education researchers have not considered cognitive load as a factor affecting decisions whether to adopt technology; and in terms of this study, little research on cognitive load factors during technology professional development for teachers appears to be available.

This literature review will discuss existing research on technology adoption, technology professional development, and cognitive load in educational settings as well as present a case for initiating research on teachers' intent to adopt technology through the lens of CLT. As this study seeks to design a survey instrument which may facilitate future exploration of a potential relationship between latent constructs related to these concepts, this literature review will also discuss researchers' prior endeavors to measure technology adoption and cognitive load.

Diffusion of Innovations in Education

DoI is a comprehensive theory for investigating how new ideas diffuse throughout a population, and the theory has proved useful in many fields such as agriculture, medicine, business, and education (Rogers, 2003; Rogers, 1975; Mahler & Rogers, 1999). DoI encompasses how, when, why, and by whom an innovation diffuses throughout a population (Rogers, 2003). A large body of research is available on Diffusion of Innovations in educational settings, particularly with a focus on adoption of innovations. Technology adoption is an area of substantial interest within this body of research.

Other frameworks are available for examining technology adoption besides DoI. Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), the Technology Acceptance Model (TAM), and the Unified Theory of Acceptance and Use of Technology (UTAUT) are theoretical models often used for investigating technology adoption. TRA proposes one's intentions are functions of one's knowledge and beliefs about whether a behavior will have a certain outcome (Madden, Ellen, & Ajzen, 1992). TPB broadens the scope of TRA to include one's resources and opportunities to perform a behavior (Ajzen, 1991; Madden et al, 1992). Madden et al.'s (1992) study which compared the respective abilities of these two models to explain technology acceptance among undergraduate business students found TPB explained more variance in the data, which seems to indicate TPB is the preferable model for investigating technology adoption. Davis (1986) proposed TAM as a model for predicting potential users' intent to use technology based on user perceptions and attitudes. TAM is a simple model for explaining technology adoption still commonly used in technology adoption research. Studies comparing TAM and TPB have found that though the models are comparable in their respective abilities to predict technology adoption, TPB provides more information on predictors of technology adoption (Mathieson, 1991; Taylor & Todd, 1995). Venkatesh, Morris, Davis, and Davis (2003) proposed the UTAUT which drew constructs explaining the highest levels of variability from eight recognized acceptance models, including the models referenced above, to provide a more comprehensive model for predicting technology acceptance. Venkatesh et al. (2003) validated the model through its application to prior datasets which had been analyzed using other acceptance models, and the researchers found that UTAUT outperformed all other models in terms of variance explained. Researchers have since had success in applying UTAUT to investigation of technology adoption among different populations in various contexts including teachers in educational settings (Teo & Noyes, 2014; Wong, Teo, & Russo, 2013). Each technology adoption framework referenced here has added insight into users' decisions whether to adopt technology.

Across applications of DoI and these other frameworks, research findings related to factors promoting or inhibiting technology adoption are fairly consistent. However, the intent of models such as TAM, UTAUT, TRA, and TPB is to predict technology adoption of individual users. DoI, on the other hand, extends beyond technology adoption decisions to encompass Diffusion of Innovations throughout a system, such as a school or school district. This section of the literature review will present findings of technology adoption research in education settings across these frameworks but with an emphasis on DoI studies.

Innovation-Decision Process

Rogers (2003) would describe technology adoption in terms of the innovation-decision process in which users proceed through "a series of choices and actions over time through which an individual or a system evaluates a new idea and decides whether or not to incorporate the innovation into ongoing practice" (Rogers, 2003, p. 168). For example, in a report to Exxon on the diffusion of four educational innovations among a population of university professors, Rogers (1975) discussed his findings in terms of the factors influencing professors' decisions whether to adopt each of the innovations, one of which was a computer-based instructional simulation. Factors such as compatibility of the simulation with existing technology, availability of time resources for learning to integrate the simulation into instruction, and access to technical support influenced professors' evaluation of the simulation and thus their decisions whether to adopt this innovation (Rogers, 1975). The stages of the innovation-decision process are knowledge, persuasion, decision, implementation, and confirmation (Rogers, 2003). During the knowledge stage, potential users first encounter an innovation and learn how the innovation functions as well as its potential benefits (Rogers, 2003). During the persuasion stage, potential users form a positive or negative attitude toward the innovation (Rogers, 2003). Potential users engage in behaviors leading to whether they adopt the innovation during the decision stage, and they put the innovation to use during the implementation stage (Rogers, 2003). Finally, users seek knowledge or feedback reinforcing their decision to adopt the innovation during the confirmation stage, and they may elect to reverse their decision to adopt based on this information (Rogers, 2003).

Researchers investigating technology adoption focus on either certain stages of this process or the process as a whole. Martin and Quan-Haase (2013) focused on the knowledge and persuasion stages of history professors' decisions whether to adopt eBooks for research and teaching, and their findings indicated users do not necessarily progress from stage to stage in a linear fashion. The participants of their study vacillated between the knowledge and persuasion stages due to their conflicting acknowledgement of the benefits of eBooks while expressing concerns over eBooks' relative advantage compared to print resources (Martin & Quan-Haase, 2013). Li and Lindner (2007) examined the progress of agriculture professors' through all five stages of the innovation-decision process in their study of web-based distance education adoption, and the researchers found only about thirty percent of professors progressed past the persuasion stage. Their findings indicated that increased training and exposure to web-based distance education might increase the rate of adoption (Li & Lindner, 2007). In their study on college professors' adoption of Web 2.0 tools for instructional use, Siha, Bell, and Roebuck (2016) investigated the innovation-decision process as a comprehensive whole with a focus on adopter categories rather than stages of the adoption process. Siha et al. (2016) used nonparametric analyses to assign professors to adopter categories and interpreted their progress through the innovation-decision process through those categories, finding that professors who teach online courses are more likely to adopt Web 2.0 tools than those teaching face-to-face courses. With faculty rank also being a significant variable but sharing a negative relationship with adoption, Siha et al., (2016) generalized that higher ranked faculty do not keep up with their technical skills. As opposed to higher education instructors, Hosman and Cvetanoska (2013) focused their study on public school teachers and their low rate of information communication technology (ICT) adoption in Macedonia, using the entire innovation-decision process as a framework. They found that even after three years following the initiation of a computer-to-schools program, most teachers felt they did not receive enough relevant professional development training and did not progress past the persuasion stage (Hosman & Cvetanoska, 2013). Less research is available on P-12 teachers' progress through the innovation-decision process than on higher education faculty, but the research available across populations suggests access to technology training would increase the likelihood of technology adoption. More research is needed on P-12 teachers' progression through the innovation-decision process.

Attributes of Adopters

In terms of potential adopters, Rogers (2003) assigned adopters to categories based on when they respectively chose to adopt an innovation as compared to other members of the population. The first adopters are innovators and then early adopters, comprising according to Rogers (2003) a small percentage of a population. Following the earliest adopters come the early majority and then the late majority, comprising the majority of the population (Rogers, 2003). Finally, the laggards are the last to adopt innovations, a segment of the population tending strongly towards traditional practices and most resistant to new ideas (Rogers, 2003). Researchers have found Rogers' (2003) adopter categories a useful framework for investigating technology adoption, such as in the previously discussed study by Siha et al. (2016) in which the researchers interpreted teachers' progress through the innovation-decision process by assigning teachers to Rogers' (2003) adopter categories. This study is an example of DoI research taking an adopter-focus, a point of view Roger (2003) criticized for bias in favor of the innovation. This bias is also evident in a literature review of technology adoption literature in higher education by Buckenmeyer (2011). While reporting findings across literature that teachers are more likely to integrate technology with access to technical support, time resources, and continuous professional development, Buckenmeyer (2011) emphasized the issue of teacher attitudes with the simple conclusion that change in technology integration should begin with the teacher. Interestingly, Richardson's (2011a; 2011b) research on Cambodian teacher educators' adoption of ICT produced separate articles respectively focusing on adopter categories and then challenges external to users such as the technology's complexity and compatibility, access to training, and the ability of the infrastructure to facilitate technology use. Through these separate articles, Richardson (2011a; 2011b) holistically addressed the issue of technology adoption among teachers by acknowledging influential factors which may not necessarily be under teachers' direct control. Research focused solely on adopter attributes and assigning adopters to discrete categories as a means of explaining adoption may overlook other important and potentially influential factors such as those found in Richardson's (2011a) study.

Many studies conducted among P-12 teachers have found teachers' attitudes and beliefs regarding technology to be significantly predictive of their adoption decisions (Blackwell, Lauricella, & Wartella, 2016; Chen, 2008; Colemen, Gibson, Cotten, Howell-Moroney, & Stringer, 2016; Curwood, 2014; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Govender & Govender, 2009; Hrtoňová, Kohout, Rohlíková, & Zounek, 2015; Hsu, Wu, & Hwang, 2007; Inan & Lowther, 2010; Kim, Kim, Lee, Spector, & DeMeester, 2013; Lee & Lee, 2014; Li, Li, & Franklin, 2016; Pittman & Gaines, 2015; Ruggiero & Mong, 2015; Sugar, Crawley, & Fine; 2004; Velazquez, 2007). Negative attitudes or beliefs towards technology across members of a population can be significant inhibitors to the success of a technology initiative (Admiraal & Lockhorst, 2009), but positive attitudes towards technology are strong predictors of successful technology integration (Ruggiero & Mong, 2015). Researchers have identified certain factors as predictors of attitudes and beliefs toward technology. Inan and Lowther (2010) found that access to professional development and school support for technology strongly influenced teachers' beliefs towards integrating laptops in the classroom. Govender and Govender (2009) found a positive relationship between teachers' attitudes towards computers in the classroom and their perceptions of ICT's relative advantage and compatibility with existing classroom practices. A study by Chia-Pin, Chin-Chung, and Meilun (2014) produced evidence indicating a web-based professional development program's perceived ease of use and elementary teachers' self-efficacy in using the program strongly predicted the teachers' attitudes towards the program. Findings across these studies not only support the necessity of considering teachers' perceptions during the process of implementing a technology initiative but also the importance of providing adequate technology training and communicating the benefits of using a technology.

Teachers are more likely to be technology adopters when they have high self-efficacy in using technology. Research indicates teachers' prior knowledge of technology as well as their self-efficacy in technology use are strong predictors of technology adoption (Botha & Herselman, 2015; Buckenmeyer, 2011; Ertmer et al., 2012; Inan & Lowther, 2010; Al-Ruz & Khasawneh, 2011; Judge, 2013; Li et al., 2016; Velazquez, 2007). Increases in teacher self-efficacy for technology use are strongly associated with effective professional development practices such as long-term training and opportunities for collaboration (Brinkerhoff, 2006; Chen, 2008; Chitiyo & Harmon, 2009; Overbaugh, Lu, & Diacopoulos, 2015; Reeves & Li, 2012; Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010; Vavasseur & MacGregor, 2008). Therefore, attention to professional development as a means of improving teachers' computer proficiency and self-efficacy may be a means of improving rates of technology adoption among teachers.

Attributes of Innovations

Rogers (2003) identified certain attributes of an innovation as influential of users' decisions to adopt an innovation, these attributes being relative advantage, complexity, compatibility, observability, and trialability. Relative advantage refers to the benefits of using an innovation; complexity relates to the difficulty of using or understanding an innovation; compatibility is the degree to which an innovation aligns with existing beliefs and resources; observability refers to the extent to which users can observe the innovation in use by others; and trialability refers to the extent to which users can try out an innovation prior to making an adoption decision (Rogers, 2003). Each of these innovation attributes has manifested in technology adoption research as factors potentially influential of adoption decisions. In this section, the review of literature focuses on research investigating the attributes of trialability, observability, and complexity due to their pertinence to this study.

Complexity of innovations shares a negative relationship with rates of adoption among users, and the complexity of technology is no exception (Rogers, 2003). Research on technology adoption supports the existence of this relationship (Aldunate & Nussbaum, 2013; Richardson, 2011a; Sánchez-Prieto, Olmos-Migueláñez, & García-Peñalvo, 2017; Smith & Sivo, 2012; Teo, 2009; Unger & Tracey, 2013). For instance, in their study comparing adoption rates of digital cameras, a web-based educational resource, and interactive whiteboards, Aldunate and Nussbaum (2013) found that the more complex the technology, the more likely a teacher will abandon the technology. They also found that teachers were less likely to adopt a technology without the presence of innovators and early adopters (Aldunate & Nussbaum, 2013), which resonates with the attribute of observability. Results from Aldunate and Nussbaum's (2013) study suggest observing innovators and early adopters using the technologies may have positively encouraged adoption among other teachers. Sánchez-Prieto et al. (2017) found in their study on preservice teachers' adoption of mobile technologies that mobile technology's perceived ease of use was significantly related to teachers' self-efficacy. Smith and Sivo (2012) found that teachers' intent to use an eLearning program for professional development was significantly determined by the program's perceived ease of use. Likewise, Teo (2009) found perceived ease of use had a direct effect on technology acceptance among preservice teachers who attended a teacher training institute in Singapore. Findings from these studies support complexity of technology as a potential deterrent to adoption. Unger and Tracey (2013) found addressing the issue of technology's perceived ease of use during professional development was a beneficial factor for participants. Their case study investigated secondary teachers' experiences during a professional development technology intervention intended to promote technology integration (Unger & Tracey, 2013). Supporting teachers through professional development lends trialability to a technology and helps teachers manage the complexity of technology. Literature presented in previous sections of this review established the importance of self-efficacy and access to professional development training in teachers' technology adoption decisions, which illustrates the importance of technology innovations having trialability. Addressing issues of complexity through ensuring observability and trialability can increase the likelihood teachers will adopt technology. Therefore, the need for teachers to have access to adequate training and support for learning to use complex technology is evident.

Professional Development as a Channel of Communication

Channels are the means by which an innovation is communicated throughout a system of users (Rogers, 2003), such as professional development used as a channel for communicating new technology to teachers. Training through effective professional development practices can be a means of promoting technology adoption among teachers and helping to ensure successful diffusion of technology throughout a school or district. Research provides ample evidence in support of the important role professional development plays in teachers' technology adoption decisions.

Many research studies report findings indicating teachers require continued training and support in connecting technology to their curriculum content and pedagogical practices (Chen, 2008; Hartsell et al., 2010; Karaca et al., 2013; Klieger et al., 2010; Liu & Kleinsasser, 2015; Liu & Szabo, 2009; Rambe, 2016; Ruggiero & Mong, 2015; Saudelli & Ciampa, 2016; Shamir-Inbal et al., 2009; Van Rooy, 2012). Simply learning to use technology will not equip teachers for successful and pedagogically sound technology integration in the classroom. Chen (2008) found improper theoretical understanding was an influential barrier to university foreign language teachers' use of web-based tools and resources for instruction and recommended presenting teachers with relevant and feasible examples of incorporating web-based resources in language instruction. Karaca et al. (2013) conducted a case study on a population of teachers in Turkey who had advantageous access to technology resources compared to teachers in more rural schools. Though the teachers used technology often for lesson preparation, they rarely used technology for instruction; and the teachers complained that they did not have enough professional development to know how to effectively use technology for instructional purposes (Karaca et al., 2013). Teachers need opportunities to learn how to apply technology within the context of their curriculum.

Effective technology professional development provides these opportunities for authentic application relevant to each teacher's classroom (Ansyari, 2015; Chen, 2008; Curwood, 2011; Hart & Laher, 2015; Jones & Dexter, 2014; McClurg & Buss, 2007; Murthy, Iyer, & Warriem, 2015; O'Hara & Pritchard, 2013). Hartsell et al.'s (2010) study showed how providing technology professional development relevant to teachers' curriculum area can make a positive impact. During a four-month technology professional development program, Hartsell et al. (2010)

found that as math teachers learned more about different technology tools relevant to math instruction, they became more motivated and proactive in using technology for teaching math. Technology training is more effective when it is relevant to teachers' curriculum areas and classroom instruction (Ruggiero & Mong, 2015). Providing relevant professional development training can support teachers in effectively integrating technology in the classroom.

Long-term professional development training consistently receives positive feedback from participants and contributes to successful technology adoption among teachers (Campbell, Longhurst, Wang, Hsu, & Coster, 2015; Duran et al., 2009; McClurg & Buss, 2007; Wright & Wilson, 2007). Brinkerhoff (2006) studied the effects a two-year Professional Development Academy on teachers' beliefs, skills, and self-efficacy toward technology. Though he did not find significant changes in teachers' beliefs over time, he found that teachers significantly increased in technology self-efficacy between the end of their first session of training and the conclusion of the academy. Campbell et al. (2015) investigated science teachers' participation in two seven-to-nine-day professional development modules providing training on integrating ICT into the science curriculum to improve student learning outcomes. Not only did their findings show a positive teacher response to the professional development and an increased use of ICT, but student performance data indicated significant academic achievement gains in science (Campbell et al., 2015). Duran et al. (2009) also examined science teachers' adoption of ICT for science instruction, but the teachers in his study participated in a three-year program in which they learned to use a variety of technology tools for science instruction. The teachers' technology proficiency, self-efficacy, and competence increased significantly over the course of the program, and teachers provided especially positive feedback on the incorporation of collaborative partnerships among colleagues during the professional development (Duran et al., 2009). Liu and Kleinsasser (2013) produced similar findings that over time foreign language teachers who participated in a year-long professional development increased their self-efficacy in using technology for language instruction. This evidence indicates the need for sustained professional development to support teachers through the process of acquiring adequate self-efficacy and proficiency in using technology in the classroom.

Other studies also report positive results from incorporating opportunities to collaborate with peers and receive support from mentors during professional development (Ansyari, 2015; Borthwick & Gallagher-Brett, 2014; Ertmer et al., 2012; Shannon & Cullen, 2016; Sugar, Patricia, & van Tryon, 2014), and researchers recommend incorporating collaboration for improving the effectiveness of professional development (Aubusson, Schuck, & Burden, 2009; DeSantis, 2012; Dutta, Roy, & Seetharaman, 2013; Kopcha, 2010; Schneckenberg, 2010; Tondeur et al., 2016; Williams et al., 2008). Including interactive training methods and opportunities among technology users which foster idea-sharing and mutual support is a practice associated with successful technology integration (Baran, 2016; DeSantis, 2012; Divaharan & Koh, 2010; Hutchison, 2012; Kopcha, 2012; Lei & Morrow, 2010; Mouza, 2009; Peeraer & Van Petegem, 2012; Ruggiero & Mong, 2015; Russell & Schneiderheinze, 2005; Staples & Edmister, 2014). In a review of literature on the integration of interactive whiteboards, DeSantis (2012) noted that across the reviewed literature, effective professional development incorporates long term partnerships among teachers as well as scaffolding of new information to support teachers as learners. In a study in the implementation of a new course management system at a university, Dutta et al. (2013) noted that intervention strategies may be necessary to facilitate continued use of the system and recommended more proficient teachers serve as peer models to support their colleagues. Opportunities for interaction and collaboration among peers promotes the observability of a technology in use, which Rogers (2003) identifies as an innovation attribute that can positively influence adoption rates.

As DeSantis (2012) found in his literature review, effective professional development provides adequate support to meet the needs of teachers as learners. Researchers recommend differentiation in professional development offerings and methods to accommodate teachers' respective areas of expertise and interest as well as their respective levels of prior knowledge and proficiency (Doherty, 2011; Dutta et al., 2013; Hixon & Buckenmeyer, 2009; Lane & Lyle, 2011; Lau & Yuen, 2013). One sees in research and discussion of professional development practices a consensus that a one-size-fits-all approach is not the best option (Hixon & Buckenmeyer, 2009; Lau & Yuen, 2013). Lau and Yuen (2013) observed that P-12 math teachers with more pedagogical experience responded differently to a technology training workshop than newer teachers by exhibiting more resistance to perceptual change toward educational technology, and the researchers felt that the professional development offerings should be tailored to teachers' level of experience. Dutta et al. (2013) recommended different levels of instructional interventions be available for different levels of learners in their study of a course management system implementation at a university. Doherty (2011) recommended providing different professional development alternatives to teachers to help them find learning opportunities that best meet their needs. As the premise of this study seeks to illustrate, teachers, like their students, come with different levels of prior knowledge and different backgrounds, each requiring different forms of support during the process of learning new technology.

