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Instructional Designer Awareness and Application of Strategies to Manage Cognitive Load

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INSTRUCTIONAL DESIGNER AWARENESS AND APPLICATION OF STRATEGIES TO MANAGE COGNITIVE LOAD

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ABSTRACT

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This study examined how practicing instructional designers manage cognitive load in a standardized scenario as they select and implement instructional strategies, message design, content sequencing, and delivery media within various domains with learners at different levels of expertise. The study employed a quasi-experimental, mixed methods design to gain insight into how practicing instructional designers perceive their awareness of strategies to manage cognitive load and implement those strategies within a standardized design scenario. The research design involved the collection of quantitative data from the participants during an initial web-based questionnaire and a second collection of both quantitative and qualitative data as the participants completed a design activity using a think-aloud protocol. The triangulation of data through observation of activity and debriefing interviews was used to clarify data gathered through the protocol.

The results of the study indicated that both novice and expert practitioners frequently used several strategies to manage extraneous load (worked examples, completion tasks, and dual modality) as prescribed by theory, as well as the simple-to-complex presentation strategy to manage intrinsic load. They also exhibited a moderate use of the variability strategy to manage

germane load as recommended by theory, but overall use of strategies to address germane load was infrequent across all participants. While participants frequently acknowledged differences in the levels of learner expertise within the instructional scenario, few employed strategies prescribed to address the expertise reversal effect as outlined by theory. Participants described a number of barriers preventing them from using additional strategies to manage cognitive load, ranging from those common to all instructional strategies (such as time constraints and lack of formative evaluation) to those specific to cognitive load strategies (such as lack of instructor buy-in regarding cognitive load and the extra design effort to create worked examples).

This dissertation is dedicated to my wife, Alisa, and my sons, Ethan and Eli. Without their understanding, encouragement, and support, this would not have been possible. Alisa, I appreciate all the work you did over the past several years to allow me the time to concentrate on my studies. Ethan and Eli, I wanted this dissertation to be an example of what you can accomplish through dedication and hard work. I hope you are as proud of me as I am of you.

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CHAPTER I

INTRODUCTION

As part of the early investigation thirty-five years ago into the manner in which prescriptive models and methods influence the day-to-day decisions and activities of those who design instruction, Kerr (1983) noted that instructional designers see their work as involving three fundamental activities. Designers first identify a number of instructional strategies that have the potential to achieve desired results to a problem or opportunity. A set of criteria are then used to determine which of the strategies will be employed and which will not be selected for the particular scenario. Upon selection of specific strategies, instructional designers will then make decisions about implementation of the design based upon those strategies (Kerr, 1983; Pieters & Bergman, 1995; Weston & Cranton, 1986).

Since its origins in research studies conducted more than thirty years ago (Sweller & Cooper, 1985; Sweller, Mawer, & Ward, 1983), cognitive load theory has helped the instructional design field consider the impact on learning that results from our understanding of the limitations of human working memory and the key role of schemas in long-term memory during the learning process. This theory has led to a number of general instructional design prescriptions for practitioners, many of which aim to minimize the amount of extraneous cognitive load within the instructional strategies employed (Owens & Sweller, 2008). The primary domains in which the effects of cognitive load have been studied have been limited to mathematics, science, and technology, and some have concluded that the applicability of the theory may be limited by the controlled conditions of experiments and lack of content personally relevant to participants in the majority of research studies to date (de Jong, 2010).

Several recent studies (Kyun, Kalyuga, & Sweller, 2013; Nievelstein, Van Gog, Van Dijck, & Boshuizen, 2013; Oksa, Kalyuga, & Chandler, 2010; Owens & Sweller, 2008; Van Gog, Paas, & van Merriënboer, 2008) have begun to provide initial empirical evidence supporting the notion that instructional strategies can be used to address cognitive load equally in both well-structured and ill-structured problem-solving domains. Well-structured problems tend to exist within a discrete domain and involve both a desired goal and prescribed solution process, while ill-structured problems often pose everyday situations involving several domains and multiple goals and paths toward a solution (Simon, 1973). This research runs counter to the typology of problems put forth by Jonassen (2000), who proposed that the instructional strategies used within well-structured domains to optimize cognitive load are too prescriptive for the types of open-ended problem-solving that exist within ill-structured domains. As has been the case since the first studies of cognitive load (Sweller & Cooper, 1985), cognitive load theory and its resulting instructional strategies have largely been tested in randomized quantitative experiments within highly controlled conditions. This fact both strengthens the validity of these findings and begs the question of applicability to broader domains and more authentic learning contexts beyond those addressed within the experiments themselves.

By taking a closer look at how instructional strategies derived from cognitive load theory are being applied in practice to more complex problem-solving, we can make a stronger connection between our current understanding of the relationship between learning processes and the strategies used to facilitate them. Because instructional design is a type of problem-solving in itself (Jonassen, 2000), one method that has been used to effectively study how instructional designers implement theory and research is through a qualitative examination of reflective thinking (Christensen & Osguthorpe, 2004; Sugar & Luterbach, 2016; Yanchar, South, Williams, Allen, & Wilson, 2010). By examining how instructional designers apply cognitive load theory to designs within both general well-structured, and complex ill-structured domains, researchers will be able to pursue studies that replicate more realistic problem-solving environments and identify strategies that are more applicable to a variety of domains. In addition, those responsible for training instructional designers will have a better sense of how cognitive load theory can be embedded within context in order to be more applicable in practice.

Conceptual Framework

The concept of cognitive load has its origins in a large number of experimental studies within educational psychology, led by the work of Sweller and his colleagues that examined the cognitive aspects of problem-solving within the domain of mathematics (Sweller & Cooper, 1985). Cognitive load theory is based on the understanding that individuals hold problem-solving expertise within their unlimited long-term memory in the form of schemas, and the process of learning involves the creation and automation of these schemas for use during subsequent problem-solving tasks. Because of the storage and processing limitations of short-term working memory, cognitive load represents the degree to which mental resources are being used and the effects that this has during the learning process (Sweller, 1988). This understanding of the role of cognitive load has provided instructional designers with a set of general instructional prescriptions to manage load and improve the resulting learning outcomes.

Cognitive Load and Instruction

Cognitive load theory describes three types of load that comprise the total cognitive load experienced by the learner – intrinsic, extraneous, and germane (Sweller, 2008). Intrinsic load represents the relative complexity of the material in relation to the expertise of the learner. Any elements of the task that do not contribute directly to learning comprise the extraneous load. Germane load encompasses the components of a task process that facilitate schema construction and automation (Sweller, 2008). By measuring the levels of load experienced through means such as subjective mental effort rating scales, researchers have examined the effects of manipulating particular variables associated with the learning task (Paas, Tuovinen, Tabbers, & van Gerven, 2003; Sweller, Chandler, Tierney, & Cooper, 1990; Ward & Sweller, 1990).

Research on cognitive load has led to the development of a number of instructional design methods that are intended to manage intrinsic load, minimize extraneous load, and foster germane load (Sweller, Ayres, & Kalyuga, 2011). These prescriptions have been devised in controlled experiments within domains such as mathematics and science, and recent research has sought to validate their use in a broader range of subject areas (Jung & Suzuki, 2015; Kyun, Kalyuga, & Sweller, 2015; Rourke & Sweller, 2009; Stark, Kopp, & Fisher, 2011; Tuovinen & Sweller, 1999). Cognitive load theory and its resulting instructional prescriptions have had a far-reaching effect on research and practice related to learning processes and instructional strategies.

Influence of Theory on Strategy Use

Various models and theories have outlined the importance of aligning the strategies employed with the type of subject content and its sequence, the message design techniques, and the media used to deliver the instruction. The process of selecting methods and strategies that match an instructional situation involves a complex consideration of the desired learning outcomes, the characteristics of individual and collective learners, and a variety of practical concerns unique to the context (Pieters & Bergman, 1995; Weston & Cranton, 1986).

Research in instructional design has led to the conclusion that instructional methods and strategies have different levels of power or potential effectiveness depending upon the particular learning situation (Reigeluth & Carr-Chellman, 2009). The subject domain and level of learning, the level of learner expertise within the domain, and the type of problem-solving to be performed during learning all have a significant impact upon the strategy selection process. Beyond the research that has produced prescriptive theories to align instructional methods to learning situations, a significant number of studies have been conducted to examine the strategy selection decisions being made by instructional designers in the field as they consider their practical contexts and constraints (Wedman & Tessmer, 1993).

Well-Structured and Ill-Structured Problems

Jonassen (2000) proposes that the ability to solve problems is the most important learning outcome associated with educational endeavors in any context, and the creation and use of problem-solving activities is an instructional method that deserves a great deal of attention. Among the several characteristics that distinguish different types of problem-solving, the degree to which a problem is structured is perhaps one of the most significant. While well-structured problems tend to exist within a discrete domain and possess both a desired goal and prescribed solution process, ill-structured problems often pose everyday situations that involve several domains and have multiple goals and paths toward a solution (Simon, 1973).

The classification of problem-solving activities for learning according to whether they are either well- or ill-structured has led some to prescribe separate instructional design models for each type of learning outcome (Jonassen, 1997). The underlying assumption of these models is that well-structured problem-solving lends itself to information processing learning theory (i.e., the mind operating like a computer), while ill-structured problem-solving involves theories of situated cognition (i.e., learning through authentic activity within context). One implication of this assumption is that instructional methods and strategies devised to manage cognitive load within well-structured domains would likely be ineffective when used within ill-structured domains, and they may even have the potential to increase both intrinsic and germane load to prohibitive levels for learning (de Jong, 2010; Jonassen, 2011; Moreno, 2010).

Problem Statement

There has been little research to date that examines the intersection of cognitive load theory, conditions-based instructional design theory, and theories of problem-solving within ill-structured domains. Recent studies in the field have been conducted to address questions regarding the applicability of instructional prescriptions from cognitive load theory to ill-structured problem-solving. In addition, researchers have increasingly questioned the role of theory in the daily work of practitioners as they select methods and strategies. By examining how practicing instructional designers manage cognitive load as they select and implement strategies, message design, content sequencing, and delivery media within ill-structured domains, we can get a better sense of how to conduct research and develop prescriptions within more realistic problem-solving environments.

Literature Review

For the purposes of this study, literature was reviewed in three primary areas in order to examine and critically analyze recent related research methods and findings that would inform the present study. The first area includes empirical studies that initially identified cognitive load effects and resulting instructional strategies to address those effects, primarily within well-structured technical domains such as mathematics and science. The research included studies that reported data from experiments with learners and excluded theoretical articles on cognitive load theory. Because measures of cognitive load were not well established at the time of several of these studies, research was included for either its inferences of cognitive load effects from learning outcomes or its explicit consideration of cognitive load implications stemming from instructional strategies.

The second area involves empirical studies that seek to extend the instructional strategies intended to manage cognitive load beyond well-structured domains such as mathematics to more complex, ill-structured problem-solving domains. This research included studies that reported data from experiments or observation of learners, but it excluded any conceptual or theoretical articles on cognitive load within ill-structured domains. In addition, studies were selected for their explicit consideration of both the learning outcomes and the specific cognitive load implications of employing particular instructional strategies.

The third area of literature reviewed for this study included empirical studies that examined and critically analyzed the processes used by practicing instructional designers as they select specific methods and strategies to address particular learning situations. This research included studies that reported both quantitative and qualitative data regarding the strategies selected and the reasoning for those decisions, but conceptual articles on method selection by practitioners were again excluded for the purposes of this study. Studies were included for their consideration of whether instructional designers incorporate their understanding of theory into instructional strategy selection and their perceptions of how prescriptions for design align with the effectiveness of various techniques in daily practice.

Basic Cognitive Load Effects

In order to examine the research being done on the use of particular strategies to manage cognitive load in ill-structured domains, it is helpful to first frame these studies within the context of the large body of cognitive load research done in well-structured domains over the past thirty years. A majority of these initial studies involved the subject domains of mathematics or technology and participants who were studying at the trade school or undergraduate level (Sweller & Cooper, 1985; Sweller & Levine, 1982; Sweller, Mawer, & Howe, 1982; Sweller et al., 1983). When secondary students were also included in these early studies, they primarily served to represent learners who were relative novices in the subject matter compared to the undergraduate students.