Technology adoption research is consistent in findings related to factors promoting or inhibiting technology adoption among teachers. Teachers need to believe in their own abilities and have the willingness to move forward with using new technology in their classrooms, and they require access to effective professional development to achieve the levels of proficiency and self-efficacy they need for successful technology integration. While these factors are clear, what research has not seemed to accomplish is exploring beneath the surface of factors influencing adoption decisions to discover at a cognitive level why these factors are influential. Investigating factors at the level of human cognition may be a means of achieving a deeper understanding of these issues and opening unexplored domains of future research in technology adoption.

Measuring and Analyzing Technology Adoption

Prior research testing the fitness of technology adoption models conducted analyses using one or more of the following methods: principal components analysis (PCA), exploratory factor analysis (EFA), a form of confirmatory factor analysis (CFA), and/or a form of structural equation modeling (SEM). Within each of these studies included in this literature review, the researchers used a self-report questionnaire comprised of Likert-type items based on constructs defined by the theoretical model used within the study. For example, Sánchez-Prieto et al. (2017) used a survey in which they incorporated the constructs of self-efficacy and mobile anxiety with the existing TAM constructs of user perceptions of technology and user attitudes to measure pre-service teachers' intent to use mobile technologies as part of their future teaching practice. Smith and Sivo (2012) likewise used TAM but incorporated the constructs of perceived usefulness and ease of use to predict teachers' intent to continue using eLearning professional development. Agudo-Peregrina, Hernandez-Garcia, and Pascual-Miguel (2014) also researched intent to adopt an electronic learning system and incorporated the constructs of personal innovativeness and perceived interaction into TAM. In each of these studies, the researchers adapted an existing technology adoption framework to fit the context of their studies and then applied statistical data reduction procedures to validate their models.

Most studies curated for this analysis in which the researchers statistically investigated how well a technology adoption model fit the data used confirmatory methods, typically SEM or CFA. One can justify using confirmatory methods with either prior exhaustive exploratory analysis using other data sets or sufficient a priori theoretical grounding (Pituch & Stevens, 2016). For example, the studies conducted by Sánchez-Prieto et al. (2017), Smith et al. (2012), and Agudo-Peregrinan (2014) claim theoretical grounding through their use of TAM as a theoretical framework. Few studies curated for this analysis applied exploratory methods to investigate new technology adoption models. Chia-Pin et al. (2014) conducted EFA to develop a survey measuring elementary teachers' self-efficacy using online professional development. Lau and Yuen (2013) conducted EFA to explore changes in perception towards educational technology among math teachers participating in technology training. EFA is appropriate for studies without sufficient a priori theoretical grounding or for studies seeking to validate unestablished theoretical models, for the method allows researchers to explore the best fitting models for the data (Beavers et al., 2013; Costello & Osborne, 2005).

PCA is a simple method of data reduction for reducing data into uncorrelated components, or factors (Pituch & Stevens, 2016). Venkatesh and Davis (2000) as well as Gogus et al. (2012) used PCA to explore factors influencing technology adoption. Theoretically, PCA is less preferable than EFA for data reduction in studies exploring constructs likely to exhibit correlative relationships because PCA statistical procedures assume no underlying factor structure (Beavers et al., 2013). Based on recommendations from researchers specializing in psychometrics, one should conduct exploratory factor analysis when analyzing data collected as part of investigating a newly constructed model or new combination of constructs likely to exhibit some correlation (Beavers et al., 2013; Costello & Osborne, 2005).

Confirmatory analyses may follow PCA or EFA using new datasets only once exploratory procedures have established a best fitting factor model. Although many researchers have adapted prior technology adoption models by adding pertinent constructs to a model depending on their respective research topics, few of these studies conducted methods of EFA before conducting CFA. First conducting exploratory methods and then testing the best fitting model on a new dataset using confirmatory methods can provide more rigorous support for a hypothesized model than conducting CFA alone.

Rogers' Critique of Diffusion Research and the Issue of Causality

In Rogers' (2003) writings on diffusion research as of the publishing of the fifth edition of *Diffusion of Innovations*, he pointed out the prevalence of diffusion studies relying heavily on correlation analysis and the dearth of experimental studies exploring causal relationships among variables. Rogers (2003) claimed that most correlational studies investigating variables related to diffusion appeared to infer causality among variables without application of an appropriate research design capable of yielding evidence of causal relationships between variables. Rogers (2003) recommended the increased use of "field experiments" in diffusion research (p.128).

According to Rogers' (2003) discussion of field experiments, researchers would collect data within realistic conditions using a repeated measures design by administering survey instruments before and after application of an intervention. Access to an instrument validated for measuring latent constructs that may share causal relationships may facilitate future experimental research on diffusion of innovations.

Cognitive Load Theory

Sweller's Cognitive Load Theory (CLT) provides a framework for understanding how the working memory processes different forms of mental load (Sweller, 2010; Sweller, 2008; Sweller, Ayres, & Kalyuga, 2011; Kalyuga & Liu, 2015). According to CLT, the working memory must process the elements inherent to a learning task in order for learning to occur (Sweller, 2010; Sweller, 2008; Sweller et al., 2011; Kalyuga & Liu, 2015). More complex learning tasks have a larger number of interconnected elements to process (Sweller, 2010; Van Merriënboer & Ayres, 2005). This concept of interconnected elements comprising learning tasks is element interactivity: more complex concepts to be learned have higher levels of element interactivity (Sweller, 2010; Van Merriënboer & Ayres, 2005). Imposing more elements on a learner's working memory than it can process at a given time incurs excessive cognitive load, and learning may not occur (Sweller et al., 2011). CLT describes three forms of cognitive load: intrinsic load, extraneous load, and germane load (Sweller, 2010; Sweller, 2008; Sweller et al., 2011; Kalyuga & Liu, 2015). Table 1 presents definitions of these terms.

Table 1

Forms of Cognitive Load

Terms	Definitions
Intrinsic Load	Mental load imposed by the learning task.
Extraneous Load	Mental load associated with conditions of instructional delivery and unrelated to the learning task.
Germane Load	Mental resources devoted to the learning task.

(Sweller et al., 2011)

Intrinsic load is cognitive load incurred when a learner processes target learning content, and the learner must manage this load for learning to occur (Sweller, 2010; Sweller, 2008; Sweller et al., 2011; Kalyuga & Liu, 2015). Therefore, intrinsic load is inherent to the learning task itself and is directly related to the difficulty or complexity of the learning task (Sweller, 2010; Sweller, 2008; Sweller et al., 2011; Kalyuga & Liu, 2015). Processing this load involves processing the necessary related elements, or individual concepts or units, comprising the information to be learned, and more complex information has higher element interactivity (Sweller, 2010; Sweller et al., 2011; Van Merriënboer & Ayres, 2005). The more complex the information to be learned, the more the related elements that must be processed to achieve learning; thus, learning tasks with higher element interactivity can impose higher levels of intrinsic load on learners, especially novice learners who have less prior knowledge (Sweller, 2010; Sweller et al., 2011; Van Merriënboer & Ayres, 2005). Extraneous load is mental load originating from sources unrelated to the learning task itself and inhibits learning (Sweller, 2010; Sweller, 2008; Sweller et al., 2011; Kalyuga & Liu, 2015). Instructional methods inappropriate for the prior knowledge of a population of learners is an example of a source of extraneous load. For instance, Kirschner, Sweller, and Clarke (2006) described problem-based learning as an instructional method inappropriate for novice learners, because processes required for problem-solving may be a source of extraneous load for learners without sufficient prior knowledge. Intrinsic and extraneous load are additive in terms of the working memory, so excessive extraneous load imposed on a learner during instruction can prevent the learner from processing intrinsic load (Sweller, 2010; Sweller et al., 2011; Van Merriënboer & Ayres, 2005). Germane load refers to the mental resources a learner devotes to completing a learning task, and this form of cognitive load is also additive in terms of the working memory (Sweller, 2010; Sweller, 2008; Sweller et al., 2011; Kalyuga & Liu, 2015). A review of literature on these concepts comprising CLT reveals implications for instructional design as well as the use of educational technology, as the following sections will discuss.

Cognitive Load Research on Teachers as Learners

The researcher found few studies during the review of literature on cognitive load experienced by teachers during technology professional development or technology use. Feldon (2007) produced one of the most relevant articles to the topic of teachers' cognitive load. In his article, Feldon (2007) discussed sources of cognitive load for novice classroom teachers. He made the point that new teachers have not yet mastered instructional and classroom management practices to reach the point of automaticity (or completing tasks with minimal burden on the working memory); thus, their working memories are overloaded with cognitive load from sources such as content delivery, management tasks, and student behavior (Feldon, 2007). In terms of this study, one might extend his argument to teachers' use of technology in the classroom: without sufficient prior knowledge of technology, a teacher will not have reached automaticity in its use. Thus, technology integration may be a source of excessive cognitive load for such a teacher. Kear et al. (2012) provided an example of this in their study which focused on a distance learning module in which tutors worked with students using web conferencing technology. They investigated tutors' experiences with cognitive load while using online tutorials with their students and found that having to navigate between multiple online tasks produced excessive cognitive load that was difficult for the tutors to manage (Kear et al., 2012). The researchers used these findings to improve the experiences of the tutors and their students in future iterations of their project (Kear et al., 2012). This study provided an example of how integrating technology in instruction can be a source of cognitive load for the individual serving the educator's role

CLT research on pre-service teachers has provided some evidence indicating efforts to manage cognitive load while preservice teachers use educational technology improves their learning outcomes (Kennedy, Driver, Pullen, Ely, & Cole, 2013; Tasir & Pin, 2012; Ong & Tasir, 2015; Moreno, 2007). Tasir and Pin (2012) conducted a study on preservice teachers' information retention using a self-instructed print learning module to support their learning computer spreadsheet skills. Their results showed the supplemental module improved performance and lowered cognitive load (Tasir & Pin, 2012). Ong and Tasir (2015) repeated this study among another sample of preservice teachers. Though they did not produce clear evidence indicating the success of this intervention, they reported high learning scores across participating preservice teachers and inferred their intervention may have contributed to the participants' information retention (Ong and Tasir, 2015). Moreno (2007) conducted a study in which preservice teachers learned teaching skills through observing instructional videos with animation. Participants who observed instructional videos segmented into smaller chunks reported less cognitive load and had higher learning outcomes than other groups (Moreno, 2007), which provides evidence linking methods of using educational technology that reduce cognitive load to improved learning outcomes. Additional evidence comes from Kennedy et al.'s (2013) study in which the researchers tested Content Acquisition Podcasts (CAPs) designed to minimize extraneous load and teach phonemic awareness skills to educators. Participants in this study were preservice teachers, and the results indicated that participants who used CAPs had significantly higher learning outcomes than participants who used a text resource for learning phonemic awareness. These studies suggest a positive relationship between efforts to manage cognitive load during experiences with educational technology and users' learning outcomes.

As far as cognitive load affecting teachers' technology adoption decisions, research from the education field has not explored this possibility. However, a research study from the information systems design field suggests a connection may exist between individuals' levels of cognitive load when using a technology and their intent to adopt the technology. Dang (2011) presented police trainees in his study two web-based knowledge management systems, and he found the trainees exhibited significantly higher intent to adopt the system designed to minimize users' cognitive load. This study provides evidence that cognitive load experienced by users when learning and exploring a new technology may influence their decisions whether to adopt the technology. Research on teachers’ intent to adopt technology and how cognitive load experienced when learning technology might be an influential factor seems to be an area of need and may add valuable knowledge to existing research on CLT in the education field.

Instructional Design Implications

CLT is a useful framework for investigating effective methods of instructional design (Sweller, 2010; Sweller, Ayres, & Kalyuga, 2011; Kalyuga & Liu, 2015). Exploring how different forms of cognitive load affect the learning process may produce valuable knowledge allowing educators to design instruction more suited to the affordances and limitations of the human cognitive architecture (Sweller, 2010; Sweller et al., 2011; Kalyuga & Liu, 2015). CLT research curated for this literature review has for the most part been experimental in design to manipulate factors within a learning context and test effects of the manipulations on learning outcomes and learners’ levels of cognitive load. This research has produced evidence in support of certain instructional practices found to improve learning outcomes.

Intrinsic load, extraneous load, and germane load are additive in nature, which means they respectively and theoretically occupy the same amount of space in the working memory (Sweller, 2010; Sweller et al., 2011; Van Merriënboer & Ayres, 2005). Therefore, instructional designers must ensure the germane load of each learner is devoted to processing the intrinsic load of the learning objectives with minimal imposition from extraneous load (Sweller, 2010; Sweller et al., 2011; Feldon, 2007; Gerjets & Scheiter, 2003).

CLT researchers recognize a positive relationship between the complexity of target content and perceived mental load (Çevik & Andre, 2013; Haji, et al., 2015; Wirzberger et al., 2016), therefore using instructional methods which minimize extraneous load is especially important when learners encounter more complex content. Applying methods of differentiation to ensure learners receive the support they need in terms of their prior knowledge is a method of reducing extraneous load originating from inappropriate instructional methods, and research has shown differentiation improves learning outcomes (Baloian, Pino, & Hoppe, 2008; Blayney et al., 2015; Khacharem, Zoudjo, & Kalyuga, 2015; Kissane et al., 2008; Moos, 2013; Moran, 2012; Morrison & Anglin, 2005; Van Merriënboer & Ayres, 2005). Providing learners guidance through scaffolding may help them to manage the mental load of processing new information (Çevik & Andre, 2013; Howarth, 2015; Hutchins, Wickens, Carolan, & Cumming, 2013; Kissane et al., 2008; Lin & Yu, 2017). For example, Hutchins et al. (2012) found in their research on error prevention training for army trainees that providing scaffolding and guidance through worked examples and conceptual prompts resulted in positive learning outcomes. Kissane et al. (2008) also experienced success with using worked examples and found that presenting novice learners with worked examples and then gradually removing support as they gained knowledge produced positive learning outcomes. Kissane et al.'s (2008) findings resonate with those of Wang, Hsu, Reeves, and Coster (2014) who found science students' skills improved when instructional methods allowed students to use technology with gradually increasing levels of independence. Providing guidance through scaffolding is especially important when presenting learners with more complex information, or information eliciting higher levels of intrinsic load.

However, not all learners who encounter complex information are novices, and CLT research indicates learners with higher levels of expertise require different instructional methods than novices (Blayney et al., 2015; Çevik & Andre, 2013; Clarke et al., 2005; Khacharem et al., 2015; Moos, 2013; Scheiter, Gerjets, Vollmann, & Catrambone, 2009). This trend is known in CLT research as the expertise-reversal effect which Sweller et al. (2011) explained as the load-inducing redundancy learners with expertise encounter when they must process introductory information and methods intended for novices. Scaffolding and other methods of support benefitting novice learners may be a source of extraneous load for learners with more expertise. Instructional designers must recognize instructional methods are more likely to be successful when they minimize extraneous load through differentiation according to learners' prior levels of knowledge and proficiency.

CLT research has found opportunities for peer interaction during instruction facilitate learning (Kear, Chetwynd, Williams, & Donelam, 2012; Hwang & Chang, 2016; Bower, Dalgarno, Kennedy, Lee, & Kennedy, 2015; Baloian et al., 2008; Cho & Lim, 2017). Cho and Lim (2017) found that students felt more motivated to engage during collaborative problem solving with peers than during teacher-led instruction while using immersive 3-D virtual technology. In the study by Hwang and Chang (2016) as well as a study by Chang et al. (2017), researchers found interactive game-based instructional methods reduced extraneous load and increased students' motivation. Collaboration allows learners to share prior knowledge which can be a means of supporting learners with less expertise (Sweller, 2008). As for the apparent benefits of incorporating game-based elements in group learning activities, perhaps familiarity with and popularity of game-based dynamics allow learners to better devote germane load toward managing the intrinsic load of a learning task. Designing instruction according to the prior knowledge, needs, and interests of learners may lead to learning experiences in which extraneous load-inducing factors are minimal.

Extraneous load is unrelated to the mental load incurred by processing target information, but this form of load can consume a learner's germane resources and thus be a deterrent to learning (Sweller, 2010; Sweller et al., 2011; Kalyuga & Liu, 2015). Certain instructional practices can be a source of extraneous load. As discussed previously, learners with expertise may encounter extraneous load when participating in instructional activities intended for novices, which is known as the expertise reversal effect (Sweller et al., 2011; Sweller, 2010). Conversely, engaging novice learners in instructional activities requiring the use of problem-solving strategies with minimal support is a source of extraneous load due to their lack of prior knowledge on the target content (Kirschner et al. 2006). Forcing a learner to divide his or her attention between multiple sources of information can cause extraneous load, a phenomenon known as the split-attention effect (Sweller, 2008; Sweller et al., 2011). CLT research on this phenomenon has found evidence the split-attention effect has a negative effect on learning (Al-Shehri & Gitsaki, 2010;

Tindall-Ford et al., 2015). When comparing learning outcomes between math students who managed split-attention by integrating multiple sources of information into one source with students who divided their attention between sources of information, Tindall-Ford et al. (2015) found students who managed split-attention outperformed those who did not. This evidence indicating sources of extraneous load such as instructional methods poorly matched with learners' prior knowledge or the split-attention effect can inform educators on best practices for presenting content to learners.

Educational Technology Implications

Factors inherent to educational technology and teachers' methods of integrating technology in the classroom can facilitate or inhibit learners' cognitive load management. CLT research has produced evidence indicating the use of multimedia technology may facilitate learners' cognitive load management (Gutiérrez-Carreón et al., 2015; Holzinger et al., 2008; Huang et al., 2013; Kennedy, Driver, Pullen, Ely, & Cole, 2013; Martin, 2012; Oliveira Neto, Huang, & Azevedo Melli, 2015; Pekerti, 2015; Shadiev et al., 2015; Cheng et al., 2015). For instance, Holzinger et al. (2008) found learners benefited from supporting animations when target information was more complex, and this benefit appeared to increase with the complexity of the content. Several studies reported results in which the use of multimedia during instruction reduced learners' cognitive load (Martin, 2012; Shadiev et al., 2015; Cheng et al., 2015; Gutiérrez-Carreón et al., 2015). Shadiev et al. (2015), for example, found that students who used a mobile tablet learning system experienced less cognitive load than students who learned without technological support. However, educational technology can be source of extraneous load for learners (Sweller, 2008; Kalyuga & Liu, 2015; Schwonke, 2015; Chen, 2009), and researchers have identified cases in which technology design elements or methods of using technology can increase cognitive load (Bower et al., 2015; Chen, 2016; Cooper, 2009; Deegan, 2013; Kear, Chetwynd, Williams, & Donelan, 2012; McEwen & Dubé, 2015). In the study by Chen (2016) on learners' perceptions of an online project-based learning program, students reported distractions within the online interface of the learning program as well as limitations in its affordances as the most significant inhibitors to learning. Deegan (2013) likewise found that distractions within a mobile learning interface can increase students' perceived cognitive load. Cooper (2009) illustrated in her article how design flaws in PowerPoint presentations such as excessive text, irrelevant visual media, and overuse of animation and sound effects can induce extraneous load. Moreno (2007) found that segmenting instructional video into smaller chunks better facilitated learning and incurred less cognitive load than unsegmented video. These findings indicate the need for evaluating educational technology considered for classroom use to ensure design elements promote rather than distract from learning.

Methods of integrating educational technology may be sources of cognitive load. Kear et al. (2012) found managing multiple tasks in an online environment to be a significant source of extraneous load. McEwen et al. (2015) found highly complex and interactive mobile learning apps were beneficial for higher functioning students but overwhelmed lower functioning students, which supports the need for consideration of the range of abilities and needs among learners as well as the limitations of each learner's working memory. As suggested in previous discussed studies on technology adoption and teacher professional development, a one-size-fits-all approach to instruction will not benefit all learners, and research on CLT supports this statement as well.

Subjective Measures of Cognitive Load

Researchers have attempted measuring cognitive load through subjective rating scales, measuring physiological indicators of cognitive load, and using secondary tasks to obtain indirect measures of cognitive load (Sweller et al., 2011; Paas et al., 2003). As this study seeks to explore relationships between cognitive load and intent to adopt technology through subjective, self-report measures, this section will focus on research emphasizing subjective measures of cognitive load.

The Paas Scale (Paas, 1992), a nine-point scale designed for self-reporting perceived mental effort, was the first scale developed as a subjective measure of cognitive load. Research supports the validity and reliability of using self-report subjective measures of cognitive load such as the Paas Scale (Sweller et al., 2011; Paas et al., 2003; Ayres, 2006; Leppink, Paas, Van der Vleuten, Van Gog, & Van Merriënboer, 2013; Sewell, Boscardin, Young, Ten Cate, & O'Sullivan, 2016). Ayres (2006) found subjective measures of cognitive load to be sensitive to differences in element interactivity, or the complexity of learning tasks. Though Young et al. (2016) had mixed success in validating an instrument for use in measuring cognitive load of medical students during training, their analysis revealed a positive correlation between intrinsic load and the Paas Scale and that learners with more expertise experienced lower levels of cognitive load. Learners' estimates of their own mental effort may provide information that performance measures do not reflect (Paas et al., 2003; Paas & Van Merriënboer, 1993; Paas & Van Merriënboer 1994). Therefore, subjective measures continue to be a commonly recognized and used method of measuring cognitive load among researchers.

As of the publishing of Paas et al.'s (2003) article, researchers using different scales of measurement for cognitive load did not always report data supporting reliability or validity of their instruments; and if they provided this information, it was in the form of simply a Cronbach's alpha (Paas, 2003). Paas et al. (2003) recommended researchers using adapted scales for measuring cognitive load account for reliability and validity with psychometric measures. More recent studies have supplied more rigorous accounts of reliability and validity (Leppink et al., 2013; Leppink, Paas, Van Gog, Van Der Vleuten, & Van Merriënboer, 2014; Schlairet, Schlairet, Sauls, & Bellflowers, 2015; Sewell et al., 2016; Young et al., 2016). For example, Schlairet et al. (2015) used exploratory factor analysis (EFA) to provide measures of reliability and validity for using the Paas Scale along with other scales to measure nursing students' experiences during a high-fidelity simulation training. Leppink, Paas, Van der Vleuten, Van Gog, and Van Merriënboer (2013) proposed a ten-item scale of nine-point Likert-type items intended to measure the three forms of cognitive load: intrinsic, extraneous, and germane. The researchers began instrument validation with principal components analysis (PCA) using a very small sample size of only approximately six participants per scale item (Leppink et al., 2013). Though recommendations for sample sizes vary in discussions of data reduction methods, researchers specializing in psychometrics recommend a minimum of ten participants per item (Beavers et al., 2013). Leppink et al. (2013) justified their choice of PCA saying the less restrictive assumptions of the method made it a better choice than EFA considering their small sample size, and they confirmed the factor model produced through PCA by conducting confirmatory factor analysis (CFA) on other datasets. In the field of medicine, Sewell et al. (2016) validated a nineteen-item scale measuring cognitive load during colonoscopy training. Sewell et al. (2016) first conducted EFA followed by CFA, each analysis conducted with data from at least 400 participants. Leppink et al. (2013) and Sewell et al. (2016) are examples of researchers first conducting exploratory methods to select a factor model that best fits the data before conducting confirmatory methods. According to the review of articles curated for this analysis, few studies on cognitive load among educational technology users appear to have first applied EFA methods to explore possibilities in factor structures or to investigate the reliability and validity of subjective measures of cognitive load, which may indicate an area of need in research.

Operationalizing and Measuring Forms of Cognitive Load

Operationalizing and measuring specific forms of cognitive load has posed challenges to researchers (Paas, Tuovinen, Tabbers, & Van Gerven, 2003; Beckmann, 2010). Beckmann (2010) argued that CLT research has yet to be successful in respectively measuring the individual forms of cognitive load as defined by Sweller (2010). Beckmann (2010) pointed out that the challenge in operationalizing and obtaining valid measures for intrinsic, extraneous, and germane load comes from the idea that a learner's experience cognitive load is specific to the learning task as well as attributes unique to the learner such as prior knowledge. Leppink et al. (2013) argued that a learner's prior knowledge affects whether subjective measures of concentration and focus provide are actually measuring extraneous load or germane load. Leppink et al. (2013) designed and validated a ten-item scale measuring individual forms of cognitive load. However, although their use of principal components analysis followed by confirmatory factor analysis on new datasets confirmed a three-factor solution, Leppink et al. (2013) provided no evidence of content validity for their items. Further, Leppink et al. (2013) used very small population sizes all recruited from the same institution which indicates their model may not hold stable when tested among other populations (Costello & Osborne, 2005). Debue and van de Leemput (2014) attempted to differentiate measures of germane and extraneous load by applying experimental conditions in their study of learners' allocation of cognitive resources while engaging with hypermedia such as online newspapers. The researchers found that purposeful manipulations of extraneous load sources did affect information retention and that germane and extraneous load exhibited a negative relationship aligning with theory (Debue & van de Leemput, 2014). Obtaining content validity for operational definitions and subjective measures of individual forms of cognitive load may require testing under similar controlled experimental conditions.

Summary

Though research has not explored how cognitive load during technology professional development may affect teachers' intent to adopt new technology, themes from research on technology adoption and cognitive load in educational settings appear to indicate a potential area for future research. Rogers (2003) claims innovations with more complexity tend to have lower rates of adoption. Likewise, research on technology adoption among teachers has produced evidence associating technology's perceived ease of use with teachers' willingness to adopt technology. Cognitive load research has produced evidence associating the complexity of learning tasks with the levels of cognitive load imposed on learners. This research has also provided evidence which suggests efforts to facilitate learners' management of this load improves learning outcomes and in terms of learning technology may improve learners' intent to adopt technology. Thus, one might infer teachers' levels of cognitive load experienced while learning new technology may influence their intent to adopt the technology. Researchers suggest access to effective professional development responsive to learners' levels of expertise may improve rates of technology adoption among teachers. Differentiated instruction receives support from cognitive load research as well. The importance of access to effective professional development suggests whether teacher successfully learn technology influences their decisions to become technology adopters; and according to CLT, cognitive load management directly affects whether learning is successful.

CHAPTER III

METHODOLOGY

Introduction

Factors related to the mental load inherent to learning a technology have not been fully explored in technology adoption research on P-12 teachers. An instrument designed to measure the latent constructs of cognitive load and intent to adopt technology can facilitate future research on a potential relationship between the constructs. As defined in Chapter 1, latent constructs are variables of interest to this study which are not directly observable. This study pursued the process of designing a self-report survey instrument measuring the latent constructs of P-12 teachers' intent to adopt technology and the cognitive load incurred as they learn about the technology during professional development. Designing such an instrument may facilitate future research on the potential relationship between these latent constructs.

This chapter outlines the processes and methods selected for designing an instrument measuring P-12 teachers' cognitive load during technology professional development and their intent to adopt the technology. The researcher will include explanations of procedures for instrument design, content validation, and measures of reliability. Then, the researcher will present procedures for exploratory factor analysis including methods of factor reduction, retention, and rotation.

Problem and Purpose Overview

Technology adoption research has not explored a possible relationship between P-12 teachers' cognitive load while learning a technology and their intent to adopt the technology. Lack of access to a single instrument measuring the latent constructs of P-12 teachers' cognitive load and their intent to adopt technology may be an inhibitor to exploring this relationship. Thus, the purpose of this study is to design a self-report survey instrument measuring the latent constructs of P-12 teachers' cognitive load experienced during technology professional development and teachers' intent to adopt technology.

Research Questions

This study seeks to answer the following questions and provide support for the accompanying hypotheses. Figure 1 follows with a data matrix outlining the data collection procedures and methods of analysis used in this study.

- Do the results of the index of item-objective congruence support the instrument's content validity?
    - Hypothesis 1: The results of the index of item-objective congruence support the instrument's content validity.
- Does the instrument demonstrate internal consistency within the context of P-12 teachers self-reporting intent to adopt technology and cognitive load after participating in a single-session technology professional development?
    - Hypothesis 2: The instrument demonstrates internal consistency.
- Does the instrument's factor structure account for most of the variability in the measured constructs?

- Hypothesis 3: The instrument's factor structure accounts for most of the variability in the measured constructs.

- Do the instrument items demonstrate a theoretical factor structure?
  - Hypothesis 4: The instrument items demonstrate a theoretical factor structure.

What does the researcher need to know?	Why does the researcher need to know it?	What is the hypothesis?	What kind of data will answer the question?	Where can the researcher find the data?	Whom does the researcher contact for access?	Collection Timeline	What form of data analysis is needed?
Do the results of the index of item-objective congruence support the instrument's content validity?	IIOC measures provide support for content validity	The results of the index of item-objective congruence support the instrument's content validity	Feedback from content experts who judge the content each item measures through a blind rating procedure.	Content experts from related research fields.	Content experts via email.	Fall 2017 to Spring 2018	Index of item-objective congruence.
Does the instrument demonstrate internal consistency within the context of P-12 teachers self-reporting intent to adopt technology and cognitive load after participating in a single-session technology professional development?	Internal consistency supports the reliability of the instrument.	The instrument demonstrates internal consistency.	Survey data.	Public schools where the researcher provided professional development services.	District or site administrators via email.	Fall 2017 to Spring 2018	Cronbach's alpha.
Does the instrument's factor structure account for most of the variability in the measured constructs?	A factor structure accounting for most of the variability in the measured constructs indicates the constructs of interest explained most of the variability in the data with a minimal amount of variability attributed to unknown factors.	The instrument's factor structure accounts for most of the variability in the measured constructs.	Survey data.	Public schools where the researcher provided professional development services.	District and site administrators via email.	Fall 2017 to Spring 2018	Principal axis factoring: examination of initial eigenvalues, percent variance explained, and extracted communalities.
Do the instrument items demonstrate a theoretical	A meaningful factor structure would provide support for the instrument as an appropriate tool	The instrument items demonstrate a theoretical	Survey data.	Public schools where the researcher provided professional	District or site administrators via email.	Fall 2017 to Spring 2018	Principal axis factoring: examination of initial eigenvalues

factor structure?	for measuring the latent constructs of interest.	factor structure.		development services.			using parallel analysis, Kaiser's Criterion, and the scree test and examination of rotated factor loadings.

Figure 1. Data matrix. This figure presents a data matrix outlining data collection procedures and analysis methods for each research question of this study.

Research Design

This section will present the research design for this study. The research design follows the process of designing a self-report survey instrument measuring the latent constructs of P-12 teachers' cognitive load and their intent to adopt technology. The researcher selected this research design for its potential to produce a survey instrument which may facilitate future research on cognitive load's potential influence on P-12 teachers' technology adoption decisions. Discussion of the instrument design stage will begin this section. Methods of establishing content validity, collecting data, and conducting statistical analyses to provide measures of reliability and examine the instrument's factor structure and variance explained will follow.

Instrument Design

The initial draft of the instrument was in the form of a self-report survey. Sweller et al. (2011) testified to the reliability of subjective measures of cognitive load, and prior CLT studies have made successful use of self-report instruments measuring cognitive load (Paas et al., 2003; Ayres, 2006; Leppink et al., 2013; Sewell et al., 2016). Because the population for this study consisted of P-12 in-service teachers participating in technology professional development, and the study's sample size was prospectively large, a subjective self-report survey was most appropriate. Methods of measuring cognitive load through achievement indicators or physiological indicators, the other two common methods of measuring cognitive load, would be less feasible for this population. Achievement indicators were not possible to obtain within the time frame of this study, though future longitudinal research on this topic might consider the use of achievement indicators for measuring cognitive load of P-12 teachers in experimental settings. Equipment for measuring physiological indicators of cognitive load were not available for use on the large sample size sought for this study at the time this study was conducted. In addition, obtaining physiological indicators of cognitive load during professional development might have been perceived as intrusive among participating teachers. A self-report survey instrument intended for subjective measures of cognitive load is an established method in CLT research and would be the least intrusive and most practical means of collecting data from the population of interest to this study.

The survey consisted of eighteen items intended to measure the latent constructs of cognitive load and intent to adopt technology. These items were six-point Likert-type items measuring the degree to which participants agree or disagree with statements intended to address indicators of cognitive load or intent to adopt technology. Operational definitions drawn from the study's theoretical framework guided the development of items for this instrument.

Operational definitions. Designing an instrument for measuring latent constructs begins with developing operational definitions for those constructs (Raykov & Marcoulides, 2011). The researcher used the following operational definitions which evolved from this study's theoretical framework. These operational definitions define ability to manage intrinsic load, influence of extraneous load on intrinsic load management, germane load, influence of extraneous load on germane load, and intent to adopt technology. From Sweller's (2010; 2008) definitions of intrinsic, extraneous, and germane load, the researcher derived operational definitions for latent constructs related to cognitive load. Rogers' (2003) definition for adoption of an innovation formed the basis of the operational definition for intent to adopt technology. The researcher presented these definitions to a panel of experts as part of the process for establishing content validity, which will be discussed in detail later in this chapter.

Ability to manage intrinsic cognitive load. Intrinsic cognitive load is the mental load which individuals must process to learn target content. One's ability to manage intrinsic load is evident in how well one understands the content or the perceived difficulty or ease of learning the content.

Influence of extraneous cognitive load on intrinsic cognitive load management. Extraneous cognitive load is mental load originating from variables related to the instructional delivery of the target content. These variables are not directly related to the target content and can be an impediment to managing intrinsic load. Sources of extraneous cognitive load can include poor design of presentation materials or media used during teaching or ineffective methods of instruction used to present content. Individuals perceiving instructional methods, materials, or media as not contributing to their learning of target content is indicative of the influence of extraneous cognitive load on intrinsic cognitive load management.

Germane cognitive load. Germane load refers to the mental resources an individual devotes to learning. Application of germane load is evident in a learner's ability to concentrate or focus on learning the target content.

Influence of extraneous cognitive load on germane cognitive load. Extraneous cognitive load is mental load originating from variables related to the instructional delivery of the target content. These variables are not directly related to the target content and can be an impediment to managing intrinsic load. Sources of extraneous cognitive load can include poor design of presentation materials or media used during teaching or ineffective methods of instruction used to present content. Individuals perceiving instructional methods, materials, or media as not helping them to focus or concentrate on the target content is indicative of the influence of extraneous cognitive load on germane cognitive load.

Intent to adopt technology. Intent to adopt technology is one's willingness to begin using a technology. One who considers adopting a particular technology has not actively made prior use of it. Intent to adopt technology is evident when one expresses willingness to make use of a technology currently or in the future.

Item creation. Once a researcher develops operational definitions for the latent constructs to be measured, the operational definitions then guide the creation of items for the instrument (Raykov & Marcoulides, 2011). The researcher of this study wrote the following items from the above operational definitions.

Items measuring the influence of extraneous load on intrinsic load management. The following items measure the influence of extraneous load on an individual's ability to manage intrinsic load.

- Item 1: The instruction provided in this professional development helped me learn the content.
- Item 2: The materials used during this professional development helped me learn the content.
- Item 5: The presentation methods used during the professional development helped me learn the content.
- Item 15: The trainer's instructional methods helped me learn the content presented.

These items address potential sources of extraneous load such as instructional design practices and instructional materials (Sweller, 2010; Sweller, Ayres, & Kalyuga, 2011; Kalyuga & Liu, 2015; Sweller, 2008). The items assess whether such variables promoted learning the target content, or the processing of intrinsic load. Cierniak, Scheiter, and Gerjets (2009) used similar items in their instrument intending to obtain a measure of extraneous load but found participants' responses to these items positively correlated with items measuring intrinsic load, contrary to their expectations. This finding corroborates the researcher's decision that the above items measure the influence of extraneous load on intrinsic load management: since the items designed for this study ask participants to rate learning along with the effectiveness of instructional delivery and materials, the researcher proposes these items are also indicators of ability to manage intrinsic load.

Items measuring the influence of extraneous load on germane load. The following items measure the effects of extraneous load on an individual's level of germane load, or an individual's application of mental resources to learning the target content.

- Item 3: The materials used during this professional development helped me concentrate.
- Item 5: The presentation methods used during this professional development helped me to focus.
- Item 16: The trainer's instructional methods helped me focus on the content presented.

Researchers have used similar items asking participants to rate their abilities to focus and concentrate for measuring germane load, or the learner's attribution of mental resources to a learning task (Cerniak et al., 2009). The items above ask whether different variables related to instructional delivery enhanced an individual's ability to focus or concentrate. Cognitive load originating from variables such as ineffective instructional delivery is extraneous load and inhibits the learner's ability to process and learn target content (Sweller, 2010). Therefore, responses to these items indicate the degree to which extraneous load-inducing variables affect participants' levels of germane load.

Items measuring germane load. The following items measure germane load or an individual's application of mental resources for learning the target content.

- Item 4: I was not distracted during this professional development.
- Item 7: I was able to concentrate on learning the presented content.

- Item 9: During this professional development, I was able to focus on learning the content.

The items ask whether individuals were able to devote germane resources to learning the target content. Researchers have used items asking participants to rate their abilities to focus and concentrate to measure germane load, or the learner's attribution of mental resources to a learning task (Cerniak et al., 2009). Other researchers claim such measures can indicate germane load in some learners and extraneous load in others, depending on the prior expertise of learners (Leppink, Paas, Van der Vleuten, Van Gog, & Van Merriënboer, 2013). The researcher proposes the items above measure germane load in this study because they ask participants to rate their abilities to concentrate and focus on learning the target content.

Items measuring ability to manage intrinsic load. The following items measure ability to manage intrinsic load.

- Item 8: I had no difficulty understanding the content presented during the professional development.
- Item 10: I understood the content presented during the training.
- Item 13: I was able to manage the mental effort required to learn the content presented in this professional development.
- Item 14: The content presented during this professional development was not difficult for me to learn.

These items ask individuals to assess the perceived difficulty of the content or how well they understood or managed the mental effort of learning the target content. The Paas scale (1992) intended to measure intrinsic load asked respondents to rate mental effort on a nine-point scale from "very, very low mental effort" to "very, very high mental effort." Prior research supports the reliability and validity of this scale for measuring intrinsic load (Sweller et al., 2011; Paas, Tuovinen, Tabbers, & Van Gerven, 2003; Ayres, 2006; Young et al., 2016; Leppink et al., 2013). Other researchers have used items similar to the items in this study's instrument to measure intrinsic load or obtain a general measure of cognitive load. Moreno (2007) created and administered an instrument that included items asking pre-service teachers to rate the difficulty and required mental effort of learning a teaching strategy using a computer program. Likewise, Cerniak et al. (2009) used items in their instrument asking participants to rate the difficulty of learning tasks to measure intrinsic load. Kalyuga et al. (1998) obtained intrinsic load measures by asking participants to rate the difficulty of understanding a concept. Therefore, one may deem the items above appropriate for measuring ability to manage intrinsic load.

Items measuring intent to adopt technology. The following items measure intent to adopt the technology presented during the professional development.