Domains Explored

The fifteen studies that were conducted during the initial formulation of various cognitive load effects and resulting instructional prescriptions covered a somewhat narrow range of subject areas, primarily related to mathematics and other technical domains. These subject areas allowed for the manipulation of conditions within experiments due to their algorithmic nature of having a prescribed set of steps toward a single solution. Initial studies involving mathematics included algebra (Sweller & Cooper, 1985) and geometry (Mousavi, Low, & Sweller, 1995; Paas & van Merriënboer, 1994; Sweller et al., 1983; Tarmizi & Sweller, 1988). Early studies of cognitive load in science primarily involved concepts in kinematics or physics (Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Sweller et al., 1983), as well as the systems aspects of biology (Chandler & Sweller, 1991).

A couple of later studies expanded into other areas of mathematics such as statistics (Paas, 1992) and probability (Renkl, Atkinson, Maier, & Staley, 2002), but this subject matter was similar in that it still involved students following a specific set of solution steps. Domains involving more applied science-related subject matter were also explored, such as electrical circuits and engineering (Chandler & Sweller, 1991; Kalyuga, Chandler, & Sweller, 1998; Pollock, Chandler, & Sweller, 2002; Sweller & Chandler, 1994) and the manipulation of manufacturing materials (Kalyuga, Chandler, & Sweller, 2000). Three additional studies examined the completion of tasks on the computer such as moving a cursor according to specific patterns (Jelsma & van Merriënboer, 1989), introductory computer programming (van Merriënboer, 1990), and the use of productivity software (Sweller & Chandler, 1994).

The commonality among these initial studies from the 1980s through the early 2000s is that they almost exclusively involved content domains with very specific solution paths that could be manipulated through experiments that altered particular aspects of the learning context in order to determine effects on the learner. This early research led to the identification of intrinsic, extraneous, and germane cognitive load effects and a set of instructional prescriptions intended to address those effects in order to improve learning outcomes. A number of replication studies built upon these preliminary findings, but the studies included in this review involve some of the initial reports of the various cognitive load effects.

Participants and Settings in Cognitive Load Studies

The majority of the initial studies involving cognitive load effects and the corresponding instructional prescriptions took place within technical education and higher education settings, with seven of the studies being conducted at trade schools and five at universities. Seven additional studies were conducted within the setting of secondary education, although four of those (Chandler & Sweller, 1991; Sweller & Chandler, 1994; Sweller & Cooper, 1985; Sweller et al., 1983) included secondary students in order to make comparisons between the cognitive load effects on novice learners and learners with more expertise. One study (Mousavi et al., 1995) included experiments within a primary education setting, which was also intended to make comparisons to more expert learners in the secondary grades.

For many of these initial studies of cognitive load effects of various instructional interventions, it seems appropriate to focus on learners such as technical school students and trade apprentices. Their relatively uniform curricula lend themselves to experimental studies that involve technical concepts that the learners have previously experienced to a particular degree. The same can be said for undergraduate students, whose exposure to mathematical or technical material can often be determined by their major of study and the number of years they have completed to date. The researchers often made use of secondary and undergraduate students, or secondary students at different grade levels, in order to determine the degree to which certain cognitive load effects existed for learners with different levels of expertise within a particular subject matter. As with the domains explored in these studies, there was not a significant amount of variation in the types of learners involved across these initial research efforts to arrive at instructional prescriptions to manage cognitive load.

Sample Sizes and Duration of Interventions

The majority of the early studies of cognitive load effects had relatively large sample sizes within experiments, with only two of the studies examined having fewer than 50 participants (Chi et al., 1989; Paas, 1992). Eight of the studies had between 50 and 100 participants, with anywhere between a single and as many as six experiments to explore a particular aspect of cognitive load. The remaining five studies examined had rather large sample sizes exceeding 100 participants, ranging from 110 learners across four experiments (Sweller & Chandler, 1994) to 200 learners across six experiments (Mousavi et al., 1995). The relatively large sample sizes of these initial research studies allowed for the use of data analysis techniques to identify statistically significant differences between groups of learners who were placed in different experimental conditions involving the structure of subject matter or presentation of instruction. These large samples of participants were used to arrive at results with high validity that could be further explored in replication studies in the years that followed.

Due to the controlled laboratory environments of the majority of early cognitive load research, the duration of most study interventions were relatively short. Thirteen of the studies involved experiments that lasted less than three hours for all of the research activities, including any pretesting, the intervention itself, and post-intervention testing. A couple of the studies included experiments that lasted for 90 minutes per week over 10 weeks (van Merriënboer, 1990) and during regular instruction periods for a twelve-week period (Chandler & Sweller, 1991). The longest intervention duration involved a large range of time for participants working at their own pace, with learners taking anywhere from eight to 29 hours over several weeks to complete the experiment (Chi et al., 1989). Since the intent of most of these initial studies was to establish fundamental cognitive load effects within controlled conditions, the relatively short intervention durations were appropriate for determining how various types of instruction affected the learning outcomes of study participants.

Data Types and Measurement of Load

As would be expected with research involving controlled laboratory conditions, all 15 of the studies reviewed involved an experimental research approach. Twelve of the studies involved an experimental design with random assignment of participants to either treatment or control groups. One study (van Merriënboer, 1990) employed a design where participants were randomly assigned to conditions in exactly matched pairs based on prior experience with the subject matter. Another used an experimental design that involved participants solving the same set of problems but in a different order based on group assignment (Sweller et al., 1983). A final study employed a longitudinal approach whereby participants all solved the same set of problems, and the quality of their approaches to problem-solving were examined through the use of talk-aloud protocols. The use of quantitative experimental research designs with random assignment of participants to instructional treatments served to strengthen the validity of these initial studies of cognitive load effects and allowed for replication studies that employed similar empirical approaches.

Each of the studies gathered data regarding problem-solving performance, with either a post-test where participants solved problems involving near and far transfer or a count of the number of solution steps and errors during problem solution. Twelve of the studies included data related to the time participants spent solving problems during both the learning and testing phases of the experiments. While the majority of the studies inferred cognitive load from the learning outcome data, six of the studies did incorporate some subjective measure of perceived mental effort or task difficulty associated with problem solving in order to determine cognitive load effects. One study (Paas & van Merriënboer, 1994) used a combination of heart rate variability data and perceived mental effort ratings to arrive at a cognitive load measurement. A couple of the studies (Kalyuga et al., 1998; Kalyuga et al., 2000) reported an efficiency measure that compared post-test scores relative to the mental effort ratings of participants. As previously mentioned, Chi et al. (1989) reported data on idea statements collected from a talk-aloud protocol during problem solving.

Extraneous Load and Instructional Prescriptions

Six of the studies examined for this review reported learning outcomes related to the effects of extraneous cognitive load, which includes any elements of the instruction that do not directly contribute to learning. The first of these extraneous load effects to be identified was that learners who studied with materials using reduced goal specificity during problem solving were more efficient than those who engaged in traditional means-ends problem solving (Sweller et al., 1983). The resulting instructional prescription was to use goal-free tasks during the acquisition phase of learning rather than having them engage in conventional problem solving from the beginning. Sweller & Cooper (1985) reported that learners who studied worked examples that showed the full problem solution were more efficient and made significantly fewer errors on a post-test than those who engaged in traditional problem solving during the learning phase. As a result, the authors prescribed the use of worked examples for learners to study as they become familiar with particular subject matter rather than attempting to generate solutions themselves. A related type of extraneous load effect was noted by Paas (1992), who reported that learners who studied using a problem completion strategy exhibited superior transfer performance on a post-test in comparison to those who studied with a problem solving strategy. The subsequent instructional prescription was to use completion tasks that provide a partial problem solution that learners need to finish as they work with the material.

Other experiments reported learning outcomes that indicated the design of instructional materials may introduce extraneous load that can significantly affect the learner. According to Tarmizi and Sweller (1988), learners who studied worked examples that integrated diagrams and text together performed better during the testing phase than those who studied worked examples that split their attention between separate diagrams and text. The resulting instructional prescription was to integrate multiple sources of related information into a single element to allow learners to focus on the material at the same time. Mousavi et al. (1995) observed a related extraneous load effect that showed learners who studied worked examples presented with written diagrams and auditory explanations performed better than those who studied written diagrams and explanations. As a result, an instructional prescription was to use a strategy of supplementing visual information with a second mode of delivery such as spoken explanatory text. Chandler and Sweller (1991) noted a final extraneous load effect that students performed better on written and practical post-tests when visual and verbal instructions that could be understood independently were integrated. This led to the instructional prescription that redundant information should be eliminated if the learner is able to understand the material from a single element.

Intrinsic Load and Instructional Prescriptions

Two of the studies included in this review identified learning outcomes related to intrinsic cognitive load, which is the complexity of the material in relation to the expertise of the learner in the subject domain. Sweller and Chandler (1994) reported that learners who studied with only an integrated instructional manual performed better than those who had access to both a manual and physical equipment, due to the overall complexity and high number of interacting elements within the material. The instructional prescription was that subject matter should be examined for its number of constituent interacting elements in order to determine its level of complexity relative to the prior experience of learners. The learning outcomes observed by Pollock et al. (2002) built upon these findings by reporting that novice learners experienced lower mental load and performed better on a practical post-test when studying with isolated elements first and interacting elements second. As a result, the instructional prescription is that traditional problem solving should be replaced with a strategy of gradually moving the learner from simple, isolated tasks to realistic problems of full complexity.

Germane Load and Instructional Prescriptions

Beyond the examination of extraneous and intrinsic load effects of instructional materials and subject matter, researchers began to identify the effects of germane cognitive load. Three of the studies noted these cognitive load effects, which are attributed to the aspects of the learning process that facilitate the construction and automation of schemas and foster transfer. Paas and van Merriënboer (1994) reported that learners who studied worked examples presented with a high degree of variability in surface characteristics experienced lower mental effort and performed better on a post-test than those who studied worked examples involving problems with low variability. The resulting instructional prescription was to encourage transfer of problem solving skills by presenting a series of tasks that differ in their surface features as they would in realistic situations. Similarly, Jelsma and van Merriënboer (1989) noted that learners who studied using a randomized practice schedule took less time and made fewer errors during testing than those who used a blocked practice schedule of similar problems. As a result, the instructional prescription was to present a series of random tasks to learners that contain high contextual interference in order to foster their ability to work with variations of the task. Finally, Chi et al. (1989) made a related observation that learners who study with worked examples tend to perform better when they generate explanations that expand upon the example solutions and monitor their understanding of the material. Their recommended strategy was to prompt learners to produce self-explanations while they are studying worked examples and finishing completion problems.

Expertise Reversal and Instructional Prescriptions

Within the studies that identified intrinsic, extraneous, and germane cognitive load effects, several researchers noted that effects were often reduced by the relative expertise of the learners within the content domains involved. Four of the studies examined were concerned specifically with the nature of these expertise reversal effects and their implications on learning outcomes for learners at different points on the expertise continuum. Van Merriënboer (1990) reported that learners who worked through a progression of tasks from worked examples to completion problems to solution generation performed better in an introductory computer programming course than those who used a generation strategy throughout. The resulting instructional prescription was to present tasks to learners that appropriately follow their developing expertise in the content domain by having them complete larger portions of a solution until they are prepared to engage in conventional generation of problem solutions. A similar effect was noted by Renkl et al. (2002), who reported that learners who studied materials that gradually faded instructional guidance over time performed better on a near transfer post-test than those who exclusively studied worked examples throughout. As a result, the authors prescribed a scaffolding strategy whereby learners begin with a larger amount of instructional guidance that is progressively faded over time as expertise is developed.

Kalyuga et al. (1998) expanded upon the findings of Tarmizi and Sweller (1988) by reporting that learners initially performed better when studying integrated diagrams and text, but they exhibited superior performance when studying diagrams with no integrated text as they developed expertise within the content domain. The resulting instructional prescription was to replace worked examples including fully integrated information with examples that contain only visual or textual elements as the learner exhibits developing expertise. Kalyuga et al. (2000) similarly built upon the conclusions of Mousavi et al. (1995) by noting that the performance advantage of pairing visual diagrams and audio explanations during learning decreased as learners gained expertise over time. The authors prescribed a strategy whereby instructional materials using a dual modality approach are replaced by visual materials with no auditory supplemental information as learners gain expertise. These initial studies of expertise reversal effects provided a blueprint for replication studies that would examine the potential for cognitive load effects of various types to produce differential learning outcomes for novice and expert learners.

Cognitive Load in Ill-Structured Domains

In response to calls for empirical studies to address the role of germane load during problem-solving and cognitive load effects in domains beyond mathematics and science (de Jong, 2010; Moreno, 2010), researchers have begun to extend cognitive load studies to more complex and ill-structured domains. It is notable that the techniques that were used historically to establish the theory and its instructional prescriptions continue to be the primary means of studying these new areas, which both allows researchers to validate their results against previous studies and calls into question the external validity of effects outside of controlled conditions.