- Item 11: I intend to put into practice what I learned about technology in this professional development.
- Item 12: I intend to use the technology presented during the professional development.
- Item 17: I will use the technology presented in this professional development in my classroom.
- Item 18: I will use the technology presented in this professional development with my students.

These items draw from Rogers' (2003) definition of adoption as "a decision to make full use of an innovation as the best course of action available" (p. 473). The wording of these items is similar to items used in Davis' (1986) Technology Acceptance Model for measuring behavioral intent to use technology.

Table of specifications. Table 2 presents the table of specifications for the items in the initial draft of the instrument. This table indicates with values of 1 which latent constructs the researcher intends these items to measure. The researcher compared feedback from the panel of experts received from the content validation process to this table of specifications, which will be discussed in detail later in this chapter.

Table 2

Table of Specifications

	Ability to Manage Intrinsic Load	Influence of Extraneous Load on Intrinsic Load Management	Germane Load	Influence of Extraneous Load on Germane Load	Intent to Adopt Technology
Item 1. The instruction provided in this professional development helped me learn the content.		1			
Item 2. The materials used during this professional development helped me learn the content.		1			
Item 3. The materials used during this professional development helped me concentrate.				1	
Item 4. I was not distracted during this professional development.			1		
Item 5. The presentation methods used during this professional development helped me to focus.				1	
Item 6. The presentation methods used during the professional development helped me learn the content.		1			
Item 7. I was able to concentrate on learning the presented content.			1		

Item 8. I had no difficulty understanding the content presented during the professional development.	1				
Item 9. During this professional development, I was able to focus on learning the content.			1		
Item 10. I understood the content presented during the training.	1				
Item 11. I intend to put into practice what I learned in this professional development.					1
Item 12. I intend to use the technology presented during the professional development.					1
Item 13. I was able to manage the mental effort required to learn the content presented in this professional development.	1				
Item 14. The content presented during this professional development was not difficult for me to learn.	1				
Item 15. The trainer’s instructional methods helped me learn the content presented.		1			
Item 16. The trainer’s instructional methods helped me				1	

focus on the content presented.					
Item 17. I will use the technology presented in this professional development in my classroom.					1
Item 18. I will use the technology presented in this professional development with my students.					1

Figure 2 depicts the table of specifications as a factor model. The model illustrates how the latent factors of ability to manage intrinsic load, influence of extraneous load on intrinsic load management, germane load, influence of extraneous load on germane load, and intent to adopt technology might exhibit a causal relationship with item responses which serve as observable and measurable variables. Examination of the results of exploratory factor analysis allowed the researcher to investigate the latent factor structure emerging from data collected for this study and determine to what extent the observed structure is theoretically meaningful, as will be discussed in later sections.

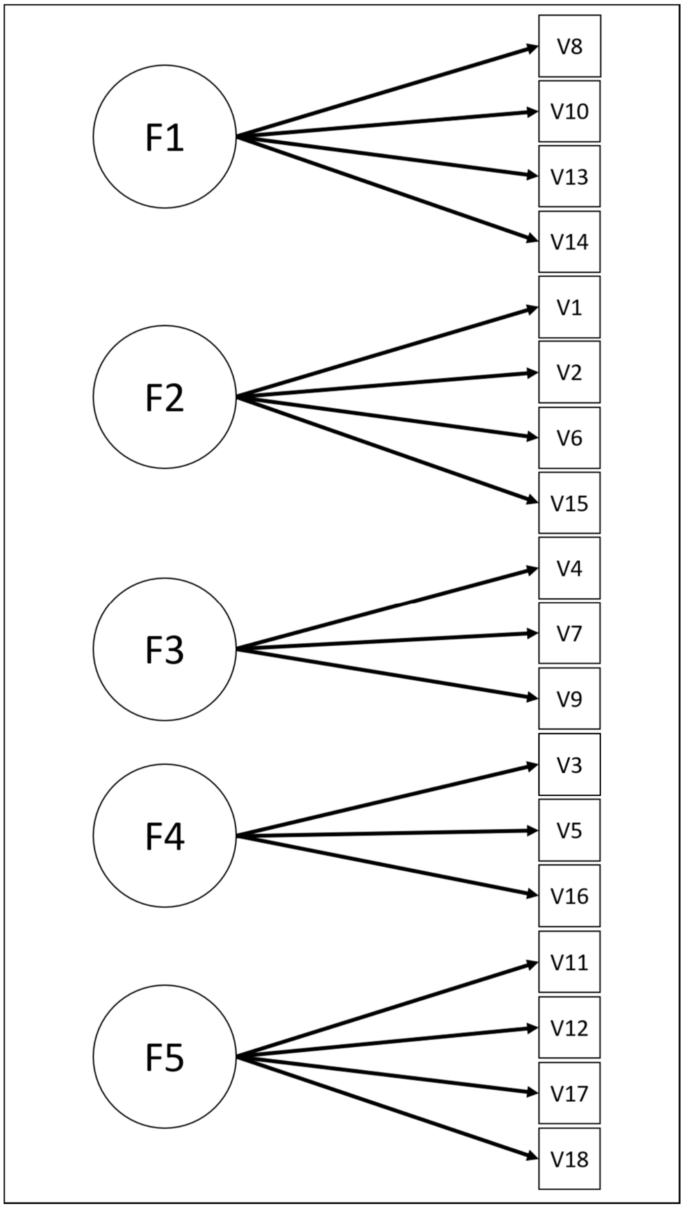


Figure 2. Table of specifications as a factor model. This figure illustrates the table of specifications in Table 2 as a potential factor model. F1 through F5 represent the following latent factors in order: ability to manage intrinsic load, influence of extraneous load on intrinsic load management, germane load, influence of extraneous load on germane load, and intent to adopt technology. V1 through V18 are the observable variables hypothetically sharing a causal relationship with the latent factors. These variables are measured by their corresponding items on the survey instrument (e.g. V1 corresponding with Question 1, etc.).

Likert-type scale. Participants responded to each item using a six-point Likert-type scale indicating the degree to which they agreed or disagreed with a statement. The six points are as follows: 6 = “strongly agree,” 5 = “agree,” 4 = “slightly agree,” 3 = “slightly disagree,” 2 = “disagree,” 1 = “strongly disagree.” As opposed to an odd-numbered scale which includes a neutral response option such as “neither agree nor disagree,” the use of an even-numbered scale elicited agreement or disagreement from the participants in their responses. Likert-type scales between five and seven points are preferable in terms of their ease of use for respondents (Johns, 2010). Six-point Likert-type scales have proven useful in other research studies seeking subjective measures of cognitive load (Lin & Lin, 2016; Hsu & Hwang, 2014; Cierniak et al., 2009) and measures of latent constructs related to educational technology (Juarez Collazo, Wu, & Clarebout, 2014; Alonso, Manrique, & Viñes, 2009; Sun & Chen, 2016). Though Jamieson (2004) criticized data collected from Likert-type scales being treated as interval data and analyzed using parametric methods, Norman (2010) countered her argument pointing out that parametric measures are robust to this potential violation. Likert-type scales have proven to be versatile and practical tools of measurement in the social sciences (Johns, 2010), and have been the means of facilitating much of social science research (Norman, 2010).

Content Validity

Rovinelli and Hambleton’s index of item objective congruence (IIOC) procedure provided a means of evaluating the instrument’s content validity through a blind rating of items by a panel of experts (as cited in Turner & Carlson, 2003, p.163). IIOC is an assessment of an instrument’s content validity at the item development stage (Turner & Carlson, 2003). To conduct this procedure, the researcher presented operational definitions and a draft of survey items to experts in the fields of educational technology or psychometric theory who served as judges. The researcher provided the judges a form which presented the operational definitions and survey items as well as instructions for using the form to provide feedback on the extent to which they felt each item measured each construct according to the operational definitions. This form is available in Appendix C. The researcher submitted the form to each judge as a Microsoft Word document attached to an email. The judges completed the form to assess which constructs each item appears to measure. During this assessment, each judge used the form to assign one of the following values to each construct for each item: 1 = “measures this construct,” -1 = “does not measure this construct,” 0 = “ambiguous.” The judges then returned completed forms to the researcher as email attachments. The researcher assimilated the judges’ feedback on a single table which will be presented in Chapter 4. As part of the IIOC procedure, the researcher compared these values to the values presented in the table of specifications shown in Table 2 using a formula developed by Turner and Carlson (2003). This formula, as seen in Equation 3.1, produced measures that served as indicators of each item’s content validity according to the judges’ feedback.

$$I'_{ik} = \frac{(N)\mu_k - (N - p)\mu_l}{2N - p} \tag{3.1}$$

I'_{ik} is the IIOC measure for item i and set of constructs k; N is the total number of constructs; p is the number of valid constructs for item i; μ_k is the judges’ mean rating of item i on the valid constructs k; and μ_l is the judges’ mean rating of item i on the invalid constructs l (Turner & Carlson, 2003). The researcher used the IIOC measures to identify items which may be in need of revision, or items with IIOC values less than 0.750 (Turner & Carlson, 2003). The researcher may consider revising or omitting these items from the instrument.

Data Collection

This section will outline the procedures the researcher followed to collect data for this study. The research will present the population of interest followed by procedures for recruiting participants and data collection.

Population. Public school teachers employed in school districts located in the southwest United States who participated in a one-time technology-related professional development are the population for this study. These teachers serve as either classroom teachers (teachers assigned rosters of students for whom they provide instruction), activity teachers (teachers who provide students instruction on subjects such as physical education and music while providing release time for classroom teachers), or school librarians who provide formal instruction to students. These teachers participated in technology professional development training scheduled by their administration as part of their annual professional development requirement.

Recruitment. The researcher communicated through email to offer district and school site administrators free professional development for teachers on creating interactive lessons using PowerPoint. PowerPoint is a widely available slide-presentation software. A PDF flyer attached to the email communicated details of this service as well as the purpose of the research study and concomitant administration of a survey to participants after the professional development. The email and flyer asked administrators to respond through email or by phone if they were interested in providing this training for their teachers. Through communication with administrators, the researcher confirmed the teachers have access to PowerPoint and thus reasonable opportunity to adopt the technology strategies taught during the professional development if they choose. The training was approximately one hour. The researcher conducted training at the time and place selected by respective administrators.

Data collection procedures. Data collection proceeded as follows. The researcher conducted one-hour professional development sessions in which she trained teachers on the use of three techniques for creating interactive lessons using PowerPoint. PowerPoint is a slide presentation software produced by Microsoft. Each training session took place at a school in a classroom or library equipped with a projector and screen, and the researcher provided handouts with which teachers could take notes. Using the projector and screen provided at each site, the researcher projected the content on a screen which was either a Smart Board, Promethean, or non-interactive screen depending on the equipment available at each site. The delivery and process of the professional development was the same regardless of the type of screen available.

In the design and delivery of the professional development, the researcher did not attempt to mitigate potential cognitive load but endeavored to provide a standard professional development experience in which a trainer demonstrates technology tools and strategies and provides examples of practical application. The first technique presented during the training was a three-slide question and answer activity in which a single slide presents students a learning task with a choice of responses, each response hyperlinked to a slide that provides feedback on the student's response choice. The second technique was creating a slide with a game interface which presents students multiple choices in learning tasks they can access using hyperlinks. The third technique demonstrated to teachers how they can apply the second technique to create a hyperlinked graphic in which students can interact with different components of the graphic with hyperlinks. Along with a demonstration of each technique, the researcher presented authentic examples of the techniques in the form of actual PowerPoint lessons previously created by the researcher. An example of an interactive PowerPoint lesson is available in Appendix D.

PowerPoint was the selected topic for this professional development due to the wide availability of the software in the region where recruitment took place. PowerPoint is also versatile enough to be accessible to the devices and auxiliary equipment available to teachers who participated in this study. The researcher had sufficient proficiency working with and teaching the software to be able to present strategies novel and unfamiliar to many participants. To offer additional support after the training concluded, the researcher emailed site administrators links to video tutorials of the techniques demonstrated during the training as well as a ready-made PowerPoint activity teachers can tailor to any subject area or grade level. The researcher had previously created all provided additional resources, and Appendix E includes links to or thumbnail images of these resources. This professional development provided practical applications beneficial to most teachers as well as resources for follow-up support, thus helping to ensure mutually beneficial conditions of research.

Immediately following the professional development, the researcher discussed the research study in general terms, provided instructions for completing the survey and IRB-approved consent form, and verbally communicated that participation was voluntary. The researcher also explained that collected information was not personally identifiable and would be confidential. Then, the researcher distributed paper copies of the consent forms and the surveys to the teachers. The teachers left the surveys and consent forms, whether completed or uncompleted, at the site of the professional development training. The researcher then collected the surveys and consent forms.

The researcher transferred survey responses to a digital spreadsheet for use in data analysis. Surveys with missing responses or multiple responses to single items were removed from the dataset. As part of descriptive data collection, the survey asked participants whether they provide instruction to students and whether they had previously attended the professional development conducted by the researcher. Surveys in which the participants indicated they do not provide instruction to students or that they have previously attended the training presented by the researcher were also removed from the dataset. After transferring data to a digital spreadsheet, the researcher stored completed surveys as well as consent forms in a secure location where they will remain until the conclusion of the study, after which the surveys will be destroyed, per IRB-approved protocol. Electronic data was stored on a password-protected computer and does not include any personally identifiable information.

Preliminary Reliability Estimate

Following the IIOC procedures, the researcher began data collection for this study. Upon collecting data from a minimum of thirty of the first participants in this study, the researcher used SPSS to obtain an estimate of reliability in the form of Cronbach’s alpha. Cronbach’s alpha provides a measure of the instrument’s internal consistency (Gliem & Gliem, 2003). If Cronbach’s alpha was at least 0.700 on each subset of items, the researcher would continue data collection with no revisions to the instrument. A Cronbach’s alpha of at least 0.700 is a rule-ofthumb benchmark of acceptable internal consistency (Gliem & Gliem, 2003). If Cronbach's alpha was less than 0.700 for any subset, the researcher would omit items negatively affecting reliability and would reanalyze the data without the omitted items. If a second reliability analysis yielded a Cronbach's alpha of at least 0.700, data collection would begin anew with the revised instrument, and subsequent data analysis would not include data collected for any omitted items. In the case that any Cronbach's alpha values continued to be below 0.700, the researcher would return to the design of the instrument and revisit the latent constructs, operational definitions, and theoretical framework.

Exploratory Factor Analysis

As the term implies, exploratory factor analysis (EFA) allows researchers to apply exploratory data analysis procedures to select a factor model that best fits the variability in the data. This section will discuss the methods of data reduction, factor retention, and data rotation to be used during factor analysis procedures.

Principal axis factoring. Once data collection was complete, the researcher conducted principal axis factoring (PAF) analysis using SPSS software. PAF is a form of EFA appropriate for investigating an underlying factor structure in a dataset, and the procedure does not require strict adherence to assumptions of multivariate normality as with other forms of EFA such as maximum likelihood (Beaver et al., 2013; Costello & Osborne, 2005). PAF analyzes shared variance among item responses in order to focus on the latent constructs, or factors, underlying the response data (Henson & Roberts, 2006). This analysis allowed for exploration of factor model(s) which best represent the data.

Criteria for factor analysis. The researcher conducted a priori procedures in order to verify the data met the assumptions of PAF. Justification for use of PAF proceeded from examination of the correlation matrix, correlation matrix determinant, results of the Kaiser-Meyer-Olkin (KMO) test, and Bartlett's test of sphericity. The researcher examined the inter-item correlation matrix to ensure items shared at least one moderate (greater than or equal to 0.300) to strong (greater than or equal to 0.700) correlation with at least one other item. If the correlation matrix determinant was equal to neither zero nor one, the researcher could conclude the correlation matrix was neither singular nor equal to the identity matrix, conditions which would indicate the data may not have met the assumptions of principal axis factoring (Beavers et al., 2013). KMO results of at least 0.600 would provide sufficient evidence for an underlying factor structure in the data (Beavers et al., 2013). Finally, significant results from Bartlett's test of sphericity would indicate the presence of relationships among item responses, thus further justifying the use of a data reduction method. If the data met these criteria, the researcher would proceed with PAF.

Factor retention. Results of parallel analysis, a procedure using simulated data to predict the factor structure for a given population size and number of items, determined the number of factors to retain in the model. Parallel analysis produced simulated eigenvalues to which the researcher compared eigenvalues produced through PAF. The researcher retained factors whose eigenvalues were higher than corresponding eigenvalues produced by parallel analysis. The researcher also considered the results of the scree test (examination of the scree plot to determine the number of factors plotted before the bend in the data) and the application of Kaiser's Criterion (retaining factors with eigenvalues greater than 1). If respective results of these tests varied, the researcher retained factors based on the results of parallel analysis. Experts on factor analysis procedures agree parallel analysis provides the most reliable guidance in factor retention decisions (Beaver et al., 2013; Costello & Osborne, 2005).

Data rotation. To facilitate interpretation of the retained factors and which items load on which factors, the researcher applied a Promax rotation to the data. Promax is an oblique rotation appropriate when researchers anticipate some correlation among factors, which is likely in social sciences research (Osborne, 2015). Results of this analysis provided indicators of the factor models best fitting the data as well as identified poorly loading items which should be omitted. Results also guided the researcher in interpreting and tentatively labeling the factors. Analyzing the PAF results, the researcher further revised the survey by omitting any poorly loading items: items without factor loadings of at least 0.500 on one factor or cross-loading items exhibiting loadings of at least 0.300 on more than one factor (Costello & Osborne, 2005). Pending the necessity of omitting poorly loading items, the researcher would repeat the above discussed procedures for conducting a PAF without the omitted items to investigate whether the factor model would improve in variance explained.

Interpretation. Examining how each item loads on each factor, the researcher then made tentative interpretations of each factor retained in the model. The researcher referred to the theoretical framework and operational definitions to triangulate interpretations of the factors and assess to what degree the factor model is theoretically meaningful. Strong factor loadings and a factor structure aligning with theory would provide evidence the survey may be a valid instrument for measuring the latent constructs of interest, pending validation procedures to take place after this study. Therefore, this assessment allowed the researcher to draw tentative conclusions on the extent to which the survey measures the latent constructs of P-12 teachers' cognitive load during technology professional development and intent to adopt technology.

Summary

This chapter presented the procedures and methods of instrument design, data collection, and data analysis for this study. These procedures and methods facilitated the design of a survey instrument measuring the latent constructs of P-12 teachers' cognitive load during technology professional development and their intent to adopt technology. In the following chapter, the researcher will present the results of content validation and data analysis.

CHAPTER IV

FINDINGS

The potential influence of P-12 teachers' cognitive load experienced during technology professional development on their intent to adopt technology is under-researched (Dalinger et al., 2016). Lack of access to an instrument measuring the latent constructs of cognitive load and intent to adopt technology within the context of P-12 teachers learning new technology may be an inhibitor to research in this area. To address this gap in the research, this study pursued the design of a self-report survey instrument measuring the latent constructs of cognitive load and intent to adopt technology among P-12 teachers participating in a technology professional development in which they learned how to create interactive PowerPoint lessons.

This chapter presents the results of analyses conducted to determine the instrument's content validity, obtain measures of internal consistency, explore the latent factor model most representative of the collected data, and determine the variance explained by the latent factor model. The chapter will begin with the results of the index of item-objective congruence conducted to obtain evidence of the instrument's content validity. Then, results of the preliminary estimates of reliability will be reported to provide evidence of the instrument's internal consistency. Finally, the researcher will present results of exploratory factor analysis to provide evidence of the causal factor structure accounting for the variance in the observed data and the amount of variance explained.

Index of Item-Objective Congruence

Research Question 1 asked: *Do the results of the index of item-objective congruence support the instrument's content validity?* From this question, the researcher proposed Hypothesis 1: *The results of the index of item-objective congruence support the instrument's content validity.* Rovinelli and Hambleton (1977) developed the index of item-objective congruence (IIOC) as a procedure for assessing content validity at the item development stage. In this study, IIOC provided a means by which the researcher could obtain measurable feedback from content experts on how well each item measures different forms of cognitive load and intent to adopt technology. Five experts from the field of educational technology or psychometric theory contributed to the content validity process by serving as judges for the IIOC or offering comments on the instrument. Four of these experts participated in the IIOC as judges. The fifth expert, a researcher specializing in Cognitive Load Theory, provided general approval of the instrument's content but did not participate in the IIOC.

The researcher solicited participation from the experts through email. The email provided an attached form for the experts to use in order to judge the content validity of each survey item. Experts who agreed to serve as judges returned the completed form to the researcher through email. This form is available in Appendix C. Table 3 presents the feedback from the four experts who served as judges. Terms presented in the table in bold text indicate which factor each item is intended to measure. Table 4 presents the IIOC values calculated from the judges' feedback with values greater than or equal to 0.750 presented in bold. The researcher obtained feedback measures using Turner and Carlson's (2003) formula, which is presented and defined in Chapter 3 and also provided below.

$$I'_{ik} = \frac{(N)\mu_k - (N-p)\mu_l}{2N-p} \qquad (3.1)$$

Table 3

Judges' Feedback for the Index of Item-Objective Congruence

Item 1: The instruction provided in this professional development helped me learn the content.					
Judge	Factor 1	**Factor 2**	Factor 3	Factor 4	Factor 5
1	0	-1	1	-1	-1
2	1	-1	-1	-1	-1
3	1	1	-1	-1	-1
4	-1	-1	-1	-1	1
Item 2: The materials used during this professional development helped me learn the content.					
Judge	Factor 1	**Factor 2**	Factor 3	Factor 4	Factor 5
1	-1	-1	1	-1	-1
2	1	-1	-1	-1	-1
3	1	1	-1	-1	-1
4	-1	-1	0	0	1
Item 3: The materials used during this professional development helped me concentrate.					
Judge	Factor 1	Factor 2	Factor 3	**Factor 4**	Factor 5
1	-1	-1	1	-1	-1
2	-1	-1	1	-1	-1
3	-1	-1	1	1	-1
4	0	0	0	0	0
Item 4: I was not distracted during this professional development.					
Judge	Factor 1	Factor 2	**Factor 3**	Factor 4	Factor 5
1	1	0	-1	1	-1
2	-1	-1	-1	1	-1
3	-1	-1	1	-1	-1
4	0	0	0	0	0
Item 5: The presentation methods used during the professional development helped me to focus.					
Judge	Factor 1	Factor 2	Factor 3	**Factor 4**	Factor 5
1	0	-1	1	-1	-1
2	-1	-1	1	-1	-1
3	-1	-1	1	1	-1
4	0	0	0	0	0
Item 6: The presentation methods used during the professional development helped me learn the content.					
Judge	Factor 1	**Factor 2**	Factor 3	Factor 4	Factor 5

1	-1	-1	1	-1	-1
2	1	-1	-1	-1	-1
3	1	1	-1	-1	-1
4	0	1	1	1	0

Item 7: I was able to concentrate on learning the presented content.

Judge	Factor 1	Factor 2	**Factor 3**	Factor 4	Factor 5
1	-1	0	1	0	-1
2	-1	-1	1	-1	-1
3	1	-1	1	-1	-1
4	0	0	0	0	1

Item 8: I had no difficulty understanding the content presented during the professional development.

Judge	**Factor 1**	Factor 2	Factor 3	Factor 4	Factor 5
1	-1	-1	1	-1	-1
2	1	-1	-1	-1	-1
3	1	-1	-1	-1	-1
4	0	0	0	0	1

Item 9: During this professional development, I was able to focus on learning the content.

Judge	Factor 1	Factor 2	**Factor 3**	Factor 4	Factor 5
1	-1	-1	1	-1	-1
2	-1	-1	1	-1	-1
3	1	-1	1	-1	-1
4	0	0	0	0	1

Item 10: I understood the content presented during the training.

Judge	**Factor 1**	Factor 2	Factor 3	Factor 4	Factor 5
1	-1	-1	1	-1	-1
2	1	-1	-1	-1	-1
3	1	-1	-1	-1	-1
4	0	0	0	0	1

Item 11: I intend to put into practice what I learned in this professional development.

Judge	Factor 1	Factor 2	Factor 3	Factor 4	**Factor 5**
1	-1	-1	-1	-1	1
2	-1	-1	-1	-1	1
3	1	-1	-1	-1	1
4	0	0	0	0	0

Item 12: I intend to use the technology presented during the professional development.

Judge	Factor 1	Factor 2	Factor 3	Factor 4	**Factor 5**

1	-1	-1	-1	-1	1
2	-1	-1	-1	-1	1
3	-1	-1	-1	-1	1
4	0	0	0	0	0

Item 13: I was able to manage the mental effort required to learn the content presented in this professional development.

Judge	**Factor 1**	Factor 2	Factor 3	Factor 4	Factor 5
1	1	1	-1	1	-1
2	-1	-1	1	-1	-1
3	-1	-1	1	-1	-1
4	1	1	1	1	-1

Item 14: The content presented during this professional development was not difficult for me to learn.

Judge	**Factor 1**	Factor 2	Factor 3	Factor 4	Factor 5
1	1	-1	1	-1	-1
2	1	-1	-1	-1	-1
3	1	-1	-1	-1	-1
4	0	0	0	0	1

Item 15: The trainer's instructional methods helped me learn the content presented.

Judge	Factor 1	**Factor 2**	Factor 3	Factor 4	Factor 5
1	1	-1	1	-1	-1
2	1	-1	-1	-1	-1
3	-1	1	-1	-1	-1
4	0	0	0	0	1

Item 16: The trainer's instructional methods helped me focus on the content presented.

Judge	Factor 1	Factor 2	Factor 3	**Factor 4**	Factor 5
1	-1	-1	1	-1	-1
2	-1	-1	1	-1	-1
3	-1	-1	-1	1	-1
4	0	0	0	0	1

Item 17: I will use the technology presented in this professional development in my classroom.

Judge	Factor 1	Factor 2	Factor 3	Factor 4	**Factor 5**
1	-1	-1	-1	-1	1
2	-1	-1	-1	-1	1
3	-1	-1	-1	-1	1
4	0	0	0	0	1

Item 18: I will use the technology presented in this professional development with my students.

Judge	Factor 1	Factor 2	Factor 3	Factor 4	**Factor 5**

1	-1	-1	-1	-1	-1
2	-1	-1	-1	-1	-1
3	-1	-1	-1	-1	-1
4	0	0	0	0	0

Note. Factors 1 through 5 indicate the following latent factors in order: ability to manage intrinsic load, influence of extraneous load on intrinsic load management, germane load, influence of extraneous load on germane load, and intent to adopt technology. Factor headings in bold indicate which factor the researcher intended each item to measure. Feedback values are as follows: 1 = measures this factor, -1 = does not measure this factor, 0 = ambivalent.

Table 4

Index of Item-Objective Congruence Values

Items	IIOC Value
1. The instruction provided in this professional development helped me learn the content.	-0.083
2. The materials used during this professional development helped me learn the content.	-0.111
3. The materials used during this professional development helped me concentrate.	0.028
4. I was not distracted during this professional development.	0.000
5. The presentation methods used during this professional development helped me to focus.	0.000
6. The presentation methods used during the professional development helped me learn the content.	0.111
7. I was able to concentrate on learning the presented content.	0.611
8. I had no difficulty understanding the content presented during the professional development.	0.389
9. During this professional development, I was able to focus on learning the content.	0.667
10. I understood the content presented during the training.	0.417
11. I intend to put into practice what I learned in this professional development.	0.694
12. I intend to use the technology presented during the professional development.	**0.750**

13. I was able to manage the mental effort required to learn the content presented in this professional development.	0.056
14. The content presented during this professional development was not difficult for me to learn.	0.667
15. The trainer's instructional methods helped me learn the content presented.	0.028
16. The trainer's instructional methods helped me focus on the content presented.	0.083
17. I will use the technology presented in this professional development in my classroom.	**0.889**
18. I will use the technology presented in this professional development with my students.	**0.750**

Note. IIOC values in bold are greater than or equal to 0.750 and thus indicate adequate content validity according to the judges' feedback.

The IIOC values presented in Table 4 indicate the survey instrument's overall content validity was inconclusive in terms of items intended to measure forms of cognitive load; thus Hypothesis 1 was not supported. The following results led the researcher to this determination. The IIOC values for items measuring cognitive load factors ranged from -0.111 to 0.667, all of which fall below the accepted baseline of 0.750 recommended by Turner and Carlson (2003). Although the IIOC values for the items measuring forms of cognitive load do not indicate content validity per the judges' feedback, the results do indicate the judges' general consensus that these items do measure some form of cognitive load. The mean judge ratings for cognitive load items on Factor 5, *intent to adopt technology*, ranged from -0.500 to -1.000 indicating at least three of the four judges agreed that each cognitive load item does measure a form of cognitive load rather than intent to adopt technology. However, the judges did not reach a clear consensus as to which form of cognitive load each item measures. The judges reached an overall consensus that items 11, 12, 17, and 18 measure intent to adopt technology with these items' IIOC values ranging from 0.694 to 0.889. While items 12, 17, and 18 had IIOC values of at least 0.750 indicating adequate content validity according to the judges' feedback (Turner & Carlson, 2003), the IIOC value for item 11 was slightly below 0.750. Based on results for item 11, some judges concluded this item may also measure intrinsic load: Judge 3 rated item 11 on Factor 1, *intrinsic load management*, as a 1 while Judge 4 assigned a 0 rating. (A rating of 1 means *measures this factor*, and a rating of 0 means *ambivalent*.) The inconclusive results of the IIOC indicate Hypothesis 1 was not supported. Even though the judges' feedback was inconclusive regarding the content validity of items measuring forms of cognitive load, the researcher retained all items in order to collect additional information through exploratory factor analysis following data collection.

Preliminary Reliability Estimate

Research Question 2 asked: *Does the instrument demonstrate internal consistency within the context of P-12 teachers self-reporting intent to adopt technology and cognitive load after participating in a single-session technology professional development?* From this question, the researcher proposed Hypothesis 2: *The instrument demonstrates internal consistency.* The researcher used Cronbach's alpha to obtain a preliminary estimate of the instrument's reliability early in the data collection process. Cronbach's alpha provides a measure of the instrument's internal consistency (Gliem & Gliem, 2003), and examining these values allowed the researcher to determine whether any amendments to the instrument were needed to improve reliability. After collecting data from the first two school districts visited during the data collection process, the researcher used SPSS to obtain Cronbach's alpha values for the entire instrument as well as each subsection. Data had been collected from $n = 56$ participants at this point in the data collection process. Table 5 provides the Cronbach's alpha values for the entire instrument as well as each subsection.

Table 5

Preliminary Reliability Estimates

Section	Cronbach's α
Factor 1	0.957

Factor 2	0.963
Factor 3	0.906
Factor 4	0.914
Factor 5	0.982
All Sections	0.979

Note. Factors 1 through 5 are subsections of the survey instrument respectively measuring the following latent constructs in order: ability to manage intrinsic load, influence of extraneous load on intrinsic load management, germane load, influence of extraneous load on germane load, and intent to adopt technology.

All Cronbach's alpha values were greater than 0.700, the commonly accepted baseline for measures of internal consistency (Gliem & Gliem, 2003). Therefore, Hypothesis 2 is supported by the results of the preliminary reliability estimate. No items were eliminated based on low estimates of reliability. Data collection proceeded without omissions to the survey instrument.

Exploratory Factor Analysis

Research Question 3 asks: *Does the instrument's factor structure account for most of the variability in the measured constructs?*; and Research Question 4 asks: *Do the instrument items demonstrate a theoretical factor structure?* From these questions, the researcher respectively drew the following hypotheses: *The instrument's factor structure accounts for most of the variability in the measured constructs*; *the instrument items demonstrate a theoretical factor structure*. The following section will discuss the procedures used for conducting exploratory factor analysis which served to answer the above research questions. The researcher used exploratory factor analysis to investigate an underlying causal factor structure explaining the variability in data collected through administering the self-report survey instrument designed as part of this study. Results of this analysis allowed the researcher determine whether the latent factor model apparent in the data is meaningful in terms of the theoretical framework. Results of the analysis also allowed the researcher to determine amount of variance explained by the latent factor model.

Sample

P-12 teachers who had participated in a one-hour technology professional development training conducted by the researcher served as the sample for this study. The researcher conducted technology professional development in fifteen school districts located throughout a state in the southwest region of the United States. At each school district, the researcher administered the survey immediately following the professional development. After collecting completed surveys, the researcher identified surveys with missing or duplicate responses, surveys from participants not responsible for providing instruction to students, and surveys from participants who reported having already participated in the professional development during a previous session. Having omitted these identified surveys, the research proceeded with data analysis using data collected from $n = 322$ participants. Researchers consider this sample size in relation to the number of items in the administered survey instrument adequate for data reduction methods (Costello & Osborne, 2005; Beavers et al., 2013). Table 6 presents descriptive statistics for the sample.

Table 6

Sample Descriptive Statistics

Variable	Freq.	%	Cum. %
Gender			
Male	70	21.7	21.7
Female	249	77.3	99.1
Other	3	0.9	100.0
Age in Years			
18-24	13	4.0	4.0
25-34	70	21.7	25.8
35-44	86	26.7	52.5
45-54	76	23.6	76.1
≥ 55	77	23.9	100.0
Ethnicity			
Native American	18	5.6	5.6
African American/Black	7	2.2	7.8
Asian/Pacific Islander	2	0.6	8.4
Caucasian/White	276	85.7	94.1
Hispanic/Latino	6	1.9	96.0
Other	13	4.0	100.0
School Level			
Elementary	154	47.8	47.8

Middle School	26	8.1	56.2
Junior High	25	7.8	64.0
High School	77	23.9	87.9
Other	40	12.4	100.0
District Location			
Urban	54	16.8	16.8
Suburban	40	12.4	29.2
Rural	228	70.8	100.0
Teaching Position			
Teacher	280	87.0	87.0
Administrator	1	0.3	87.3
Support Staff	8	2.5	89.8
Other	33	10.2	100.0
Teaching Experience			
1-5	76	23.6	23.6
6-10	50	15.5	39.1
11-15	49	15.2	54.3
16-20	54	16.8	71.1
21-25	32	9.9	81.1
≥ 26	61	18.9	100.0
Technology Expertise			
Technology Novice	95	29.5	29.7
Moderate Expertise	197	61.2	91.3
Technology Expert	27	8.4	99.7[a]
PowerPoint Expertise			
Technology Novice	140	43.5	43.5
Moderate Expertise	158	49.1	92.6
Technology Expert	23	7.1	99.7[a]

[a] One participant chose not to respond to this item.

As seen in Table 6, participants were fairly evenly distributed in terms of age, years of experience as a teacher, and whether they were elementary or secondary (middle, junior, or high school) teachers. The sample was unevenly distributed in terms of gender and ethnicity, with the majority of the participants being female (77.3%) and Caucasian (85%). The majority of the participants worked in rural school districts (70.8%). Most participants reported having low to moderate expertise in technology (91.3%) and in using the technology presented during the professional development (92.6%).

Descriptive Statistics

Participants completed an eighteen-item self-report survey instrument measuring factors related to cognitive load and intent to adopt technology on a six-point Likert-type scale. Table 7 presents descriptive statistics for each survey item.

Table 7

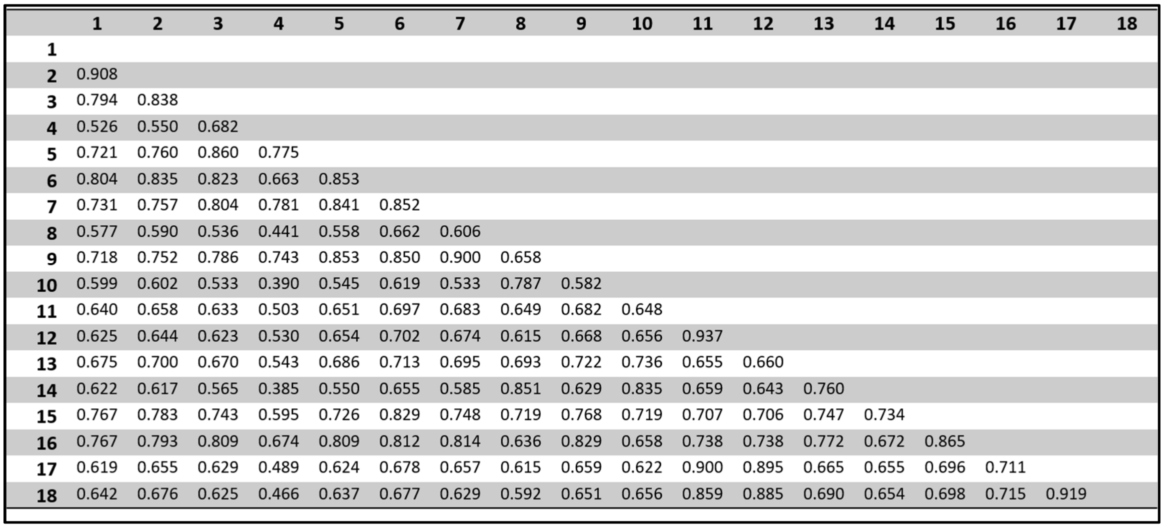
Survey Item Descriptive Statistics

Survey Item	Mean	SD
1. The instruction provided in this professional development helped me learn the content.	5.040	1.060
2. The materials used during this professional development helped me learn the content.	5.010	1.068
3. The materials used during this professional development helped me concentrate.	4.860	1.147
4. I was not distracted during this professional development.	4.590	1.383
5. The presentation methods used during the professional development helped me to focus.	4.850	1.133
6. The presentation methods used during the professional development helped me learn the content.	4.980	1.084
7. I was able to concentrate on learning the presented content.	4.820	1.211
8. I had no difficulty understanding the content presented during the professional development.	4.930	1.202
9. During this professional development, I was able to focus on learning the content.	4.890	1.165
10. I understood the content presented during the training.	5.090	1.070
11. I intend to put into practice what I learned in this professional development.	4.970	1.100
12. I intend to use the technology presented during the professional development.	4.950	1.137
13. I was able to manage the mental effort required to learn the content presented in this professional development.	5.060	1.045
14. The content presented during this professional development was not difficult for me to learn.	5.070	1.116
15. The trainer’s instructional methods helped me learn the content presented.	5.090	1.046
16. The trainer’s instructional methods helped me focus on the content presented.	5.020	1.041

17. I will use the technology presented in this professional development in my classroom.	4.980	1.141
18. I will use the technology presented in this professional development with my students.	5.000	1.118

Item means ranged from approximately 4.590 to 5.090 with standard deviations ranging from approximately 1.041 to 1.383. Thus, variability in item responses was fairly homogeneous across items.