Domains Explored

The sixteen studies that examined cognitive load effects within ill-structured domains covered a range of subject areas, from technical domains to education and the humanities. Several of the studies extended earlier experiments involving well-structured domains such as mathematics and science by looking at less structured problem-solving within areas such as applied physics and computer programming. These studies included the troubleshooting of electrical circuits (Mulder, Lazonder, & de Jong, 2014; Reisslein, Atkinson, Seeling, & Reisslein, 2006; Van Gog et al., 2008), the use of computer databases (Tuovinen & Sweller, 1999), and the solution of open-ended computer application problems (Chang, Hsu, & Yu, 2011; Margulieux & Catrambone, 2016; Si, Kim, & Na, 2014).

A couple of studies examined cognitive load effects within the domain of education, including instructional design techniques used by pre-service teachers (Schworm & Renkl, 2006) and university faculty members (Hoogveld, Paas, & Jochems, 2005). The additional research involved advanced professional domains, such as clinical diagnosis in medicine (Stark et al., 2011) and the argumentation of legal cases (Nievelstein et al., 2013). The domain of language studies was examined in three of the studies, with two involving English literature (Kyun et al., 2013; Oksa et al., 2010) and one involving the learning of Japanese as a second language (Jung & Suzuki, 2015). Two additional studies looked at cognitive load effects within the subject domains of music (Owens & Sweller, 2008) and the history of visual design (Rourke & Sweller, 2009).

Although the cognitive load effects of various strategies were examined in a range of domains that vary in their distance from initial experiments conducted in mathematics, each was selected in order to examine ill-structured tasks within that domain that do not have a single solution or prescribed process to arrive at a solution. Initial results seemed to indicate extraneous, intrinsic, and germane cognitive load effects similar to those observed within well-structured domains, while expertise reversal effects were largely inconclusive. While these studies have been more frequent in the past ten years, it is clear from a search of the literature that there are many additional opportunities to examine cognitive load within less structured subject domains. The studies within areas of education, law, and medicine could be expanded to determine the cognitive load effects in additional advanced professional domains such as business, counseling, and social work. In addition to the study of the less structured aspects of technical areas, research on cognitive load in domains such as art and literature holds a great deal of potential for extending instructional prescriptions to new areas of the arts and humanities.

Participants and Settings

The large majority of studies to date examining cognitive load within ill-structured domains have been conducted within the setting of higher education. Eleven of the sixteen studies reviewed included participants who were studying at the undergraduate, student teacher or graduate (medicine and law) levels. One study (Oksa et al., 2010) was conducted in both secondary education and higher education settings, as high school students and adult learners were compared in order to test the expertise reversal effects of explanatory notes within the domain of literature. Studies that were conducted solely within a secondary education setting involved middle school music students (Owens & Sweller, 2008) and high school participants studying physics (Mulder et al., 2014; Van Gog et al., 2008). Only one study examined was conducted within the setting of professional continuing education, with the participants including mid-career university professors (Hoogveld et al., 2005).

As with much of the formative research done on the cognitive load effects of various instructional strategies, higher education and undergraduate students have been the primary focus of experiments examining cognitive load within ill-structured domains. Relatively little research has been done on cognitive load effects within corporate, government, or military training, which present realistic learning settings in which ill-structured problem-solving is likely to occur (Sweller et al., 2011). While primary and secondary education traditionally involves learning in more well-structured than ill-structured domains, an increased emphasis on problem-solving in realistic situations that may involve multiple domains presents the opportunity to expand studies of cognitive load into these areas as well. Much as a broader range of subject domains will serve to enhance our understanding of strategies to manage cognitive load, a greater variety of participants and research settings will allow us to examine cognitive load effects within more learning contexts (de Jong, 2010; Moreno, 2010).

Sample Sizes and Duration of Interventions

The various studies that examine cognitive load effects within ill-structured domains had sample sizes that ranged from relatively small to rather large. Seven of the sixteen experiments involved fewer than 100 participants, with the smallest sample including twenty-five university professors (Hoogveld et al., 2005). The other nine studies involved larger sample sizes to study the effects of instructional strategies to manage cognitive load in ill-structured domains, with the largest including 287 medical school students in their third and fifth years (Stark et al., 2011). Since the majority of research related to cognitive load has sought to find statistical significance supporting the use of particular instructional strategies to manage load, it is appropriate that most of the studies examined involved larger sample sizes. Beyond establishing the validity of these results through quantitative research, there is an opportunity to expand our understanding of cognitive load within ill-structured domains through the addition of qualitative studies with fewer participants that seek a deeper understanding of the reasons behind the effects that are noted in the experimental studies with larger numbers of participants.

Because studies of cognitive load in ill-structured domains have employed experimental methods similar to those of the studies that led to cognitive load theory, the duration of the interventions within each study have tended to be rather short. Nine of the experiments conducted pre-testing, a learning phase, and post-testing within one session that lasted between one and three hours. Six studies involved interventions that took place over the course of several weeks, but all activities were conducted within three to five hours. Only one research study (Jung & Suzuki, 2015) had an intervention that was significantly longer, with learning activities and cognitive load measurements taking place in one-hour sessions over a ten week period. Since critics have questioned the external validity of cognitive load studies due to their short intervention lengths (de Jong, 2010), both longer interventions and repeated measures of the cognitive load effects of various instructional strategies would serve to deepen our understanding of cognitive load on longer-term learning outcomes beyond problem-solving on a single post-test.

Data Types and Measurement of Load

As was common with much of the early research on cognitive load within well-structured domains, the majority of studies of cognitive load within ill-structured domains has employed an experimental research design in controlled learning environments in an attempt to isolate specific variables. Eleven of the sixteen studies examined for this review used an experimental design with random assignment of participants to the treatment and control groups. Four studies used a quasi-experimental design, where participants were either assigned to experimental conditions based on existing class sections or to ensure that each condition had an equal distribution of learner expertise based on pre-test scores. Only one study examined employed an action research design (Jung & Suzuki, 2015), which highlighted the adjustments made to scaffolding strategies over the course of many weeks as a result of ongoing cognitive load measurements that indicated the need for less prescriptive worked examples in ill-structured domains. While the use of experimental designs has served to strengthen the validity of learning outcomes in studies of cognitive load, the use of qualitative approaches and design research holds potential for examining strategies that manage cognitive load within more realistic classroom and training environments due to the use of subject matter than is more personally relevant and meaningful to the participants.

All of the studies examining cognitive load in ill-structured domains employed post-test scores on near and far transfer as a measure of learning outcomes after instructional interventions, and nine of the sixteen studies reviewed compared these scores to pre-test scores that were gathered to measure prior domain knowledge. The majority of the studies employed subjective measures of cognitive load or mental effort, and five studies used measures of time on task to measure cognitive load effects indirectly following experimental interventions. Only two studies employed the use of think-aloud protocols to supplement the quantitative data gathered regarding the cognitive load effects of particular instructional strategies (Chang et al., 2011; Schworm & Renkl, 2006). The combination of mental effort ratings and performance scores to calculate learning efficiency measures has helped to establish the existence of various cognitive load effects in experiments, but the relative lack of qualitative or explanatory data has the potential to leave the reasons for these effects open to interpretation.

Cognitive Load Effects

One of the most significant conclusions from an examination of the studies of cognitive load effects in ill-structured domains is that several of the instructional prescriptions for managing load extend to domains beyond those of well-structured domains such as mathematics. For example, Oksa et al. (2010) found that novice high school learners experienced lower cognitive load while studying Shakespearean plays when they were provided with explanatory notes in Modern English. Si et al. (2014) concluded that undergraduate students learning to solve programming problems using worked examples were better able to construct and automate schemas due to the management of cognitive load. Several other cognitive load effects were observed in these studies, including the reduction of split attention through simultaneous presentation of materials (Owens & Sweller, 2008), the expertise reversal effect (Kyun et al., 2013; Oksa et al., 2010; Reisslein et al., 2006), and the benefits of fading steps within a problem solution as learners gain problem-solving skills (Si et al., 2014).

However, a few notable differences in cognitive load effects were observed in some of the studies that may be attributable to the ill-structured domains involved. For example, Rourke and Sweller (2009) did not observe an expertise reversal effect among second-year art education undergraduates learning visual literacy through worked examples in comparison to first-year undergraduates. Nievelstein et al. (2013) also noted the absence of an expertise reversal effect after observing similar mental effort ratings for first-year and third-year law students learning argumentation of law cases. Reisslein et al. (2006) did observe an expertise reversal effect with undergraduate engineering students learning about electrical circuits, but they noted that the experimental condition using faded problem-solving did not experience the hypothesized differences in cognitive load when compared to learners with high levels of prior domain knowledge who studied example-problem pairs throughout. In each of these studies, the authors questioned whether the expertise reversal effect is as applicable to ill-structured domains and called for further examination of this aspect of strategies to manage cognitive load for learners with more expertise in the domain.

Learning Outcomes

In addition to the cognitive load effects observed within ill-structured domains in the various studies, several of the experiments involved significant improvements in learning outcomes that were similar to those observed in studies of well-structured domains. Rourke and Sweller (2009) found that undergraduates learning to identify the work of a visual designer using worked examples performed better than students who used a traditional problem-solving approach. Nievelstein et al. (2013) also observed that law students who were supplied with worked examples on arguing civil cases had better results on post-test far transfer tasks than learners who were given only a description of argumentation steps or no instructional support. In their study of Korean undergraduate students learning English literature, Kyun et al. (2013) reported that learners who studied worked examples of model essay answers performed better on a post-test than those who constructed essays without instructional guidance.

It is notable that some of the learning outcomes observed within ill-structured domains differed from the results of research studies conducted within well-structured domains such as basic mathematics and science. Stark et al. (2011) found in their study of medical students learning to diagnose hypertension and hyperthyroidism that worked examples containing errors with elaborated feedback were associated with better learning outcomes on strategic and conditional knowledge than correct worked examples. Jung and Suzuki (2015) reported in their action research study that undergraduate students learning to write reports in Japanese were inhibited from thinking creatively and independently when supplied with comprehensive worked examples, but they had significantly higher assessment scores when they were given examples that were less indicative of desired solutions in the semesters that followed.

The results of these studies of cognitive load within ill-structured domains and their resulting instructional prescriptions raise several questions about practical heuristics and future research within problem-solving environments beyond mathematics. Because problem-solving in less structured domains does not involve outlining the steps in a single correct solution for the learner, instructional designers must carefully consider the specific learning outcomes associated with the instruction before determining whether to use a strategy intended to manage cognitive load. In addition, the absence or significant delay in producing an expertise reversal effect within ill-structured domains requires instructional designers to closely align the subject matter with the levels of learner expertise before deciding how long to employ a strategy such as worked examples and introducing changes such as the fading of solution steps. Any ill-structured domains that involve creative problem-solving necessitate that instructional designers balance the benefits of strategies to manage cognitive load with the disadvantages of providing instruction that is overly prescriptive and impedes independent thinking. For these reasons, an examination of practicing instructional designers attempting to manage cognitive load through strategy selection will serve to supplement the studies of load within ill-structured domains.

The findings from studies involving ill-structured domains largely reinforce the instructional prescriptions for managing cognitive load that resulted from earlier studies in well-structured domains. With regard to extraneous load, the prescriptions extended to a broader group of domains include the use of worked examples (Nievelstein et al., 2013; Rourke & Sweller, 2009; Si et al., 2014), problem completion (Si et al., 2014), and the integration of information to reduce split attention (Owens & Sweller, 2008). To address the intrinsic load of material in ill-structured domains, the prescriptions established within well-structured material of examining the number of interacting elements (Margulieux & Catrambone, 2016, Si et al., 2014) and moving the learner from tasks of low to full complexity (Chang et al., 2011; Mulder et al., 2014) have shown to be effective.

Instructional prescriptions for managing germane load also extend into ill-structured domains and include using a high degree of task variability (Nievelstein et al., 2013), randomized practice of problem solving tasks (Rourke & Sweller, 2009), and prompting learners to produce self-explanations during problem solving (Stark et al., 2011). Although the nature of the expertise reversal effect appears to be more complex within ill-structured domains, instructional prescriptions appear to be effective with regard to moving learners through a progression from worked examples to solution generation (Kyun et al., 2013) and fading instructional guidance over time (Oksa et al., 2010; Reisslein et al., 2006). The table in Appendix A summarizes both the initial studies that identified strategies to manage cognitive load and the more recent studies that have supported the use of those strategies within broader subject domains.

Use of Theory by Instructional Designers

Since the initial work of researchers such as Kerr (1983) more than thirty years ago, various studies have been conducted in order to determine whether the prescriptive models and methods within the instructional design knowledge base influence the day-to-day decisions and activities of practitioners. Much of the early research was concerned primarily with the role of instructional systems design models in the steps taken by designers to complete projects, but more recent studies have also begun to examine the particular instructional methods and strategies used by designers to produce desired learning outcomes. Several of these studies were reviewed to determine the methods used and conclusions made by researchers seeking to connect prescriptive theory to instructional design practice.

Aspects of Design Explored

The ten studies examined for this review investigated the use of theory by instructional designers in practice from a range of different angles. Several of the earlier studies from the early to mid-1990s were concerned primarily with the types of activities that instructional designers engaged in as they completed a design project (Pieters & Bergman, 1995; Rowland, 1992; Wedman & Tessmer, 1993; Winer & Vázquez-Abad, 1995). The goal of this research coincided with a concern within the field focused on the validation of instructional systems design models and determining the degree to which they were being used in practice. Studies in the past fifteen years have focused on more specific aspects of instructional design practice, such as the relative importance of design principles (Kirschner, Carr, & van Merriënboer, 2002), the frequency of prescriptive instructional strategy use (Christensen & Osguthorpe, 2004), and the usefulness of instructional methods for different levels of content (Honebein & Honebein, 2014).

Recent studies have also delved into the use of formal theories throughout the design process (Yanchar et al., 2010), the operationalization of design judgments (Gray et al., 2015), and the association of particular instructional design practices with positive or negative learning outcomes (Sugar & Luterbach, 2016). It is notable that while a few of these studies have begun to look at how theory influences the selection and implementation of instructional methods and strategies, the research to date has yet to examine how specific theories or associated prescriptions affect the decisions instructional designers make regarding strategies. Christensen and Osguthorpe (2004) asked practitioners to list instructional design and learning theories that they find useful in their work, and it is interesting to note that only one respondent mentioned cognitive load theory as being useful in day-to-day practice. Although cognitive load theory and its prescriptions are widely known and accepted components of the instructional design knowledge base, no studies have been conducted to examine how practicing instructional designers implement methods or strategies to manage cognitive load in their work.

Participants and Settings

The studies included in this review used a variety of approaches for identifying participants, and their inclusion served different purposes depending on the particular purpose of the research. Three of the studies (Christensen & Osguthorpe, 2004; Pieters & Bergman, 1995; Sugar & Luterbach, 2016) involved practicing instructional designers who were alumni from particular graduate programs at universities, both for the sake of convenience and to determine how common training influenced practice in different settings. Other studies included students taking a graduate course in instructional design as continuing education (Honebein & Honebein, 2014) or a mix of novice designers taking an introductory course and expert designers to compare their approaches to design problems (Rowland, 1992).

The remaining studies employed various purposive sampling techniques to recruit participants who were involved in different aspects of instructional design and development from a variety of practice settings. While most of the studies reported the number of years of instructional design experience for their participants, only two of the studies (Pieters & Bergman, 1995; Rowland, 1992) focused on differences in results as they related to designer experience. It is important to note that while some of the studies claimed to have participants from a broad range of sectors, none of the research intentionally drew samples from large professional associations in order to target practitioners along the entire spectrum.

Unlike much of the research on cognitive load, the studies focusing on the use of theory among instructional designers examined individuals in a variety of settings. A couple of the studies were concerned primarily with instructional designers in business and industry (Wedman & Tessmer, 1993; Winer & Vázquez-Abad, 1995), while others compared practitioners in corporate training to those in education (Kirschner et al., 2002; Pieters & Bergman, 1995; Yanchar et al., 2010). The remaining studies examined instructional designers in a variety of practice settings, including business, government, military, higher education, K-12 education, and adult education. As additional research is conducted to determine how specific theories influence the selection and implementation of instructional strategies, this broad representation of participants and settings would enhance the external validity of findings.

Sample Sizes and Study Durations

The studies that examined the relationship between theory and the activities of practicing instructional designers had very different sample sizes, which were dependent upon the type of research design used to study the variables of interest. Four of the studies involved sample sizes of fifteen or fewer, with the smallest sample size of seven participants (Yanchar et al., 2010).

Each of these employed a qualitative research approach, which typically involves sample sizes of this nature. The remaining studies had sample sizes that ranged from thirty-five (Pieters & Bergman, 1995) to as many as 113 (Christensen & Osguthorpe, 2004). These six studies employed either a purely quantitative research approach or a quantitative technique supplemented by qualitative information, which makes the relatively larger sample sizes appropriate in order to use statistical techniques to determine the significance of the findings.

Much like the studies conducted on cognitive load, the durations of the studies related to theory and practicing instructional designers had rather short durations. Four of the studies involved the completion of a single survey or questionnaire that took approximately an hour or less, while two additional studies followed up initial surveys with brief interviews that lasted 45 minutes to an hour. The remaining four studies employed various observational techniques that lasted between 90 minutes and three hours. Since most of these research studies were intended to gain a general understanding of how theory influences the activities of practicing instructional designers, these short durations seem appropriate for gathering anecdotal information about their experiences. Depending upon the goals of future research, longer durations have the potential to shed light on the manner in which theory informs the practice of instructional designers during various points in time as they complete projects.

Research and Data Types

Six of the studies employed a quantitative research design and used survey instruments to gather data about the activities completed and strategies employed by practicing instructional designers in their day-to-day work. While survey responses have the potential to be biased because the information is self-reported, these instruments are perhaps the best method of capturing information about behaviors that occur over a longer period of time and would be prohibitive to observe directly. Two of the quantitative studies did include follow-up interviews that provided qualitative information to support the quantitative data that was statistically analyzed. The remaining four studies employed qualitative research designs that involved reflective interviews (Yanchar et al., 2010), interviews using the Critical Incident Technique (Sugar & Luterbach, 2016), and observations of activity (Gray et al., 2015; Rowland, 1992) in order to gain a better understanding of the reasons behind the decisions made by designers in practice. In order to understand both the degree to which theory influences the selection and implementation of instructional strategies and the reasoning for those decisions, mixed methods approaches have the potential to provide the most information during future studies.

The types of data gathered and analyzed in the studies of practicing instructional designers closely aligned with the research designs used. The quantitative studies that employed surveys or questionnaires reported response frequencies for design activities and percentages of respondents who indicated using various design strategies prescribed by theory. The authors of the qualitative studies used thematic data analysis and validation with participants to categorize their results into themes that described the manner in which practicing instructional designers made decisions based on theory.

Theory in Practice

The results of the studies on the influence of theory on instructional designers provide insight into the relationship between theory and practice, and they pose several questions that should be addressed in future research. Several of the studies noted that practicing designers tend to deviate from prescriptive instructional design models and theories based on contextual constraints (Pieters & Bergman, 1995; Wedman & Tessmer, 1993), and the use of prescriptive theories is often associated with the level of expertise and training of the instructional designers

(Rowland, 1992). However, other studies did note that a significant portion of designers use theory while generating ideas and making instructional strategy decisions in their daily practice (Christensen & Osguthorpe, 2004; Sugar & Luterbach, 2016; Yanchar et al., 2010). In addition, the judgments made by instructional designers regarding the appropriateness of particular instructional methods and strategies tended to align with best practices derived from theory, even when practitioners didn't indicate that they were explicitly following theory (Gray et al., 2015; Honebein & Honebein, 2014).

Several of the authors concluded that there is a need to close the gap between prescriptive theories and instructional design practice (Kirschner et al., 2002; Winer & Vázquez-Abad, 1995), as expert designers tend to use heuristic knowledge rather than following all elements of theory. With respect to cognitive load in particular, Sentz and Watson (2017) indicated that designers are largely using strategies to reduce extraneous load and manage intrinsic load by addressing various aspects of message design, segmentation of content, and the sequencing of instruction. Several factors were identified that limit designers from using more strategies to manage load than they currently do, including the perception that certain strategies are not applicable to particular types of instruction and constraints on time and resources.

Others recommended that instructional design programs expose students to the application of theory within specific contexts through approaches such as cognitive apprenticeships (Sugar & Luterbach, 2016; Yanchar et al., 2010). It is clear from this group of studies that a great deal can be learned about the interaction between theory and practice by researching how instructional designers apply their knowledge of theory in context. Furthermore, there has been relatively little research done on the application of specific prescriptive theories in practice and the reasons for the decisions being made. As cognitive load theory and its prescriptive strategies have previously been well grounded in experimental studies, this additional research approach holds promise for expanding our understanding of how practitioners are managing cognitive load in complex, ill-structured domains.

Purpose Statement

The purpose of this research study was to examine how practicing instructional designers manage cognitive load in a standardized scenario as they select and implement instructional strategies, message design, content sequencing, and delivery media within various domains with learners at different levels of expertise.

Research Questions

The following research questions guided the study:

1. When given a standardized instructional scenario, how do practicing instructional designers implement various prescriptive strategies to manage cognitive load?
   1.a. What are the differences between the prescriptive strategies to manage cognitive load implemented by expert instructional designers when compared to their novice counterparts?
2. How does instructional designers' stated awareness of the various strategies to manage cognitive load influence their application of these strategies to a standardized scenario?
3. How applicable do instructional designers consider the various strategies to manage cognitive load to be to the subject matter and instructional situations in their designs?
4. What obstacles do instructional designers perceive as preventing them from managing cognitive load in their designs?

CHAPTER II

METHODS

Research Design

The study employed a quasi-experimental, mixed methods design to gain insight into how practicing instructional designers perceive their awareness of strategies to manage cognitive load and implement instructional strategies, message design, content sequencing, and delivery media within a standardized design scenario. This research design took advantage of the collection of quantitative data from the participants during an initial questionnaire and a second collection of data as the participants completed a design activity. The demographic information of the participants was compared according to their relative expertise in order to determine if there were significant differences in perceived strategy use, employment of strategies during the scenario, and anticipated future strategy use (Creswell, 2015).

The use of a think-aloud protocol as a primary means of data collection was expected to provide valuable information about cognitive processes that take place while instructional designers solve a problem, as Ericsson and Simon (1993) note that this approach generates relatively reliable information when gathered concurrently with task completion. Previous studies have identified potential limitations of this type of protocol, however, that were taken into account in the design and addressed through additional data collection. Ericsson and Simon (1993) note that the technique does rely on subjective accounts of thought processes rather than objective behaviors that can be observed, which can be especially relevant with participants who are not experienced or comfortable with the protocol. In addition, it is likely that participants with more expertise in a domain may have the ability to connect specific concepts and articulate them while using a think-aloud protocol more than their novice counterparts (Wright & Ayton, 1987). Conversely, Wright and Ayton (1987) note that expert participants may operate at a level of mastery in the domain that prevents them from being able to articulate all of the steps as they solve a problem, and their automated use of heuristics could reveal potential blind spots where steps taken differ from those that are explained aloud. The think-aloud protocol remains a flexible and effective approach for eliciting the thought processes behind the decisions made by practitioners, and the triangulation of data through both observation of activity and debriefing interviews was used to clarify data gathered through the protocol (Ericsson & Simon, 1993).

The first phase of the study consisted of a self-assessment of current strategy use to manage cognitive load. The second phase provided the participants with a standardized instructional scenario in which they were asked to design a solution that called for the use of several of those strategies. An observation sheet was used to record quantitative information related to the decisions made by the participants during the scenario, and participants were also asked to use a think-aloud protocol that provided qualitative information regarding the rationale behind their design decisions (Rowland, 1992). The third and final stage involved a debriefing interview where the participants had the opportunity to discuss the design scenario and share their thoughts about expected future use of strategies for managing cognitive load. The study incorporated qualitative data collected from the participants regarding any perceived barriers preventing their use of strategies to manage cognitive load in the future, as well as their potential disagreement with the applicability or effectiveness of strategies to manage load derived from empirical studies.

Participants

Since the Association for Educational Communications and Technology (AECT) is one of the oldest and largest professional organizations in the field of designing instruction and applying technology to learning with over 2,000 members, a convenience sample taken from this group was expected to be more representative of the population of instructional designers than a typical nonprobability sample. As experimental and quasi-experimental studies ideally include at least 30 participants in order to examine the interaction between variables (Creswell, 2015), the desired sample size for this study was 30 participants.