The researcher examined the bivariate correlation matrix of survey items to assess the degree to which survey items correlated with one another. Figure 3 presents the bivariate correlation matrix.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1																		
2	0.908																	
3	0.794	0.838																
4	0.526	0.550	0.682															
5	0.721	0.760	0.860	0.775														
6	0.804	0.835	0.823	0.663	0.853													
7	0.731	0.757	0.804	0.781	0.841	0.852												
8	0.577	0.590	0.536	0.441	0.558	0.662	0.606											
9	0.718	0.752	0.786	0.743	0.853	0.850	0.900	0.658										
10	0.599	0.602	0.533	0.390	0.545	0.619	0.533	0.787	0.582									
11	0.640	0.658	0.633	0.503	0.651	0.697	0.683	0.649	0.682	0.648								
12	0.625	0.644	0.623	0.530	0.654	0.702	0.674	0.615	0.668	0.656	0.937							
13	0.675	0.700	0.670	0.543	0.686	0.713	0.695	0.693	0.722	0.736	0.655	0.660						
14	0.622	0.617	0.565	0.385	0.550	0.655	0.585	0.851	0.629	0.835	0.659	0.643	0.760					
15	0.767	0.783	0.743	0.595	0.726	0.829	0.748	0.719	0.768	0.719	0.707	0.706	0.747	0.734				
16	0.767	0.793	0.809	0.674	0.809	0.812	0.814	0.636	0.829	0.658	0.738	0.738	0.772	0.672	0.865			
17	0.619	0.655	0.629	0.489	0.624	0.678	0.657	0.615	0.659	0.622	0.900	0.895	0.665	0.655	0.696	0.711		
18	0.642	0.676	0.625	0.466	0.637	0.677	0.629	0.592	0.651	0.656	0.859	0.885	0.690	0.654	0.698	0.715	0.919	

Figure 3. Bivariate Correlation Matrix. This figure presents bivariate correlations between each item of the self-report survey instrument designed for this study.

Correlation values across items range from approximately 0.385 to 0.937 with most values falling between 0.400 and 0.800. Overall, the moderate to strong correlations present between items indicate the data are appropriate for principal axis factoring (PAF), a data reduction method appropriate for investigating factors exhibiting correlation (Costello & Osborne, 2005).

Principal Axis Factoring 1

This section presents results of the first iteration of exploratory factor analysis. Prior to conducting data reduction methods, the researcher verified the data met certain criteria and thus were appropriate for data reduction. First, the researcher examined the bivariate correlation matrix to determine whether correlations between items indicated shared relationships which should be present when sets of item responses are caused by common latent factors, as discussed in the previous section. Then the researcher examined the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO test), Bartlett's Test of Sphericity, and the correlation matrix determinant. The KMO value was 0.951, and the results of Bartlett's Test were significant with $p < 0.001$. A KMO value of at least 0.600 and significant Bartlett's test results indicate data are appropriate for data reduction (Beavers et al., 2013). The correlation matrix determinant was not equal to either zero or one which indicates the correlation matrix is neither singular nor equivalent to the identity matrix, conditions which would have indicated the data did not meet criteria for data reduction. These criteria having been met, the researcher proceeded to conduct PAF.

The researcher conducted PAF using SPSS. Results of parallel analysis supported the retention of two factors. The first two initial eigenvalues from the PAF results were respectively higher than the corresponding simulated eigenvalues, 1.438 and 1.349, produced through parallel analysis. Application of Kaiser's Criterion (retaining factors whose eigenvalues are greater than one) and results of the scree test (retaining factors falling along the vertical plot of the data before the horizontal bend on the scree plot) corroborated the retention of two factors. Table 8 presents initial eigenvalues and variance explained.

Table 8

Initial Eigenvalues

Factor	Eigenvalue	% of Var.	Cum. %
1	**12.821**	**71.228**	**71.228**
2	**1.450**	**8.055**	**79.282**
3	0.970	5.387	84.669

4	0.637	3.536	88.205
5	0.322	1.790	89.995
6	0.258	1.434	91.429
7	0.248	1.377	92.806
8	0.209	1.161	93.966
9	0.180	1.002	94.968
10	0.163	0.906	95.874
11	0.145	0.804	96.678
12	0.129	0.717	97.395
13	0.113	0.630	98.025
14	0.084	0.466	98.491
15	0.081	0.448	98.939
16	0.073	0.405	99.344
17	0.070	0.389	99.734
18	0.048	0.266	100.000

Note. Factors in bold were retained based on results of parallel analysis, Kaiser's Criterion, and results of the scree test.

According to initial eigenvalues, the retained factors accounted for approximately 79.282% of the variance in the data, which indicates good model fit according to researchers (Beavers et al., 2013). Communalities were sufficiently high across items which is also indicative of good model fit. Table 9 presents initial and extracted item communalities.

Table 9

Communalities

Item	Initial	Extracted	Item	Initial	Extracted
1	0.841	0.706	10	0.770	0.681
2	0.879	0.761	11	0.908	0.796
3	0.835	0.820	12	0.913	0.789
4	0.709	0.605	13	0.737	0.696

5	0.866	0.859	14	0.830	0.715
6	0.872	0.857	15	0.837	0.787
7	0.873	0.854	16	0.860	0.837
8	0.788	0.635	17	0.898	0.782
9	0.867	0.840	18	0.884	0.780

An item's extracted communality is the percentage of variability in participant responses to that item attributed to the retained factors. Extracted communalities for all items were greater than 0.600 with several items having communalities greater than 0.800. These values indicate the retained factors accounted for the majority of the variance in each item. Finally, only 22% of the residuals computed between the observed and reproduced correlation matrix were greater than 0.05 which is also indicative of a good model fit. Ideally, one would like to see the reproduced correlation matrix to be as close as possible to the observed correlation matrix and thus minimal residuals. These results which indicate the latent factor model accounts for the majority of the variability in the data support Hypothesis 3.

Due to the moderate to high correlations apparent among items according to the bivariate correlation matrix, the researcher applied a Promax rotation. Promax is an oblique rotation method appropriate when investigating factors likely to exhibit correlational relationships (Osborne, 2015), as with the two retained factors in the current model which exhibited a correlation of 0.769. Table 10 presents the pattern matrix of rotated factor loadings with loadings less than 0.100 constrained. Figure 4 presents a box plot of the rotated factor loadings of the pattern matrix.

Table 10

Pattern Matrix

Item	Factor 1	Factor 2
1. The instruction provided in this professional development helped me learn the content.	**0.652**	0.228

2. The materials used during this professional development helped me learn the content.	**0.700**	0.211
3. The materials used during this professional development helped me concentrate.	**0.923**	
4. I was not distracted during this professional development.	**0.906**	-0.178
5. The presentation methods used during the professional development helped me to focus.	**0.971**	
6. The presentation methods used during the professional development helped me learn the content.	**0.786**	0.173
7. I was able to concentrate on learning the presented content.	**0.919**	
8. I had no difficulty understanding the content presented during the professional development.		**0.752**
9. During this professional development, I was able to focus on learning the content.	**0.841**	
10. I understood the content presented during the training.		**0.873**
11. I intend to put into practice what I learned in this professional development.		**0.857**
12. I intend to use the technology presented during the professional development.		**0.850**
13. I was able to manage the mental effort required to learn the content presented in this professional development.	0.324	**0.559**
14. The content presented during this professional development was not difficult for me to learn.		**0.874**
15. The trainer's instructional methods helped me learn the content presented.	**0.477**	**0.467**
16. The trainer's instructional methods helped me focus on the content presented.	**0.653**	0.311
17. I will use the technology presented in this professional development in my classroom.		**0.874**
18. I will use the technology presented in this professional development with my students.		**0.875**

Note. Values in bold are strong loadings, or loadings of at least 0.400. Loadings less than 0.100 were constrained.

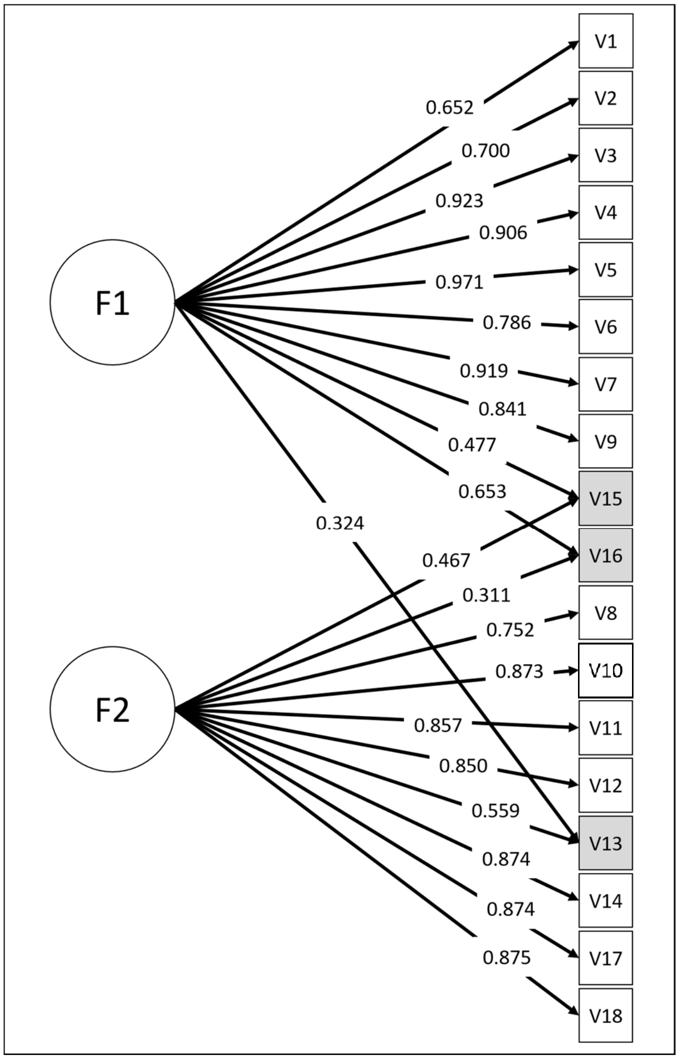


Figure 4. Plot of rotated factor loadings. This figure displays the rotated factor loadings of each item, or variable. Loadings less than 0.300 are not shown. Variables 13, 15, and 16 are gray because they each exhibit loadings of at least 0.300 on both factors.

Factor loadings greater than or equal to 0.500 are considered strong loadings (Costello & Osborne, 2005), thus most items exhibited a strong loading on at least one factor according to the pattern matrix. However, item 15 strongly cross loaded on both factors with respective factor loadings of $\lambda_{151} = 0.477$ and $\lambda_{152} = 0.467$. Additionally, items 13 and 16 each demonstrated a loading of at least 0.300 on a second factor. Item 13 exhibited a loading of 0.324 on factor 1 and a loading of 0.559 on factor 2, while item 16 exhibited a loading of 0.653 on factor 1 and a loading of 0.311 on factor 2. In view of the moderate to strong cross loadings exhibited by items 13, 15, and 16, the researcher removed these items and reconducted PAF on the remaining items to assess the potential improvement of the model. Researchers recommend reapplying factor analysis methods when identified weak items are removed (Beavers et al., 2013). The following section reports the results of the second analysis.

Principal Axis Factoring 2

This section presents results of the second iteration of exploratory factor analysis which the researcher conducted due to the poorly loading items apparent in the results of the first iteration. With items 13, 15, and 16 removed, the data continued to meet the criteria for data reduction methods. The KMO value was 0.937, and the results of Bartlett's Test were significant with $p < 0.001$. The correlation matrix determinant remained unequal to either zero or one. Thus, the researcher proceeded with a second iteration of PAF.

Results of parallel analysis continued to support the retention of two factors with the first two initial eigenvalues from the PAF results being respectively higher than the corresponding simulated eigenvalues, 1.382 and 1.297. Application of Kaiser's Criterion and results of the scree test also supported the retention of two factors. Similar to the results of the first analysis, the retained factors shared a strong relationship with a correlation value of 0.745. Table 11 compares the initial eigenvalues and variance explained of the two iterations of PAF.

Table 11

Comparison of Initial Eigenvalues for Extracted Factors

PAF 1			PAF 2		
Factors	Eigenvalues	Cum. % Var.	Factors	Eigenvalues	Cum. % Var.
1	12.821	71.228	1	10.535	70.236
2	1.450	79.282	2	1.428	79.759

According to initial eigenvalues of the second analysis, the retained factors accounted for approximately 79.759% of the variance in the data, an increase of 0.477% explained variance from the first model which indicates a very slight improvement in model fit. Communalities continued to be high across items, as indicated below in Table 12.

Table 12

Communalities

Item	Initial	Extracted	Item	Initial	Extracted
1	0.839	0.700	9	0.861	0.841
2	0.877	0.757	10	0.755	0.636
3	0.831	0.820	11	0.907	0.835
4	0.704	0.599	12	0.912	0.825
5	0.862	0.866	14	0.817	0.669
6	0.857	0.861	17	0.898	0.818
7	0.871	0.860	18	0.882	0.807
8	0.782	0.608			

Extracted communalities for all items were at least 0.599 indicating the retained factors accounted for the majority of the variability in each item. The number of residuals computed from the observed and reproduced correlation matrices greater than 0.05 increased slightly by 4%; however, having only 26% of residuals above 0.05 indicates acceptable model fit. Hypothesis 3 continues to be supported by these findings.

The researcher applied a Promax oblique rotation. Table 13 presents the pattern matrix of rotated factor loadings with loadings less than 0.100 constrained, and Figure 5 presents a box plot of the rotated factor loadings exhibited by the new factor model.

Table 13

Pattern Matrix

Item	Factor 1	Factor 2
1. The instruction provided in this professional development helped me learn the content.	**0.648**	0.233
2. The materials used during this professional development helped me	**0.694**	0.220

learn the content.		
3. The materials used during this professional development helped me concentrate.	**0.900**	
4. I was not distracted during this professional development.	**0.872**	-0.139
5. The presentation methods used during the professional development helped me to focus.	**0.951**	
6. The presentation methods used during the professional development helped me learn the content.	**0.782**	0.185
7. I was able to concentrate on learning the presented content.	**0.902**	
8. I had no difficulty understanding the content presented during the professional development.	0.116	**0.690**
9. During this professional development, I was able to focus on learning the content.	**0.830**	0.113
10. I understood the content presented during the training.		**0.796**
11. I intend to put into practice what I learned in this professional development.		**0.886**
12. I intend to use the technology presented during the professional development.		**0.879**
14. The content presented during this professional development was not difficult for me to learn.		**0.794**
17. I will use the technology presented in this professional development in my classroom.		**0.900**
18. I will use the technology presented in this professional development with my students.		**0.891**

Note. Values in bold are strong loadings, or loadings of at least 0.400. Loadings less than 0.100 were constrained.

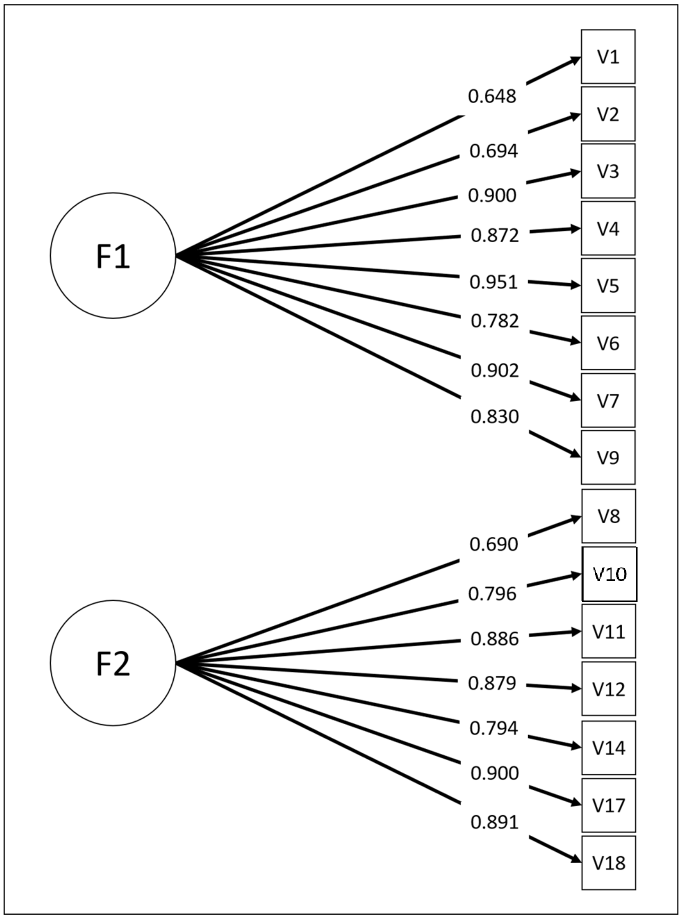


Figure 5. Plot of rotated factor loadings. This figure displays the rotated factor loadings of each item, or variable. Loadings less than 0.300 are not shown.

As seen in the pattern matrix in Table 13 and in Figure 5, the factor loadings followed a simple structure as opposed to the factor loadings seen in the results of the first PAF. In a factor model exhibiting simple structure, each item loads strongly on a single factor and each factor is represented by several items (Beavers et al., 2013). The simple structure seen in the second analysis indicates a plausible model with a slightly better fit than seen in the results of the second analysis. After examining the factor loadings seen in the pattern matrix, the researcher tentatively concluded the two-factor structure is theoretically meaningful and provides support for Hypothesis 4. How this model is meaningful in terms of the theoretical framework and thus supportive of Hypothesis 4 will be discussed in the following chapter in which the researcher will present tentative conclusions based on the results of these analyses.

Summary

This chapter presented the results of data analyses conducted as part of the instrument design process. The researcher presented the results of the IIOC procedure for assessing the instrument's content validity followed by a preliminary analysis of reliability. Then, the researcher presented results of exploratory factor analysis through which the researcher examined the underlying causal factor structure accounting for the variability in data collected through administering the newly designed instrument to P-12 teachers who had participated in a single-session technology professional development. In Chapter 5, the researcher will make tentative conclusions based on the results of these analyses as well as present a plan for seeking validation for the instrument designed in this study.

CHAPTER V

DISCUSSION, CONCLUSIONS, AND IMPLICATIONS

The purpose of this study was to design a self-report survey instrument measuring P-12 teachers' cognitive load experienced during technology professional development and their intent to adopt technology. Access to a validated instrument measuring the latent constructs of cognitive load and intent to adopt technology may open the door for research on the relationship between these constructs in the education field. This chapter will begin with a summary of the results presented in Chapter 4 and continue with the researcher's tentative conclusions drawn from these results, discussion of the next steps the researcher will take in the process of developing the instrument designed in this study, limitations of this study, and implications for future research.

Summary of Results

During the development of a self-report survey instrument measuring cognitive load experienced by P-12 teachers during technology professional development and their intent to adopt technology, the researcher conducted methods for assessing content validity and reliability and for exploring the underlying causal factor structure accounting for the variability in item responses. These analyses sought support for the following hypotheses.

Hypothesis 1: The results of the Index of Item-Objective Congruence Support the Instrument's Content Validity

The researcher collected feedback from content experts who served as judges to conduct an index of item-objective congruence (IIOC) for determining content validity. While this procedure verified the judges were able to differentiate between items measuring cognitive load and items measuring intent to adopt technology, the low IIOC measures across cognitive load items indicated their lack of consensus as to which form of cognitive load each item measures. As content validity was inconclusive based on the IIOC results, Hypothesis 1 was not supported.

Hypothesis 2: The Instrument Demonstrates Internal Consistency

The researcher assessed the reliability of the instrument using Cronbach's alpha with data collected from the first two school districts who participated in data collection and found the instrument had a strong internal consistency. Cronbach's alpha values for the entire instrument as well as each subsection were high, indicating the instrument demonstrated internal consistency. Thus, Hypothesis 2 was supported.

Hypothesis 3: The Instrument's Factor Structure Accounts for Most of the Variability in the Measured Constructs

To investigate the underlying factor structure of the observed data, the researcher conducted principal axis factoring (PAF) with a Promax rotation. Results of PAF indicated sufficient explained variance and high communalities. However, the researcher identified three items loading on two factors with moderate to strong loadings. The researcher removed the items and reapplied data reduction methods to assess improvement in the model with the cross-loading items removed. Results of the second iteration of PAF showed a model exhibiting a simple structure accounting for the majority of the variability in the observed data. Hypothesis 3 was supported by these findings.

Hypothesis 4: The Instrument Items Demonstrate a Theoretical Factor Structure

Results of parallel analysis, application of Kaiser's Criterion, and scree test results supported a two-factor model. Upon examination of the rotated factor loadings, the researcher tentatively concludes this structure aligns with theory, which will be discussed later in this chapter.

Discussion and Conclusions

This section will discuss the researcher's tentative conclusions drawn from data analysis results which will direct the researcher toward continuing developments and validation of the instrument designed in this study. The researcher will provide discussion of conclusions made based on the results of each analysis conducted as part of the instrument design process beginning with content validity and followed by exploratory factor analysis. The discussions presented below will reference the results of analyses as necessary to provide clarification and/or justification for conclusions.

Content Validity

Feedback from the IIOC indicated the content experts who served as judges by participating in a blind rating of each item's content validity succeeded in differentiating between items measuring cognitive load and items measuring intent to adopt technology. However, the judges did not reach a consensus as to which form of cognitive load is being measured by each cognitive load item. This lack of clear consensus coincides with the limited success of prior attempts in research to operationalize and measure individual forms of cognitive load (Beckmann, 2010). Items designed to measure intent to adopt technology had the highest IIOC values with only one of these values falling slightly below the 0.750 accepted benchmark for adequate content validity. Item 11 had an IIOC value of 0.694. The lower IIOC value for this item may have originated from the inclusion of the term *learned* as follows: 'I intend to put into practice what I *learned* in this professional development.' How well one learns target content is indicative of the extent to which one processes the intrinsic load of a learning task (Sweller, 2010). Therefore, item 11 can also be a measure of intrinsic load, and the judges' feedback seemed to reflect this point. The factor analysis results corroborated this view in that item 11 loaded onto the same factor as items measuring intrinsic load. Content validity assurance measures for cognitive load items may be more obtainable through experimental studies in which researchers manipulate cognitive load factors and then measure the effects of these manipulations, as with Debue and van de Leemput's (2014) study on differentiating individual forms of cognitive load in measurement. Whether the results of such experimental manipulations align with theory may provide evidentiary support that certain survey items are validly measuring certain forms of cognitive load. As discussed in Chapter 2, not all cognitive load researchers who have reported success in differentiating measures of cognitive load in its respective forms have provided content validity assurance for their instruments. For example, even though Leppink et al. (2013) provided statistical validation for the instrument they claimed measured each form of cognitive load, they provided no evidence of content validity. Researchers seeking to operationalize and measure individual forms of cognitive load may need to examine the content validity of their instruments with greater scrutiny.

Exploratory Factor Analysis

The researcher conducted two iterations of PAF with a Promax rotation in order to arrive at a factor model demonstrating a simple structure and accounting for the majority of the variance in the data. The researcher concluded the factor model seen in the results of the second analysis, in which poorly loading items were removed, was the better fitting model due to its simple structure and slight increase in variance explained. Results of parallel analysis, Kaiser's Criterion, and scree test results supported the retention of two factors. The two retained factors accounted for 79.759% of the variance in the observed data according to the initial eigenvalues of the retained factors, and items had high extracted communalities ranging from 0.599 to 0.866 - nine of fifteen items had extracted communalities greater than or equal to 0.800. Extracted communalities reflect the variance accounted for in an item by the retained factors, thus the retained factors accounted for the majority of the variance in each item. The high extracted communalities and total variance explained according to initial eigenvalues as well as the low percentage of residuals greater than 0.05 derived from the reproduced correlation matrix together support the model as good fit for the observed data.

The presence of weakly loading items in the results of the first PAF prompted the researcher to omit those items and conduct a second iteration of PAF. The researcher omitted items 13 (*I was able to manage the mental effort required to learn the content presented in this professional developmen*t), 15 (*the trainer's instructional methods helped me learn the content presented*), and 16 (*the trainer's instructional methods helped me focus on the content presented*). These items demonstrated moderate to strong cross loadings on the retained factors and thus were considered poorly loading items. Item 13 may have exhibited a poor loading due to inconsistent understanding or lack of understanding among participants of the term "mental effort." Two surveys were received in which the participants wrote question marks or comments by this item. In administering the survey in person, the researcher occasionally observed verbal comments exchanged among participants related to this item. The IRB-approved protocol for this study does not allow for collection of verbal or written feedback from participants, field observations, or the recording of field notes. In future research, including these forms of data collection in the research protocol might be advisable, as impromptu verbal or written feedback from participants on the instrument may add insight to interpretation of research findings. Interestingly, item 13 is the most similar item in the instrument to the Paas scale (1992) in which participants are asked to rate their level of mental effort on a nine-point scale. The Paas scale is the one of the most common means of obtaining subjective measures of intrinsic load (Sweller et al., 2012). However, the Paas scale has not been widely used in the population of interest in this study. The weak loading of item 13 suggests having members of this population self-report their "mental effort" may not be an effective means of measuring intrinsic load. Items 15 and 16 were the only items that directly addressed the trainer's efforts in delivering instruction during professional development. As the researcher conducted the professional development and then administered the survey in person, participants' levels of comfort in responding to these questions may have been a source of error in their responses. Administering the original eighteen-item survey online to a new sample after training has been conducted may be a means of minimizing this potential source of error.

The researcher tentatively concluded the rotated factor loadings and two-factor structure were theoretically meaningful and thus supports Hypothesis 4. The researcher made the following interpretations of the latent factors which emerged from PAF analysis. The pattern matrix of rotated factor loadings from the second analysis showed items measuring variables related to extraneous load and germane load loading onto Factor 1. Items measuring intrinsic load and intent to adopt technology loaded onto Factor 2. Thus, while intrinsic load and intent to adopt technology loaded on one factor, variables affecting a learner's ability to process intrinsic load loaded on the other factor. Paas et al. (2003) pointed out in their discussion of cognitive load measurement that extraneous load and germane load are both dependent on instructional design. Therefore, Factor 1 might be interpreted as cognitive load related to the effectiveness of instructional design decisions while factor 2 is related to learner outcomes. Items loading on Factor 2 addressed how well participants understood or learned the content of the professional development and whether they intend to use the content. The fact that participants' ability to process the intrinsic load of learning to use a technology and their intent to adopt the technology loaded onto a single factor provides compelling support for the existence of a relationship between these constructs. In addition, factors 1 and 2 shared a strong correlational relationship of 0.745. Thus, extraneous and germane load also appeared to be strongly related to participants' intrinsic load management and intent to adopt technology. As Paas et al. (2003) pointed out, individual forms of cognitive load are highly correlated, and the strength of this relationship was evident in the data collected for this study. This study's findings suggest cognitive load plays an influential role in P-12 teachers' intent to adopt technology. Difficulty in differentiating measures of cognitive load in its respective forms may originate from the strong correlative relationships between the forms, as seen in the results of this analysis. Continued research is needed for investigating whether these relationships are consistently strong in other contexts. Experimental research in which variables hypothesized to affect certain forms of cognitive load are manipulated may assist in differentiating between the forms in measurement. As the observed factor structure was meaningful in terms of the theoretical framework, the researcher proposes the results of exploratory factor analysis support Hypothesis 4. The resulting two-factor model resonates with theory and may provide insight into the nature of the relationships among cognitive load forms and their influence on technology adoption decisions.

Future Research

Continued research is needed to determine whether the two-factor model demonstrated by the results of the second PAF analysis will generalize to other samples, technologies, and professional developments. In terms of the continuing development of the instrument designed in this study, the researcher will collect data from a new sample of P-12 teachers who complete a technology professional development on a different technology and facilitated by a different trainer. Upon acquiring an appropriately large sample size, the researcher will conduct confirmatory factor analysis (CFA) to determine whether the two-factor model supported by the current study remains stable in a new context. CFA will be a means of providing validation for the instrument through fit statistics indicating the two-factor model's goodness of fit. Pending successful validation of the instrument, the researcher will use the instrument in future experimental research to investigate the relationship between cognitive load and technology adoption as well as best practices in conducting technology professional development for P-12 teachers. This study's findings clearly suggest cognitive load during technology professional development plays an influential role in P-12 teacher's willingness to adopt the technology for which they receive training to use. Awareness of the importance of helping teachers manage the cognitive load of learning technology, administrators and technology trainers can make better informed decisions in designing professional development and providing support to facilitate teachers' effective integration of technology in the classroom.

Additional insight into factors related to cognitive load and intent to adopt technology may also be available through continued analysis of the dataset collected for the current study. In view of this possibility, the researcher will investigate trends in cognitive load and intent to adopt technology in terms of the available descriptive data. Using multivariate analysis methods such as multilevel modeling, the researcher can investigate how variables such as gender, age, teaching experience, and self-reported technology expertise might influence cognitive load and technology adoption and whether these relationships are influenced by district-level variables. As little ground has been covered in research on P-12 teachers' cognitive load, prospects for future research in this domain are considerable.

Limitations

Certain limitations may affect the interpretation of this study's findings. A two-factor structure was demonstrated during analysis of data collected from P-12 teachers participating in a single session professional development on creating interactive lessons using PowerPoint, but it remains to be seen whether this factor structure will remain stable in other contexts. As discussed in the previous section, the researcher must collect data from other samples to determine whether the factor structure observed in this study generalized to other contexts and to provide validation for the instrument. The sample lacks diversity in terms of gender, ethnicity, and district location. The majority of the participants are female, Caucasian, and/or teaching in rural school districts. However, the lack of diversity in the sample may be reflective of the lack of diversity among P-12 teachers in the state where data collection took place. Another potential limitation of the study is that the researcher conducted professional development for the participants and then immediately administered the survey instrument in person upon completion of the professional development. If participants felt discomfort completing a survey soliciting feedback on their experience during the professional development in close proximity to the professional development facilitator, this discomfort may have been a source of potential error in measurement. This study is also limited in that the designed survey instrument asks participants to self-report their intent to adopt technology which may not translate to actual adoption in the future. Finally, this study is limited in the lack of consensus on the instrument's content validity during the IIOC procedure. However, the instrument's content did receive general approval from a researcher who has expertise in Cognitive Load Theory. In any case, continued research on cognitive load and intent to adopt technology among P-12 teachers can examine and evaluate the influence of these potential sources of error.

Implications

Despite the limitations discussed in the above section, this study laid the groundwork for providing a means to measure the latent constructs of cognitive load and intent to adopt technology among P-12 teachers and provided evidence supporting an influential relationship between these constructs. The instrument demonstrated a meaningful two-factor structure resonating with the theoretical framework. The resulting factor model suggests a potentially significant relationship between cognitive load and intent to adopt technology is plausible due to the fact that items measuring intent to adopt technology and intrinsic load management loaded onto a single factor. Further, the second factor on which items measuring extraneous and germane load exhibited strong loadings shared a strong correlation with the first factor which illustrates the potentially strong influences present between forms of cognitive load and intent to adopt technology. The researcher proposes the findings of this study provide a sufficient warrant for continued research on P-12 teachers' cognitive load and intent to adopt technology. Continued research in this area can lead to improvement in professional development practices and more effective diffusion and integration of educational technology in P-12 education.

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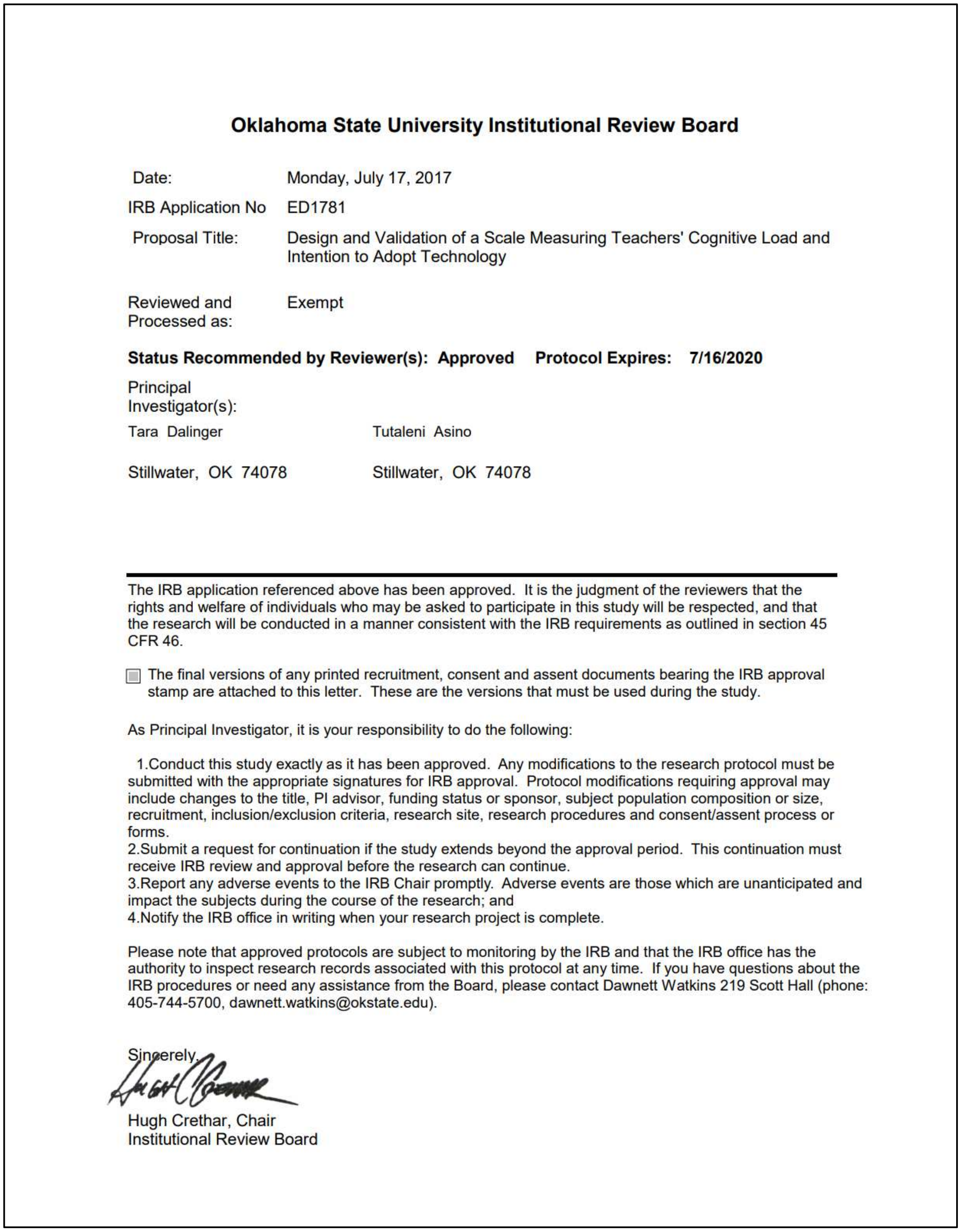
APPENDICES

Appendix A: IRB Approvals

IRB Approval as Exempt



Oklahoma State University Institutional Review Board

Date:	Monday, July 17, 2017
IRB Application No	ED1781
Proposal Title:	Design and Validation of a Scale Measuring Teachers' Cognitive Load and Intention to Adopt Technology
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 7/16/2020

Principal Investigator(s):

Tara Dalinger	Tutaleni Asino
Stillwater, OK 74078	Stillwater, OK 74078

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:

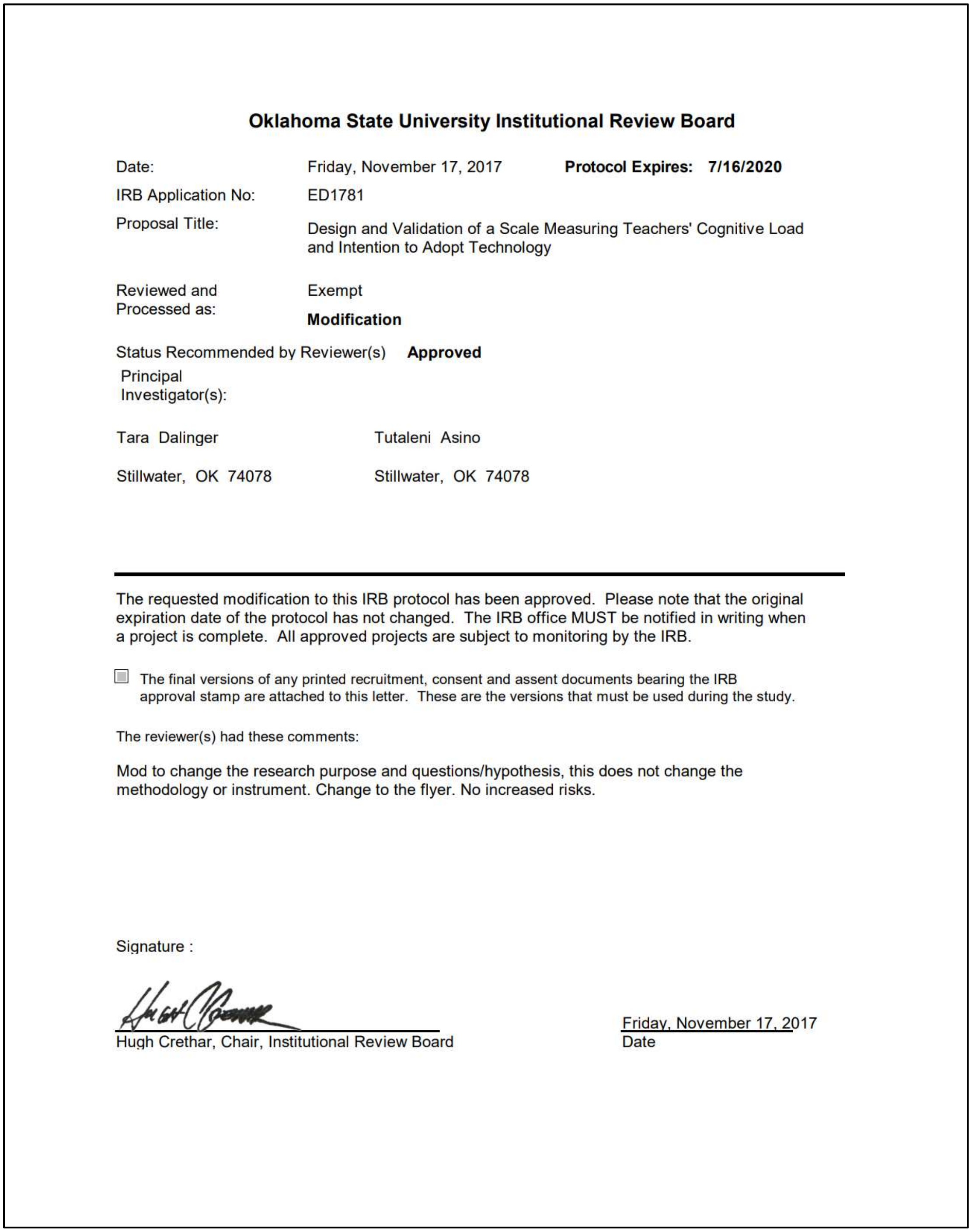
1.Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition 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 Scott Hall (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Hugh Crethar, Chair
Institutional Review Board

IRB Approval of Modifications



Oklahoma State University Institutional Review Board

Date:	Friday, November 17, 2017	**Protocol Expires: 7/16/2020**
IRB Application No:	ED1781	
Proposal Title:	Design and Validation of a Scale Measuring Teachers' Cognitive Load and Intention to Adopt Technology	
Reviewed and Processed as:	Exempt **Modification**	

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s):

Tara Dalinger	Tutaleni Asino
Stillwater, OK 74078	Stillwater, OK 74078

The requested modification to this IRB protocol has been approved. Please note that the original expiration date of the protocol has not changed. The IRB office MUST be notified in writing when a project is complete. All approved projects are subject to monitoring by the IRB.

☐ 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.

The reviewer(s) had these comments:

Mod to change the research purpose and questions/hypothesis, this does not change the methodology or instrument. Change to the flyer. No increased risks.