A rather comprehensive salary survey of AECT members (Pershing, Ryan, Harlin, & Hammond, 2006) provided an overall picture of the anticipated general characteristics of the target population from which the sample was drawn. The large majority of AECT members are concentrated into an age range of 30 to 59, and members are evenly split between males and females. The primary practice settings for members include higher education (78%), K-12 education (11%), business (4%), government/military (4%), and non-profit (3%). At the time of the survey, 58% of members held a doctoral degree, 37% a master's degree, and 4% a bachelor's degree as their highest education level achieved. The average number of years that members had been employed in the field was twelve years (Pershing et al., 2006).

In addition to the convenience sample taken from AECT, a research request was also sent to the International Society for Performance Improvement (ISPI) to capture practitioners who may be engaged in instructional design but are not members of AECT. ISPI is a professional association consisting of performance improvement practitioners and instructional designers in a variety of settings and organizations. Because the purpose of the study was to examine how practicing instructional designers of different levels of experience and education manage cognitive load, the minimum inclusion criteria for participants drawn from the two professional organizations was simply one year of full-time experience as an instructional designer and a working knowledge (self-identified) of the instructional design process.

As the level of expertise for the participants was relevant to the data analysis, information was gathered to determine whether the instructional designers were to be considered novices or experts. An examination of expert performers by Ericsson, Krampe, and Tesch-Römer (1993) indicated that experts tended to engage in an average of 20 hours per week of individual practice in their domain and accumulate more than 10,000 hours over a ten-year period. Given a 40-hour work week roughly split evenly between various administrative tasks and practice within the domain, an approximation of instructional design expertise was understood as roughly ten or more years of full-time experience in the domain. In order to further validate this assumption, the participants were asked to rate themselves using a Likert scale on the seven dimensions of expertise identified by Chi, Glaser, and Farr (2014). These include specific knowledge of the domain, identification of patterns when doing their work, speed and accuracy in problem solving, short- and long-term retention of domain concepts, complex representation of problems, extended time spent analyzing a problem before solving, and awareness of their own thought processes regarding the domain. If there were discrepancies between these two measures of expertise, a participant was considered a novice or expert at the discretion of the researchers.

Independent Treatment

The primary independent treatment for all participants was an instructional design scenario, which each participant was asked to complete real-time as a researcher observed their decision making. The use of the scenario was ultimately intended to allow the practitioners to show how they take cognitive load into account when selecting and implementing strategies, message design, content sequencing, and delivery media. This was not explicitly stated to the participants, however, so as not to influence the decisions that they made during the completion of the scenario. The scenario itself was written in a way that provided information that could be used to address the intrinsic, extraneous, and/or germane load if the participant chose to do so. Participants were told from the outset that there was no correct way to approach the scenario, and they were free to provide any solution they chose that addressed the information given.

The instructional design scenario first provided a needs assessment that included information about the problem to be addressed. This overview indicated the subject domain and the specific need for the learners to interact with the material. The scenario also provided the study participants with characteristics of the learners who were to be given the instruction, which included information regarding their expertise or prior experience with the subject matter to be addressed in the instruction. A task analysis was provided to give the instructional designers an idea of the specific concepts within the domain that needed to be covered by the instruction that was designed. Finally, a list of instructional objectives that had to be addressed by the instruction was given to the participants to review. Upon examination of these materials, the participants were given approximately 30 minutes to provide a solution using a think-aloud protocol that indicated the content sequencing, instructional strategies, message design, delivery media, and evaluation instruments they would use to address the design scenario within the given specifications.

Instruments

The study employed three different instruments for the purpose of data collection during the different phases of the research. The first instrument was a questionnaire that the participants filled out prior to the scenario regarding their demographic information and current strategy use. During the completion of the scenario itself, the comments of the participants were recorded and transcribed for the researchers to complete an observation sheet involving the decisions that were articulated through the think-aloud protocol. The final instrument was an interview protocol that was used during the debriefing activity to capture the thoughts of the participants regarding the activity and expected future use of related strategies.

First dependent measure. The first data collection instrument used was a pre-scenario questionnaire (Appendix B) that asked the participants to share both demographic information and a self-assessment of their current use of strategies to manage cognitive load in practice. With regard to demographic information, participants were asked to indicate the number of years of experience they had in instructional design in order to help determine where each participant fell on the expertise continuum (Ericsson et al., 1993). They were also asked to indicate their highest level of education completed and the area in which their degree was earned. Additional demographic questions included their primary area of practice (higher education, K-12 education, industry, government, etc.), as well as their job title within their organization. The questionnaire also asked the participants a series of questions adapted from the criteria put forth by Chi et al. (2014) regarding their perceived expertise within the area of instructional design.

After the demographic section of the questionnaire, the participants were asked to respond to a series of statements that related to their current use of strategies to manage cognitive load within their design work. The list of strategies were a modification of the design strategies and principles put forth by van Merriënboer and Sweller (2010) for each category of cognitive load prescriptions. These statements were written in general terms so as not to lead the respondents to a desired response, but they involved elements of instructional design that related to the consideration of intrinsic, extraneous, and germane load.

The questionnaire used for this study was a modification of the survey instrument utilized by Sentz and Watson (2017), which was pilot tested prior to use by students within the Instructional Design and Technology (ID&T) doctoral program at Old Dominion University to determine the validity of the questions for their intended use and the reliability of responses from the study sample. The questionnaire was reviewed a second time by Old Dominion faculty members with expertise in instructional design competencies for validity and reliability prior to the present study.

Second dependent measure. The second data collection instrument utilized in the study involved the instructional design scenario itself (Appendix C) and an observation sheet used by the primary researcher (Appendix D) to record the strategy decisions articulated by participants using the think-aloud protocol. For the purpose of this study, the subject domain of using spreadsheet software was used due to its applicability across all instructional design settings – higher education, secondary education, business and industry, as well as government and military. In addition, the scenario involved both well-structured and ill-structured tasks within the domain of productivity software. The study participants were asked to design instruction that prepares learners to be able to create a spreadsheet application that solves a practical problem of their choosing, while incorporating the use of several specific spreadsheet operations (inputting data, using equations, etc.). This type of scenario incorporated elements of other research studies on the use of spreadsheets to solve both well-structured (Blayney, Kalyuga, & Sweller, 2010; Blayney, Kalyuga, & Sweller, 2015) and ill-structured problems (Jonassen, Prevish, Christy, & Stavrulaki, 2006).

The learner analysis included characteristics that indicated most of the learners were novices with respect to the material, but there were a few learners who had prior experience with some of the content. This served to provide participants with an opportunity to address the expertise reversal effect if they chose to do so. A brief task analysis was provided that listed the types of information the learners would need to apply in order to create spreadsheets that allow for the storage and manipulation of data to solve practical problems of either a personal or organizational nature. Finally, instructional objectives were given to the participants within the scenario to indicate the desired learning outcomes with regard to both the mechanics of spreadsheet operations and the creation of an application that solves an open-ended, real-world problem of the learner's choosing.

Each participant was asked to use a think-aloud protocol during the scenario, which was both recorded and transcribed for reference by the researchers. Using a procedure similar to that described by Rowland (1992), the researchers employed a categorization scheme to encode segments of the protocol according to strategy decisions made by the participant that addressed the three different types of cognitive load (intrinsic, extraneous, and germane). The observation sheet utilized to categorize the different types of strategies was pilot tested by the researchers in order to arrive at an acceptable level of inter-rater reliability. In addition, the categories of strategy decisions were reviewed by a researcher not involved in the study in order to establish the validity of the instrument against the constructs established by van Merriënboer & Sweller (2010) for instructional prescriptions to manage cognitive load.

In addition to the observation sheet used by the researchers, a rating system that employed a modification of the structure of observed learning outcomes (SOLO) taxonomy was used to assign a rating to each participant's solution with regard to how cognitive load was addressed. Biggs and Tang (1999) presented the SOLO taxonomy as a means of indicating a learner's increasing mastery of a subject through five levels of complexity – pre-structural, uni-structural, multi-structural, relational, and extended abstract. This taxonomy has been used to measure the performance of design and technology students in previous studies, with the conclusion that SOLO had a high level of validity in relation to traditional measures of cognitive outcomes in design performance (Leung, 2000). These ratings by the researchers were compared to the self-ratings of the participants prior to the scenario to determine the relationship between perceived strategy use and actual strategy use within the standardized scenario.

Third dependent measure. The final data collection instrument used during the study was an interview protocol (Appendix E) for a short, 15-minute debriefing interview with each participant upon completion of the design scenario. This instrument provided the flexibility for participants to respond openly to semi-structured questions (Creswell, 2015) regarding the decisions they made in relation to managing cognitive load. The researcher asked each participant about their rationale for addressing the three aspects of cognitive load during the scenario (intrinsic, extraneous, and germane), as well as any potential expertise reversal effects. This interview provided the participants with the opportunity to share their thoughts regarding their potential future use of these strategies, as well as any perceived barriers within their particular practice setting that would prevent them from using certain strategies. In addition, the interview allowed for the collection of information regarding any potential disagreement that the participants had with the instructional strategy prescriptions from previous research.

The questions within the interview protocol were informed by the reflective interviews used to collect qualitative data from instructional design practitioners in previous studies (Sentz & Watson, 2017; Sugar & Luterbach, 2016; Yanchar et al., 2010). As with the other instruments, the interview protocol was pilot tested with a select group of practitioners in order to determine whether the questions were valid for the intended use and produced reliable responses that could be qualitatively coded by the researchers. The responses from the pilot test were coded separately by the researchers and compared in order to determine the inter-rater reliability of the instrument.

Procedure

Prior to conducting the study, Institutional Review Board approval was obtained. Upon notification that the application had been granted exempt status by the chair of the Old Dominion Darden College of Education Human Subjects Review Committee, a research request was submitted to both the AECT and ISPI memberships according to their stated research policies. Once participants signed up for the study through the web site provided, email invitations were sent to schedule appointments for completion of all study activities. An informed consent document was presented to all participants to explain the purpose of the research and ask for their participation in the various phases of the study.

Before the appointment, the participant was sent a link to the online questionnaire containing demographic and current strategy use questions. Participants were told that this questionnaire would take no longer than 15 minutes to complete. The design scenario activity took place within the Google Hangouts web conferencing tool, which allowed the researcher to observe the participants as they completed the scenario within a shared workspace. By sharing their desktop with the researcher within the web conferencing tool, each participant had access to applications such as Microsoft Excel to reference various spreadsheet tools or Microsoft Word to record their design ideas if they chose to do so. Participants were asked to set aside one hour for the completion of the entire study, and they were told that they had 30 minutes to review the scenario and design a solution. The think-aloud protocol was explained to the participants at the beginning of the session, and they were encouraged to create the instruction that addressed the design scenario while verbalizing all decision making steps as they were made.

Participants were assured that there was no correct or desired solution to the design scenario, as the intent of the study was to gain a better understanding of the decisions that are made by practitioners as they approach instructional design problems. Since the scenario was self-contained and included all of the information needed to complete the activity, participants were told that the researcher was only able to answer clarification questions and could not supply additional information beyond the scenario as described. As the participant completed the scenario, the researcher used the observation sheet to record actions taken by the participant and decisions noted through the think-aloud protocol that were relevant to the strategies to manage cognitive load of interest in the study. In the event that a participant was not verbalizing decisions made or failed to progress through the scenario, the researcher periodically inquired about the rationale for a particular strategy decision or actions the participant was considering.

After the participant completed the design scenario, the researcher conducted a short debriefing interview to gather additional information about the participant's rationale for making decisions during the activity. The participant was asked about the manner in which cognitive load was managed, as well as how the specific types of load (intrinsic, extraneous, and germane) were addressed. If the participant chose not to address cognitive load during the scenario, the researchers inquired about the rationale behind that decision. Finally, the participant was asked about expected future use of strategies to manage cognitive load in their practice and any perceived barriers to implementing those strategies in their practice setting. Participants were thanked for their time and asked if they were willing to be contacted for any follow-up questions.

Data Analysis

As with previous studies of instructional design practitioners and the frequency of their strategy use, the first level of data analysis for the scenario data was to calculate descriptive statistics including frequency counts and percentages of each type of strategy decision to manage cognitive load across all respondents (Christensen & Osguthorpe, 2004; Wedman & Tessmer, 1993). For the qualitative data collected through the think-aloud protocol during the scenario, a process was used to code the data for the purpose of building descriptions and themes that would allow for the elaboration of the quantitative data gathered on decisions made. The research question regarding differences between stated use of strategies and the use of strategies within the standardized scenario was addressed through the use of analysis of variance (ANOVA) to examine both the differences between the questionnaire scores and the scenario ratings, as well as the ratings assigned to participants classified as novices or experts (Creswell, 2015).