Signature :

Hugh Crethar, Chair, Institutional Review Board

Friday, November 17, 2017
Date

Appendix B: Self-Report Survey Instrument

Technology Professional Development Survey

The following survey will ask questions about your experience during this professional development and whether you are likely to use the technology presented during the training. Your participation allows us to make improvements to the survey for future research. Your thoughtful consideration of each item and honest feedback are much appreciated. Thank you so much for your participation!

1. What is your gender identification (Please circle your response.)?

Male **Female** **Other**

2. Your age falls into which of the following ranges (Please circle your response.)?

18 - 24 **25 - 34** **35 - 44** **45 - 54** **55+**

3. Which best describes your ethnicity (Please circle your response.)?

Native American **African American/Black** **Asian/Pacific Islander** **Caucasian/White** **Hispanic/Latino** **Other**

4. Which of the following best describes the school where you teach (Please circle all that apply.)?

Elementary **Middle School** **Junior High** **High School** **Other**

5. Which of the following best describes your position at your school (Please circle your response.)?

Teacher **Administrator** **Support Staff** **Other**

6. Are you responsible for providing instruction to one or more classes of students (Please circle your response.)?

Yes **No**

7. How many years of experience do you have as a professional educator (Please circle your response.)?

1 – 5 **6 – 10** **11 – 15** **16 – 20** **20 – 25** **26 or more**

8. Which best describes your level of expertise in using technology for instruction (Please circle your response.)?

Technology Novice **Moderate Expertise** **Technology Expert**

9. Which best describes your prior level of expertise in using the technology presented during this professional development (Please circle your response.)?

Technology Novice **Moderate Expertise** **Technology Expert**

10. Is this the first time you attended this professional development with this trainer (Please circle your response.)?

Yes **No**

Indicate the degree to which you agree with the statements below according to the following scale. **6 = Strongly Agree** **5 = Agree** **4 = Somewhat Agree** **3 = Somewhat Disagree** **2 = Disagree** **1 = Strongly Disagree**						
	1	**2**	**3**	**4**	**5**	**6**
1. The instruction provided in this professional development helped me learn the content.						
2. The materials used during this professional development helped me learn the content.						
3. The materials used during this professional development helped me concentrate.						
4. I was not distracted during this professional development.						
5. The presentation methods used during the professional development helped me to focus.						
6. The presentation methods used during the professional development helped me learn the content.						

7. I was able to concentrate on learning the presented content.						
8. I had no difficulty understanding the content presented during the professional development.						
9. During this professional development, I was able to focus on learning the content.						
10. I understood the content presented during the training.						
11. I intend to put into practice what I learned in this professional development.						
12. I intend to use the technology presented during the professional development.						
13. I was able to manage the mental effort required to learn the content presented in this professional development.						
14. The content presented during this professional development was not difficult for me to learn.						
15. The trainer's instructional methods helped me learn the content presented.						
16. The trainer's instructional methods helped me focus on the content presented.						
17. I will use the technology presented in this professional development in my classroom.						
18. I will use the technology presented in this professional development with my students.						

Appendix C: Index of Item-Objective Congruence Judge Form

Content Validity Check Form

The following scale measures P-12 teachers' cognitive load during technology professional development and their intent to adopt the technology for professional or pedagogical use. P-12 teachers who will have just participated in technology professional development will receive this scale. Cognitive Load Theory and Diffusion of Innovations theory supply the theoretical framework for this instrument's design.

Each item of this scale measures one of the following latent constructs on a 1-6 Likert-type scale representing a continuum of agreement to disagreement. Please carefully review the latent constructs and their operational definitions below. Then complete the table per the instructions provided to indicate which construct you believe each item measures.

- **Ability to manage intrinsic cognitive load**: Intrinsic cognitive load is the mental load which individuals must process to learn target content. One's ability to manage intrinsic load is evident in how well one understands the content or the perceived difficulty or ease of learning the content.
- **Influence of extraneous cognitive load on intrinsic load management:** Extraneous cognitive load is mental load originating from variables related to the instructional delivery of the target content. These variables are not directly related to the target content and can be an impediment to managing intrinsic load. Sources of extraneous cognitive load can include poor design of presentation materials or media used during teaching or ineffective methods of instruction used to present content. Individuals perceiving instructional methods, materials, or media as not contributing to their learning of target content is indicative of the influence of extraneous cognitive load on intrinsic cognitive load management.
- **Germane cognitive load:** Germane load refers to the mental resources an individual devotes to learning. Application of germane load is evident in a learner's ability to concentrate or focus on learning the target content.
- **Influence of extraneous cognitive load on germane cognitive load:** Extraneous cognitive load is mental load originating from variables related to the instructional delivery of the target content. These variables are not directly related to the target content and can be an impediment to managing intrinsic load. Sources of extraneous cognitive load can include poor design of presentation materials or media used during teaching or ineffective methods of instruction used to present content. Individuals perceiving instructional methods, materials, or media as not helping them to focus or concentrate on the target content is indicative of the influence of extraneous cognitive load on germane cognitive load.
- **Intent to Adopt Technology:** Intent to adopt to technology is one's willingness to begin using a technology. One who considers adopting a particular technology has not actively made prior use of it. Intent to adopt technology is evident when one expresses willingness or to make use of a technology in the future.

Please indicate which construct(s) each item measures using the values below. When the form is complete, each empty cell should have one of the values below. The first three items are examples and are not actually part of the scale.

1 = This item measures this construct.
0 = It is ambiguous
-1 = This item does not measure this construct.

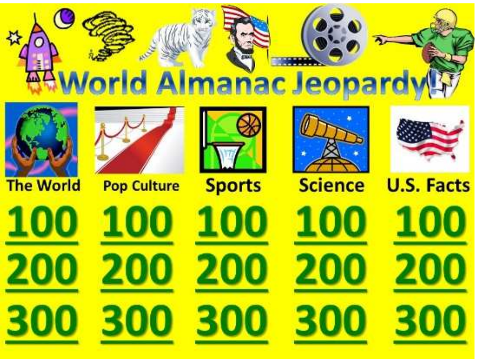
Measurement Item	Ability to Manage Intrinsic Load	Influence of Extraneous Load on Intrinsic Load Management	Germane Load	Influence of Extraneous Load on Germane Load	Intent to Adopt Technology
Example: I will probably use the technology in the future.	**-1**	**-1**	**-1**	**-1**	**1**
Example: Learning about this technology was too hard.	**1**	**-1**	**-1**	**-1**	**-1**
1. The instruction provided in this professional development helped me learn the content.					
2. The materials used during this professional development helped me learn the content.					
3. The materials used during this professional development helped me concentrate.					
4. I was not distracted during this professional development.					
5. The presentation methods used during the professional development helped me to focus.					
6. The presentation methods used during					

the professional development helped me learn the content.					
7. I was able to concentrate on learning the presented content.					
8. I had no difficulty understanding the content presented during the professional development.					
9. During this professional development, I was able to focus on learning the content.					
10. I understood the content presented during the training.					
11. I intend to put into practice what I learned in this professional development.					
12. I intend to use the technology presented during the professional development.					
13. I was able to manage the mental effort required to learn the content presented in this professional development.					
14. The content presented during this professional development was not too difficult for me to learn.					
15. The trainer's instructional methods helped me learn the content presented.					

16. The trainer’s instructional methods helped me focus on the content presented.					
17. I will use the technology presented in this professional development in my classroom.					
18. I will use the technology presented in this professional development with my students.					

Appendix D: PowerPoint Interactive Lesson Example

World Almanac Jeopardy



World Almanac Jeopardy

The World	Pop Culture	Sports	Science	U.S. Facts
100	100	100	100	100
200	200	200	200	200
300	300	300	300	300

Who was Germany's first female chancellor?

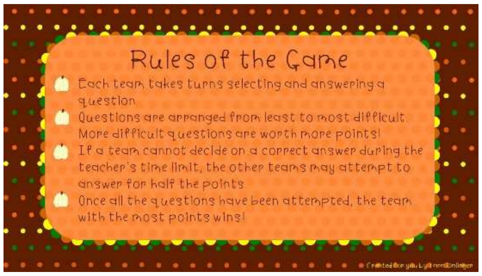
Angela Merkel

Appendix E: Resources Provided to Teachers after Professional Development Training

Pumpkin Patch Game Play: Gamified Interactive PowerPoint Activity

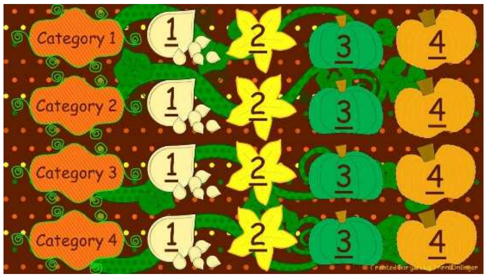
Pumpkin Patch Game Play!

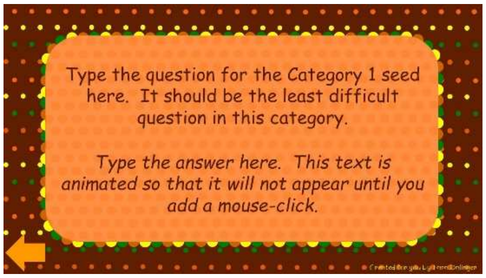
Created for you by Tara Dalinger



Rules of the Game

- Each team takes turns selecting and answering a question
- Questions are arranged from least to most difficult. More difficult questions are worth more points!
- If a team cannot decide on a correct answer during the teacher's time limit, the other teams may attempt to answer for half the points
- Once all the questions have been attempted, the team with the most points wins!





Type the question for the Category 1 seed here. It should be the least difficult question in this category.

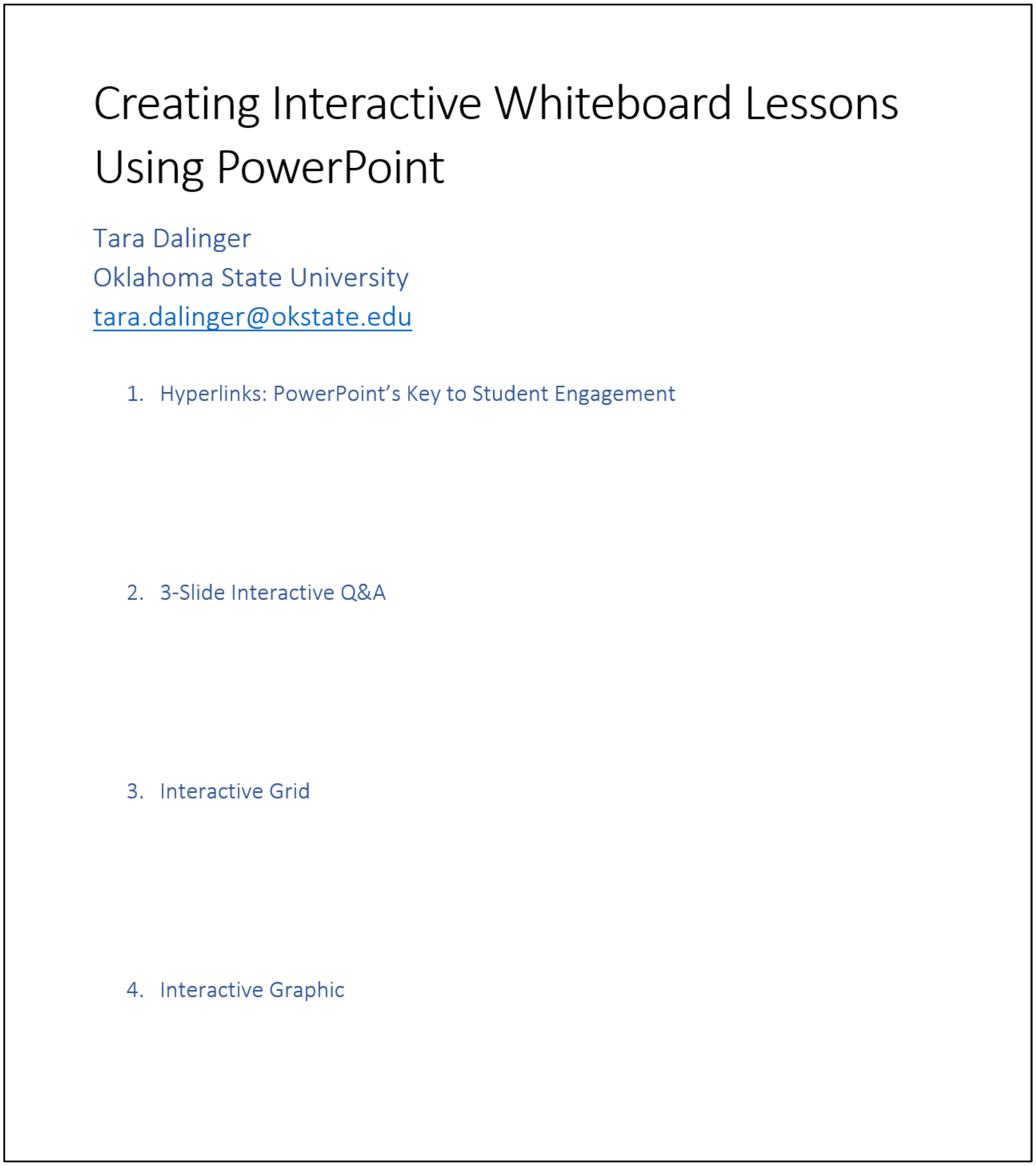
Type the answer here. This text is animated so that it will not appear until you add a mouse-click.

Video Tutorials

Dalinger, T. (2017). PowerPoint Q&A. https://youtu.be/7V9ZdS9aUMU

Dalinger, T. (2017). Jeopardy-Style Activity in PowerPoint. https://youtu.be/97OGx0RADWk

Appendix E: Professional Development Handout



Creating Interactive Whiteboard Lessons Using PowerPoint

Tara Dalinger
Oklahoma State University
tara.dalinger@okstate.edu

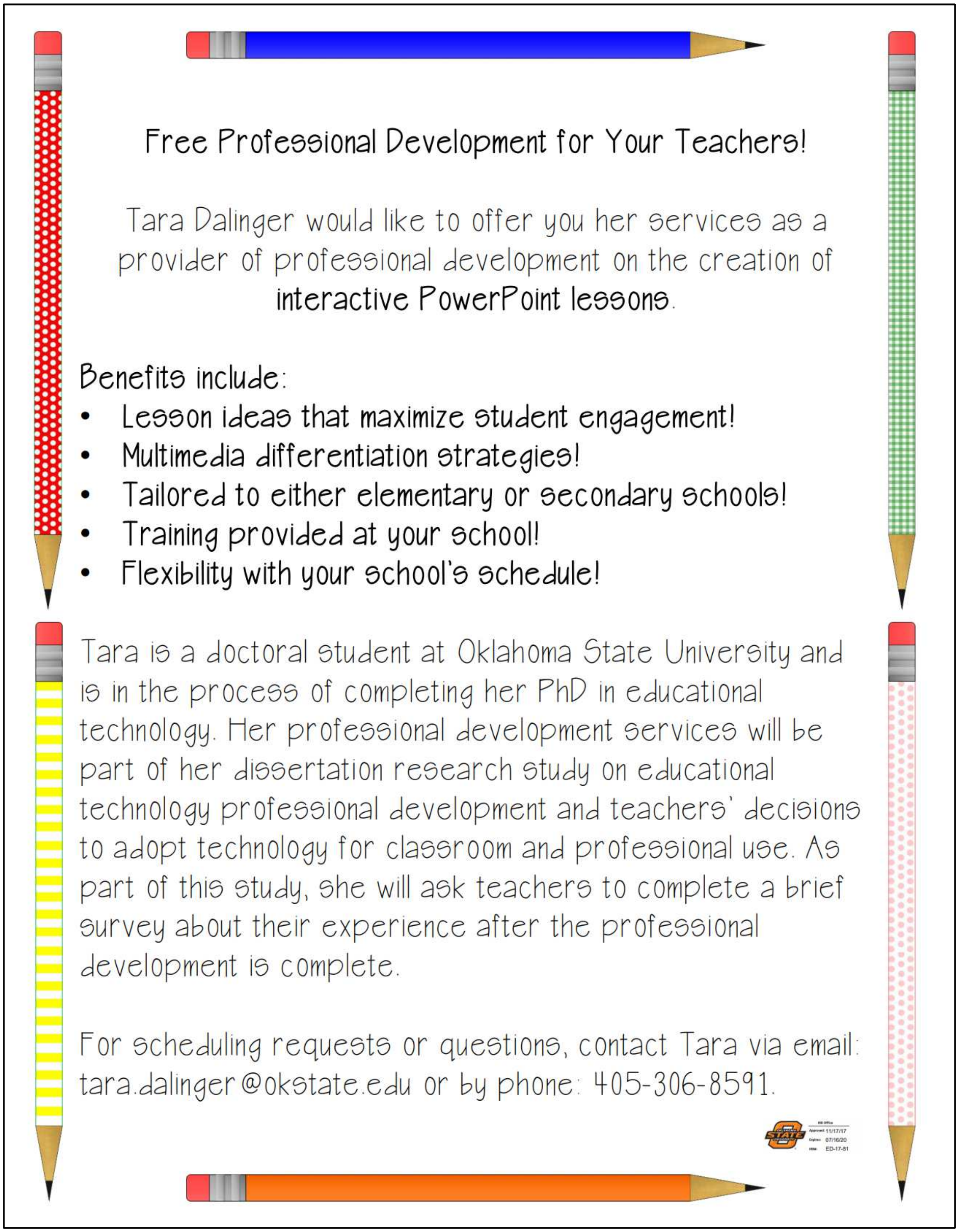
1. Hyperlinks: PowerPoint’s Key to Student Engagement

2. 3-Slide Interactive Q&A

3. Interactive Grid

4. Interactive Graphic

Appendix F: Participant Recruitment Flyer



Free Professional Development for Your Teachers!

Tara Dalinger would like to offer you her services as a provider of professional development on the creation of **interactive PowerPoint lessons**.

Benefits include:
- Lesson ideas that maximize student engagement!
- Multimedia differentiation strategies!
- Tailored to either elementary or secondary schools!
- Training provided at your school!
- Flexibility with your school's schedule!

Tara is a doctoral student at Oklahoma State University and is in the process of completing her PhD in educational technology. Her professional development services will be part of her dissertation research study on educational technology professional development and teachers' decisions to adopt technology for classroom and professional use. As part of this study, she will ask teachers to complete a brief survey about their experience after the professional development is complete.

For scheduling requests or questions, contact Tara via email: tara.dalinger@okstate.edu or by phone: 405-306-8591.

IRB Office
Approved: 11/17/17
Expires: 07/16/20
IRB#: ED-17-81

VITA

Tara Dalinger

Candidate for the Degree of

Doctor of Philosophy

Thesis: DESIGN OF AN INSTRUMENT MEASURING P-12 TEACHERS' COGNITIVE LOAD AND INTENT TO ADOPT TECHNOLOGY

Major Field: Educational Technology

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in educational technology at Oklahoma State University, Stillwater, Oklahoma in May, 2018.

Completed the requirements for the Master of Education in instructional media at the University of Central Oklahoma, Edmond, OK in 2005.

Completed the requirements for the Bachelor of Science in elementary education at the University of Central Oklahoma, Edmond, OK in 2002.

Completed the requirements for the Bachelor of Arts in French at the University of Central Oklahoma, Edmond, OK in 2002.

Experience:

Instructor at the University of Central Oklahoma, 2016 – present.

Graduate associate at Oklahoma State University, 2015 – 2016.

Library media specialist at Mid-Del Public Schools, 2012 – 2015.

Library media specialist at Choctaw/Nicoma Park Public Schools, 2008 – 2012.

Library media specialist at Mid-Del Public Schools, 2005 – 2008.

Professional Memberships:

Association of Educational Communications & Technology