Qualitative data collected during the debriefing interviews was coded for the purpose of building descriptions and themes regarding expected future strategy use and potential obstacles to implementing them in practice, as has been done in previous studies (Sugar & Luterbach, 2016; Yanchar et al., 2010). Both a priori codes from similar research (Sentz & Watson, 2017) and emergent codes were used to create a coding scheme that allowed for a meaningful interpretation of the data. All participant quotes included in the analysis were chosen due to their representativeness of the themes that emerged across a large number of the participants. The data analysis from the questionnaire, scenario, and debriefing interviews is included in the Results section of this research report. Table 1 indicates the analysis for each research question.

Table 1

Research Questions with Corresponding Data Collection Methods and Data Analysis Approaches

Research Question	Data Collection	Data Analysis
1. When given a standardized instructional scenario, how do practicing instructional designers implement various prescriptive strategies to manage cognitive load?	Think-aloud protocol during scenario Observation sheet and scenario ratings	Thematic analysis of think-aloud protocol Frequency counts of strategy decisions made; SOLO rating of strategy use

1.a. What are the differences between the prescriptive strategies to manage cognitive load implemented by expert instructional designers when compared to their novice counterparts?	Pre-scenario questionnaire demographic questions Think-aloud protocol during scenario Observation sheet and scenario ratings	ANOVA to determine differences between mean strategy use in scenario for novices vs. experts
2. How does instructional designers' stated awareness of the various strategies to manage cognitive load influence their application of these strategies to a standardized scenario?	Pre-scenario questionnaire on existing strategy use Think-aloud protocol during scenario Observation sheet and scenario ratings	ANOVA to determine differences between mean strategy use in questionnaire and scenario
3. How applicable do instructional designers consider the various strategies to manage cognitive load to be to the subject matter and instructional situations in their designs?	Pre-scenario questionnaire on existing strategy use Debriefing interview on expected future strategy use	Thematic analysis of open-ended responses regarding applicability of strategies in practice; comparison between novices and experts
4. What obstacles do instructional designers perceive as preventing them from managing cognitive load in their designs?	Debriefing interview on obstacles preventing strategy use in practice	Thematic analysis of open-ended responses regarding obstacles to strategy use in practice; comparison between novices and experts

CHAPTER III

RESULTS

Participants

A total of 30 participants completed both the instructional designer decision making questionnaire and the instructional design scenario. Of the total participants, 20 responded to the membership research request through AECT, and 10 responded to the research request through ISPI. Each of these participants met the specified minimum inclusion criteria of one year of full-time experience as an instructional designer and a self-identified working knowledge of the instructional design process.

On the online questionnaire, participants were asked to specify the number of years of experience they had in the area of instructional design. Approximately half of the participants (*n*=14) had ten years of experience or less in instructional design, while the rest of the participants (*n*=16) had more than a decade of full-time experience in instructional design. A summary of the number of years of experience appears in Table 2.

Table 2

Number of Years of Experience in Instructional Design for All Participants

Years of Experience	Number of Participants
2 years or less	1
3-5 years	6
6-10 years	7
11-15 years	4
16-20 years	3
More than 20 years	9

The participants were also asked to specify the highest degree they had earned at the time of completing the online questionnaire. One participant indicated having earned a bachelor's degree in instructional design or a related area. The largest number of participants (*n*=18) held a master's degree, with half (*n*=9) in instructional design or a related area and the other half (*n*=9) in another area of study. The remaining participants (*n*=11) indicated having earned a doctoral degree, with the large majority (*n*=9) in instructional design or a related area. A summary of the highest degrees earned appears in Table 3.

Table 3

Highest Degree Earned for All Participants

Highest Degree	Number of Participants
Bachelor's (Instructional Design or related)	1
Master's (Instructional Design or related)	9
Master's (Other)	9
Doctoral (Instructional Design or related)	9
Doctoral (Other)	2

Participants were asked to indicate the primary area(s) in which they practice instructional design. This question on the online questionnaire allowed the participants to select more than one area of practice, and 10 of the participants indicated that they did instructional design work in more than one practice area. The highest number of participants noted their primary area of practice in the areas of business/industry (*n*=12) and higher education (*n*=20), which is to be expected given their membership in ISPI and AECT, respectively. Each of the areas of practice indicated were represented by participants in the study, and no participants indicated an area of practice not listed in the questionnaire. A summary of the primary areas of instructional design practice appears in Table 4.

Table 4

Primary Areas of Practice for All Participants

Practice Area	Number of Participants
Business/Industry	12

Higher Education	20
K-12 Education	5
Government	6
Military	4
Other	0

The study participants were asked to self-identify their level of expertise within the domain of instructional design by indicating the degree to which they agreed with a series of seven statements, which were adapted from the dimensions of expertise put forth by Chi et al. (2014). This information was then compared to both the number of years of experience in instructional design and the highest degree earned for each participant, in order to take into account the accumulation of individual practice noted by Ericsson et al. (1993). These pieces of data were combined in order to assign each participant to the novice or expert group for the remainder of the study, which was reviewed and validated by a second reviewer. Two-thirds of the study participants (*n*=20) were assigned to the expert group due to their self-rating on the expertise scale, as well as having either 11 or more years of experience in instructional design or a doctoral degree in instructional design or a related area of study. A summary of the expertise grouping appears in Table 5.

Table 5

Expertise Level for All Participants

Level of Expertise	Number of Participants
Novice	10
Expert	20

Existing Strategy Use to Manage Cognitive Load

Participants were provided a list of statements regarding their current use of strategies to manage cognitive load in their work, which included a modification of the strategy prescriptions for each category of cognitive load proposed by van Merriënboer and Sweller (2010). The participant was asked to rate their existing use of each strategy on a scale ranging from 0 ("never") to 4 ("very often"). A summary of the descriptive statistics for existing strategy use scores by cognitive load type appears in Table 6. A summary of the descriptive statistics for existing strategy use scores for each of the individual strategies to manage cognitive load within the various categories appears in Table 7.

Table 6

Descriptive Statistics for Existing Strategy Use Scores by Type for All Participants, Novice Participants, and Expert Participants

Strategy Type	Mean (All)	SD (All)	Mean (Novice)	SD (Novice)	Mean (Expert)	SD (Expert)
Extraneous Load	2.24	1.00	2.17	1.01	2.28	1.00
Intrinsic Load	2.73	0.90	2.80	0.83	2.70	0.94
Germane Load	2.31	0.94	2.50	0.90	2.22	0.96
Expertise Reversal	2.70	1.09	2.60	1.22	2.75	1.02
All Strategies	2.43	1.01	2.42	1.03	2.43	1.01

Table 7

Descriptive Statistics for Existing Strategy Use Scores by Strategy for All Participants, Novice Participants, and Expert Participants

Strategy	Mean (All)	SD (All)	Mean (Novice)	SD (Novice)	Mean (Expert)	SD (Expert)
Extraneous Load						
Goal-free Tasks	2.30	0.92	2.30	1.16	2.30	0.78
Worked Examples	1.90	0.76	1.80	0.79	1.95	0.74
Completion Tasks	1.93	0.87	1.60	0.52	2.10	0.94
Integrated Information	2.57	0.90	2.80	0.63	2.45	0.97
Dual Modality	3.20	0.76	3.10	0.88	3.25	0.70
Eliminate Redundancy	1.57	0.94	1.40	0.84	1.65	0.96
Intrinsic Load						

Simple-to-complex	2.80	0.96	2.90	0.88	2.75	1.02
Low- to High-fidelity	2.67	0.84	2.70	0.82	2.65	0.88
Germane Load						
Variability	2.67	0.99	3.00	0.82	2.50	1.05
Contextual Interference	1.97	0.85	2.00	0.67	1.95	0.95
Self-explanations	2.30	0.88	2.50	0.97	2.20	0.83
Expertise Reversal						
Scaffolding/Faded Guidance	2.70	1.09	2.30	1.25	2.90	0.97
Integration to Non-integration	2.97	0.96	3.10	0.99	2.90	0.97
Dual- to Single-mode	2.43	1.17	2.40	1.35	2.45	1.10

Instructional Design Scenario Data

Upon completion of the online questionnaire, all study participants were asked to participate in an instructional design scenario activity using a think-aloud protocol via Google Hangouts. At the beginning of each scenario session, the participant was sent a link to the written instructional design scenario document through the Hangouts group chat functionality. All scenario sessions were recorded using TechSmith SnagIt software and coded by the primary investigator for instances of strategy use to manage cognitive load within the categories of extraneous, intrinsic, germane, and expertise reversal strategies. The codes were reviewed and confirmed by a second reviewer in order to ensure both validity and reliability. After completing the scenario, participants engaged in a 15-minute debriefing interview to discuss the steps they took during the scenario, their expected use of strategies in regular practice, and any perceived barriers to strategy use in their practice setting. These interviews were also recorded, coded by the primary investigator for common themes, and confirmed by a second reviewer.

Research Question 1: Implementation of Prescribed Strategies to Manage Cognitive Load in a Standardized Scenario

The strategies used by the participants during the instructional design scenario activity were recorded and coded in order to examine the types of cognitive load being addressed within the design. In addition to tracking the number of instances where a particular strategy was used, qualitative data from the think-aloud protocol was used to determine the degree to which the participant considered the implications of cognitive load relative to the overall design of the instruction. For this purpose, a modification of the SOLO taxonomy was used to assign a rating to each participant's design approach on a scale of 0 (pre-structural) to 4 (extended abstract) to indicate the degree to which cognitive load strategies were used within the overall design approach.

Analysis of the design scenario data indicated that participants frequently used strategies to manage extraneous load through worked examples (n=23), completion tasks (n=15), and dual modality (n=19). However, use of strategies to manage extraneous load through goal-free tasks, integrated information, and the elimination of redundancy was infrequent. Participants frequently used simple-to-complex presentation (n=24) to manage intrinsic load, but they infrequently used low- to high-fidelity presentation to address the same type of load. Strategy use to manage germane load among the participants was either moderate (variability), infrequent (self-explanations), or non-existent (contextual interference). While each participant acknowledged the differences in learner expertise noted within the scenario, strategies such as scaffolding with faded guidance (n=5) and integration to non-integration (n=2) were infrequently used. A summary of the strategies used to manage cognitive load within the various categories during the design scenario appears in Table 8.

Table 8

Strategies Used During Design Scenario for All Participants, Novice Participants, and Expert Participants

Strategy	All	% of All	Novices	% of Novices	Experts	% of Experts
Extraneous Load						
Goal-free Tasks	2	7%	1	10%	1	5%
Worked Examples	23	77%	6	60%	17	85%
Completion Tasks	15	50%	4	40%	11	55%
Integrated Information	3	10%	0	0%	3	15%
Dual Modality	19	63%	7	70%	12	60%
Eliminate Redundancy	2	7%	0	0%	2	10%
Intrinsic Load						
Simple-to-complex	24	80%	9	90%	15	75%
Low- to High-fidelity	4	13%	0	0%	4	20%
Germane Load						
Variability	11	37%	4	40%	7	35%
Contextual Interference	0	0%	0	0%	0	0%
Self-explanations	5	17%	2	20%	3	15%
Expertise Reversal						
Scaffolding/Faded Guidance	5	17%	2	20%	3	15%
Integration to Non-integration	2	7%	1	10%	1	5%
Dual- to Single-mode	0	0%	0	0%	0	0%

The rationale given for using strategies to manage extraneous load such as worked examples and dual modality was related to presenting information and tasks to learners in a way that eliminated unnecessary distractions, as evidenced by the following quotes from participants:

- The very first thing that I will do in the design is I would create a spreadsheet that demonstrates each of these functions. So I would create a spreadsheet where I have done all of the objectives for this. This will enable me to show the user an example of what they will do when they are completed with this task. (Participant 25, Expert)

- Whether I develop a video or sound clips or something like that, it would be driven a little bit from my learner analysis. And based on whether the learner is able to digest those… And I'm thinking of Mayer in that sense, dual coding. (Participant 8, Expert)

The use of a simple-to-complex presentation strategy to manage intrinsic load was the most commonly used of all strategies (*n*=24), and participants tended to emphasize the need to chunk material and expose learners to information gradually as they became more familiar with the material. A participant explained his design process for presenting the information in the instruction when he stated during the scenario activity:

> And so as I'm doing this, I'm creating basically a step-by-step outline of what content to present during this. And then the structure and the procedure for creating a basic chart. So I am taking a very step-by-step procedural approach. (Participant 24, Expert)

Since the design scenario did note a need for the learners to transfer what they learned into their respective settings, some of the participants (*n*=11) did employ the use of the variability strategy to present the material as it is encountered in the real world beyond the classroom. However, strategies to manage germane load were used infrequently overall. A participant explained the struggles he encounters in effectively using strategies to induce transfer:

> I think at times it can be a little bit difficult to deal with what is a meaningful way to cause germane load around the [presentation of] learning content outside of what I might think of as normal practice activities. (Participant 26, Expert)

The design scenario also explicitly presented personas that showed a range of learner expertise within the target population, which was noted by all participants as they stepped through the scenario. The strategies to manage the expertise reversal effect were the least frequently used category, which participants explained was due to the difficulty and amount of time required to employ those techniques. One participant voiced his rationale directly in this quote:

> So understanding the scenario of a couple of the students is nice, but I'm not going to create an assignment that has 15 different ways to do it to try to cover… Design like that to start the course and split people up going another direction and bring them all back at the end. That's got to be the hardest thing to do. (Participant 13, Expert)

Research Question 1.a: Differences Between Prescriptive Strategies to Manage Cognitive Load Used by Expert and Novice Designers

Upon transcribing and coding all design scenario transcripts, the primary investigator assigned an overall SOLO rating to each participant to indicate the degree to which they employed their understanding of strategies to manage cognitive load within their respective designs. The taxonomy used represents five levels of increasing complexity with regard to the consideration of the different types of cognitive load likely experienced by the learners and approaches implemented to address them. Table 9 presents a summary of the SOLO ratings assigned to participants according to their expertise level.

Table 9

Design Scenario SOLO Rating for All Participants, Novice Participants, and Expert Participants

SOLO Rating	All Participants	Novice Participants	Expert Participants
0 (Pre-Structural)	0	0	0
1 (Uni-Structural)	6	1	5
2 (Multi-Structural)	13	7	6
3 (Relational)	8	2	6
4 (Extended Abstract)	3	0	3
Mean Rating	2.27	2.10	2.35

A one-way ANOVA was conducted in order to examine whether there were significant differences between the prescriptive strategies to manage cognitive load implemented by expert instructional designers and their novice counterparts. The 10 participants in the novice group had a mean SOLO rating of 2.10 ($SD = 0.57$), and the 20 participants in the expert group had a mean SOLO rating of 2.35 ($SD = 1.04$). The one-way ANOVA showed no significant effect of expertise level on the SOLO rating of instructional designers during the design scenario, $F(1, 28) = 0.50$, $p > .05$.

Research Question 2: Influence of Stated Awareness and Use of Strategies to Manage Cognitive Load on Application of Strategies in a Standardized Scenario

Based on their mean score across all 14 cognitive load strategy questions on the online questionnaire, each participant was assigned to a category corresponding to their existing awareness and use of strategies on a scale from 0 (never) to 4 (very often). A one-way ANOVA was conducted in order to examine the influence of self-reported awareness and use of strategies to manage cognitive load in practice on the application of those same strategies in a standardized design scenario. The one-way ANOVA showed no significant effect of stated awareness and current use of strategies to manage cognitive load on the use of strategies in the design scenario, $F(1, 28) = 0.05$, $p > .05$.

This result is perhaps not surprising given the mean scores of participants on the strategy questions within the questionnaire compared to the frequency counts of strategies used and SOLO scores for the design scenario. For instance, worked examples had the second-lowest mean strategy score on the questionnaire (1.90) but was the second-most frequently used strategy by participants (n=23) during the design scenario. On the other hand, integration to non-integration to address the expertise reversal effect had the second-highest mean strategy score on the questionnaire (2.97) but was one of the least frequently used strategies during the scenario by participants (*n*=2). The scenario was designed to incorporate subject matter and a learner population that would allow for the potential use of any of the prescribed strategies to manage cognitive load, so the lack of observed influence of self-reported use of these strategies on their application during the scenario points to a possible disconnect between perceived awareness and actual implementation of the strategies.

Research Question 3: Perceived Applicability of Strategies to Manage Cognitive Load to Subject Matter and Instructional Situations in Practice

During the debriefing interviews that followed the design scenario, participants were asked how likely they were to use the various strategies to manage cognitive load within the specific subject domains and practice settings they design for on a regular basis. They were also asked whether they felt any of the strategies might not be applicable to the subject matter they work with in their practice setting. The responses to these questions were somewhat mixed, and the perceived applicability did not seem to be attributable to the expertise level of designers. Several participants reported their perception that most of the strategies were generally applicable across subject areas, as evidenced by the following quote from an expert practitioner who explained her use of strategies in multiple disciplines:

> So everything I try to do, especially when I'm doing presentations to faculty, has got to work across all disciplines… Examples on slide 1 will be math, and slide 2 will be education, and slide 3 will be English, and slide 4 will be engineering to intentionally show this works across all disciplines. Because it's not the concept, it's the psychology and the research behind it. (Participant 10, Expert)

Similarly, a novice participant voiced a similar perception that the various strategies to manage cognitive load are applicable to a broad range of subject matter in the following statement:

> I do help faculty from every college here in the university and every department… It almost seems to me like a lot of the strategies would mostly work for most [domains]… I work with online strategies, because they're all online classes. It seems like most actually would work more than would not. (Participant 12, Novice)

Some participants did note, however, that they felt some of the prescribed strategies to manage cognitive load may not be as applicable to more ill-structured domains and tasks. For example, one expert participant mentioned the following:

> Yeah, the subject matter does make a difference. If you were maybe teaching sales techniques or soft skills… I mean, job aids are wonderful for procedural things. You know, step one, two, three, and four… Managing cognitive load through job aids [for soft skills] won't work, because they can't really refer to that sheet very well while they're practicing the live scenario. (Participant 27, Expert)

A novice participant who worked in medical education noted a similar perception that certain strategies to manage cognitive load are not as applicable to subject matter in her setting:

> The memorization, learning all the bones, learning how to take a history, how to do a physical exam, all of that stuff which is very rote and step-by-step. The kind of things that I do in an online environment which is daunting is the soft sciences like teaching students how to use motivational interviewing techniques in an online environment… It's really challenging to figure that out as far as any strategies. (Participant 3, Novice)

One aspect of the perceived applicability of strategies to manage cognitive load in various content domains seemed to be a lack of examples of application the participants were able to draw upon for certain subject matter. A novice participant mentioned the difficulty of convincing a corporate training client to use a particular strategy to manage extraneous load:

> I said here's an example of a very simple cognitive load device. And they'd already said they don't use those. But I think that just points to them not knowing it when they see it. And is it helpful, or do they just like it? I don't know because they haven't done an independent study that isolates whether or not [it's effective]. What's the value? We have to sell the value. (Participant 28, Novice)

Research Question 4: Perceived Obstacles Preventing Designers from Managing Cognitive Load in Practice

Participants were asked during the debriefing interview whether there were any barriers within their practice setting that might prevent them from using various strategies to manage cognitive load that would likely otherwise be effective. Several perceived barriers were identified by the majority of participants, and they included both barriers common to the use of all instructional strategies and those specific to the implementation of strategies designed to manage cognitive load. As with the perceived applicability of the strategies across subject domains, the barriers to implementing the strategies appeared to be shared across both novice and expert instructional designers in the study.

The barriers preventing the use of strategies to manage cognitive load that participants mentioned affecting all instructional strategies included time constraints, budgetary and resource restrictions, the absence of sufficient learner or content analysis, the fact that instructors rather than designers control the implementation (or lack thereof) of strategies, and the lack of learner feedback resulting from insufficient formative evaluation. A novice participant noted these barriers related to implementing strategies in the following quote:

> I think the biggest barrier that I have in my particular field is that I never actually get to see any of the learners. It is 100 percent online… So if I realize very early on something's not working, I cannot change it until the next academic year. We don't have the ability to actually ever talk with the students, so it's just based on whatever information they fill out on the survey. (Participant 4, Novice)

An expert participant also noted her frustrations with barriers to implementing these strategies to manage cognitive load, which apply to the use of many instructional strategies within a practical design setting:

> The other barrier is sometimes we don't have enough time to develop something the way we'd like to develop it. Or we don't have enough budget or enough resources, so we have to settle. And that's always very frustrating to work in that way. (Participant 14, Expert)

Beyond the barriers common to the implementation of prescribed instructional strategies in general, several of the participants identified perceived barriers within their practice settings specific to the use of strategies to manage cognitive load. These included the need to sell cognitive load strategies to instructors and clients who are unfamiliar or resistant, the extra design effort associated with some of the strategies, the large amount of content the instructor needs to cover in a specified timeframe, the wide diversity of learner expertise, and cultural differences among learners. One of the expert participants noted the combination of barriers related to lack of familiarity and the sheer amount of content to be covered:

> Basically any faculty member is [ultimately] responsible for designing their classes, and not everyone has a background in education or psychology of learning or anything like

> that. So they don't know what to consider when they're designing instruction and how to make sure that it's effective… Another difficult challenge or barrier [is] being able to make sure that you didn't overload students cognitively with the amount of information that you're presenting. (Participant 20, Expert)

A novice participant mentioned similar barriers to implementing strategies to manage cognitive load in her practice setting, as evidenced by the following quote:

> It's usually just the problem where there's a massive amount of content, and the instructor really wants to include it all. And we have to work with them to deconstruct that, to break it down. We kind of have to sell them on the idea, because they often give me a giant textbook and say they should know everything in this textbook by the end of 15 weeks. (Participant 1, Novice)

Despite a widely held awareness of strategies to manage cognitive load and the learner benefits of using these strategies within instruction, each of the participants noted that practical barriers do exist in all settings that can prevent the effective implementation of these strategies. While some of these barriers are organizational in nature and may impact the use of prescribed instructional strategies more generally, several of them appear to result from a lack of familiarity among subject matter experts and instructors regarding the value of these cognitive load strategies and the absence of examples illustrating the utilization of the strategies within a broad range of subject domains.

CHAPTER IV

DISCUSSION

The purpose of this study was to examine how instructional design practitioners manage cognitive load in a standardized scenario as they select and implement instructional strategies, message design, content sequencing, and delivery media for learners at different levels of expertise. The findings suggest that instructional designers are aware of multiple strategies to manage cognitive load and their potential benefits, and they apply these strategies either explicitly or implicitly during the design of instruction. However, both novice and expert instructional designers appear to have a relatively narrow view of the specific strategies to be employed due to a lack of prescriptions for their use in a broad range of subject domains.

While the participants in the study self-reported a higher level of awareness and use of strategies to manage cognitive load than in a similar study (Sentz & Watson, 2017), they primarily employed strategies to reduce the extraneous load of instruction and manage the intrinsic load of complex material. These findings would seem to indicate a degree of support for the concerns of de Jong (2010) and Moreno (2010) with regard to the lack of applicability for prescriptive strategies related to cognitive load theory within real-world subject domains that are personally relevant to learners, rather than highly controlled laboratory conditions. However, the interview responses of participants appeared to indicate an absence of awareness related to the use of strategies to manage germane load (Nievelstein et al., 2013; Rourke & Sweller, 2009; Stark et al., 2011) and expertise reversal effects (Kyun et al., 2013; Oksa et al., 2010; Reisslein et al., 2006) within ill-structured domains. It should be noted that some practitioners may have potentially been influenced by assertions that germane load is inextricably tied to either extraneous load (Cierniak, Scheiter, & Gerjets, 2009) or intrinsic load (Schnotz & Kürschner, 2007). Despite the relatively recent argument that cognitive load theory can be fully understood through the lens of extraneous and intrinsic load alone (Kalyuga, 2011), none of the participants mentioned this when explaining their rationale for choosing whether to address germane load.

In addition, the participants in the study expressed a need to weigh the value of using these strategies against a number of perceived organizational or contextual constraints that may prevent their implementation, which is consistent with the findings of several previous studies involving the use of theory by practitioners (Pieters & Bergman, 1995; Sentz & Watson, 2017; Wedman & Tessmer, 1993). By examining both the relative use of prescriptive strategies to manage cognitive load in practice and the rationale behind these decisions, we can gain better insight into the need for expanding our understanding of these strategies in broader domains.

Implementation of Strategies to Manage Cognitive Load in a Scenario

The results of the instructional design activity indicated that all of the participants used theory to some degree as they generated ideas to address the scenario and made decisions about strategy use, which is consistent with the findings of previous studies involving practitioners (Christensen & Osguthorpe, 2004; Sugar & Luterbach, 2016; Yanchar et al., 2010). These considerations of cognitive load theory were often explicitly stated, but they also sometimes aligned with prescribed strategies based on implicit assumptions that the participants didn't necessarily acknowledge as being derived from theory during the scenario. This type of decision making is similar to that observed in studies of judgments made in practice by instructional designers (Gray et al., 2015; Honebein & Honebein, 2014; Williams, South, Yanchar, Wilson, & Allen, 2011).

At least half of the participants implemented strategies to reduce extraneous load during the scenario by using worked examples, completion tasks, and dual modality. This is perhaps not surprising given the widely accepted empirical results of foundational studies in the literature that have shown the effectiveness of these strategies (Mousavi et al., 1995; Paas, 1992; Sweller & Cooper, 1985). In addition, more than three-quarters of the participants used a simple-to-complex strategy to manage intrinsic load during the scenario, which is likely attributable to the fundamental concept within cognitive load theory of interacting elements within material contributing to its overall complexity (Sweller & Chandler, 1994).

While about one-third of the participants recognized the value of using a strategy involving task variability within an ill-structured domain (Nievelstein et al., 2013), the relative lack of strategy use to foster germane load overall may be the result of fewer studies with corresponding prescriptions outside of algorithmic domains such as mathematics. Similarly, only about one-fifth of the participants in the study attempted to address the expertise reversal effect using a strategy of scaffolding with faded guidance. While this approach has been shown to be effective within ill-structured domains (Oksa et al., 2010; Reisslein et al., 2006), the observed complexity of the expertise reversal effect may explain the reluctance of participants to go beyond more basic prescriptions of having learners simply test out of the material.

Differences in Strategies Implemented by Experts Compared to Novices

No significant differences were found between novice and expert participants with regard to strategy use to manage cognitive load during the design scenario. This finding runs counter to some of the previous research on practitioner use of prescriptive instructional design theory more generally (Rowland, 1992), which indicated that use of theory was often associated with the amount of training and professional experience of the participants. Since none of the previous research has focused specifically on the use of cognitive load theory by practicing instructional designers, the findings of the current study suggest that prescriptive strategies related to cognitive load in particular may not be widely covered in the types of graduate education or ongoing training that would lead to increased use of theory associated with experts having more experience with those strategies. In addition, the lack of incorporation of reflective thinking (Christensen & Osguthorpe, 2004; Yanchar et al., 2010) to prompt students to articulate their rationale for addressing cognitive load could potentially explain relatively low use in context.

All participants, regardless of their level of expertise, were observed implementing strategies to manage cognitive load to some degree. This implementation of strategy was both explicit and implicit in nature, which supports the findings of previous studies that indicated designers sometimes using heuristic knowledge rather than applying all elements of theory (Kirschner et al., 2002; Winer & Vázquez-Abad, 1995). More specifically, the current study confirms a preceding study (Sentz & Watson, 2017) that showed the heuristics used by practitioners are primarily concerned with the more widely known strategies to reduce extraneous load (such as worked examples and dual modality) and manage intrinsic load (such as simple-to-complex presentation of content). This finding adds to the body of knowledge regarding practitioner use of theory that points to a need to close the gap between prescriptive theories resulting from empirical research and instructional design practice. While prescribed strategies to foster germane load and address the expertise reversal effect have been shown to be effective in the research, these prescriptions do not seem to be used as often as expected in practice by either expert or novice practitioners.

Influence of Stated Awareness and Use of Strategies on Application in a Scenario

The results from the online questionnaire in the current study indicated a somewhat higher level of awareness and use of strategies to manage cognitive load among practitioners than a previous study examining similar self-reported behavior (Sentz & Watson, 2017).

However, this finding could be at least partially attributable to the present study's use of example statements related to the use of each strategy rather than the previous study's use of formal names and definitions for each strategy. Since the findings of this study indicate no significant effect of self-reported use of these strategies in practice on their actual application within the standardized design scenario activity, it appears that practitioners are more conceptually aware of strategies to manage cognitive load and their potential benefits than they are likely to implement a large number of them in practice.

This apparent disconnect between awareness and application of strategies to manage cognitive load aligns with previous studies regarding strategy use by practitioners more generally that indicated an insufficient amount of exposure to the application of theory within specific contexts in instructional design education and training (Sugar & Luterbach, 2016; Yanchar et al., 2010). The recommendations of these studies to use approaches such as cognitive apprenticeships to move students from general awareness to an ability to apply prescriptive strategies in context would appear to be as applicable to cognitive load theory as to instructional design theory in general. This approach has the potential to especially address the stated desire of several participants to gain a better understanding of strategies to foster germane load, as well as the overall lack of use related to strategies for addressing the expertise reversal effect.

Perceived Applicability of Strategies to Subject Matter and Instructional Situations

In addition to a relatively low overall observed application of a large number of the prescribed strategies to manage cognitive load within the scenario, the qualitative data gathered during the debriefing interviews showed a notable amount of uncertainty among participants regarding the applicability of these strategies to the types of subject matter and instructional situations they deal with on a daily basis. The participants who reported a perception that most of the strategies seemed generally applicable frequently had a difficult time providing examples of the use of these strategies across multiple domains. Others expressed some uncertainty that some of the prescriptive strategies would work in subject areas or instructional situations that are less algorithmic or procedural in nature. These perceptions seem to at least partially relate to the concerns stated previously by others who questioned the potential effectiveness of strategies devised to manage cognitive load in well-structured domains within more authentic, ill-structured domains (de Jong, 2010; Jonassen, 2011; Moreno, 2010).

While there have been a number of studies examining the effectiveness of various strategies to manage cognitive load in different domains, there have been very few instances of research leading to a set of heuristics for applying these strategies to practical design situations. Clark, Nguyen, and Sweller (2006) outlined the implementation of fourteen different strategies to manage cognitive load within the domain of spreadsheet applications similar to that examined in the current study, but this type of comprehensive set of prescriptions within a particular subject matter is not available to practitioners working with a wide range of domains. Several of the participants in the study expressed uncertainty about the applicability of strategies to manage cognitive load within ill-structured domains that involve soft skills or complex interactions. Since the importance of managing cognitive load within these complex domains is of the utmost importance due to the cognitive demands placed upon the learner, the lack of examples within advanced professional domains such as social work, business, and education is particularly problematic. Jonassen (2000) noted that instructional design itself is a type of ill-structured problem solving, and it would seem that practicing instructional designers would benefit from a set of worked examples in various domains that illustrate the applicability of the strategies to address the different categories of cognitive load.

Perceived Obstacles Preventing Practitioners from Managing Cognitive Load

The results of the study indicated that even when practicing instructional designers recognize the potential value of strategies to manage cognitive load, they perceive a number of practical and organizational obstacles that would prevent them from effectively or efficiently implementing them. This is consistent with previous studies that showed practitioners deviate from prescriptive instructional design theories in general based on a wide variety of contextual constraints (Pieters & Bergman, 1995; Wedman & Tessmer, 1993). As with the use of instructional design models or the alignment of assessment with objectives, the case often needs to be made by practicing instructional designers that the strategies to manage cognitive load will result in learning outcomes that are worth the time, resources, and budget required to implement them. In addition, the absence of learner and content analysis at the beginning of the process or feedback through formative evaluation during design poses a significant obstacle to the effective utilization of strategies to manage cognitive load that depend on an extensive understanding of the instructional material and the learners themselves.

The qualitative data from the debriefing interviews also provided support for the findings of the preceding study (Sentz & Watson, 2017) that indicated a number of obstacles specific to the implementation of strategies to manage cognitive load. The previously mentioned uncertainty among instructional designers regarding the applicability of these strategies to certain subject matter makes it difficult for practitioners to sell their value to subject matter experts and instructors who are unfamiliar with the management of cognitive load. Without this buy-in from clients, instructional designers find it challenging to justify the extra design effort associated with strategies that involve creating a number of worked examples or practice tasks with a high degree of contextual interference. Without a solid grasp of the benefits of using strategies to address cognitive load in specific domains, practitioners struggle with convincing instructors of the need to adjust the amount of content to cover in a specified timeframe or to consider the implications of learners entering with a wide diversity of expertise in the subject matter.

Implications

The primary implication of the present study is the confirmation that practicing instructional designers are largely using strategies to manage cognitive load to direct attention to the pertinent details of the instruction (worked examples, completion tasks, and dual modality) and deal with the inherent complexity of subject material (simple-to-complex presentation). This supports the findings of previous research examining the types of cognitive load strategies being used by practitioners (Sentz & Watson, 2017). Even within the categories of strategies to address extraneous and intrinsic load, there were several strategies that practitioners seem less likely to consider using (goal-free tasks, integrated information, eliminating redundancy, and low- to high-fidelity presentation). These results bring into question whether more recent studies to examine cognitive load strategies in broader domains have done enough to help practitioners to think of their application beyond the realm of mathematics.

Another implication of the study is that outside of the strategy of task variability, practitioners infrequently implemented strategies to foster germane load or address the expertise reversal effect during instruction. This observation could lead us to question whether we have sufficiently answered the call for empirical studies to address the role of germane load in domains of various complexities and degrees of structure (de Jong, 2010; Moreno, 2010). While the literature may include research that points to the effectiveness of strategies to promote transfer to other contexts and deeper processing among more expert learners working with the same material, a lack of application by practitioners is a cause for concern about the connection between prescriptive theory and practice.

The present study did not support the findings of previous research that indicated the use of prescriptive theories often increases along with additional training and experience among instructional designers (Rowland, 1992). The implication is that relatively low strategy use does not appear to be related to a lack of exposure to cognitive load strategies during training or opportunities to apply them in practice, but the absence of specific examples for implementing prescriptive strategies in a broad variety of domains. Practitioners displayed an awareness of strategies to manage cognitive load both explicitly through their decisions (Christensen & Osguthorpe, 2004; Sugar & Luterbach, 2016) and implicitly through their assumptions (Gray et al., 2015; Honebein & Honebein, 2014; Williams et al., 2011). The findings of the study, however, indicated that the self-reported awareness and use of these strategies didn’t have an effect on the likelihood that the strategies would be applied within a design scenario where learners could have potentially benefitted from their implementation.

The final implication of the present study is that strategies to manage cognitive load are not exempt from the deviation from prescriptive theories observed among practitioners when faced with particular contextual constraints (Pieters & Bergman, 1995; Wedman & Tessmer, 1993). In addition, participants reported facing perceived obstacles specific to the strategies to manage cognitive load, which supported the findings of a preceding study of practitioner behaviors (Sentz & Watson, 2017). These results point to the utmost importance of tying empirical studies to a better understanding of the applicability of prescriptive strategies to the wide variety of subject domains and instructional situations practicing designers face on a regular basis. While seeking to provide additional evidence for the effective use of strategies to manage cognitive load, researchers can simultaneously strengthen the understanding among practitioners regarding the application of well-established strategies in subject matter that may seem on the surface to be unrelated to the domains included in studies to date.

Cognitive Load Overlay Model

As noted by several of the participants in the study, many instructors and clients are unfamiliar with the impact that cognitive load has on learners. For that reason, they often dismiss the need to implement strategies to manage cognitive load due to the perception that it would not be worth the time or resources required. The research has shown, however, that managing cognitive load for the learner consistently results in more efficient learning and superior transfer performance. If the instructional design field were provided with a more comprehensive set of heuristics for implementing strategies to manage cognitive load in a variety of domains, practitioners would be better able to make the case that addressing cognitive load can make a significant contribution to the goals of efficiency and effectiveness that instructors and clients are seeking. Strategies that can be shown to foster the transfer of learning and the development of deeper understanding of material by learners at all levels of expertise have the potential to bridge the gap between theory and practice, which will ultimately lead to better learning outcomes and increase the value of instruction for all involved.

As a starting point for establishing a set of heuristics for implementing strategies to manage cognitive load, the following cognitive load overlay model has been developed to be used in conjunction with other systems models of the instructional design process. In a manner similar to the ARCS model for motivational design of Keller (2010), this proposed model serves as a conceptual framework for using cognitive load strategies in parallel with the steps for designing instruction present in the majority of instructional design models. The integration of this overlay model throughout the process leads to a set of heuristics that address several of the perceived obstacles identified by participants in the study that prevent them from sufficiently managing cognitive load in practice. Figure 1 presents a list of steps within each phase of most instructional design models, along with the corresponding steps in the overlay model to address cognitive load during each phase.

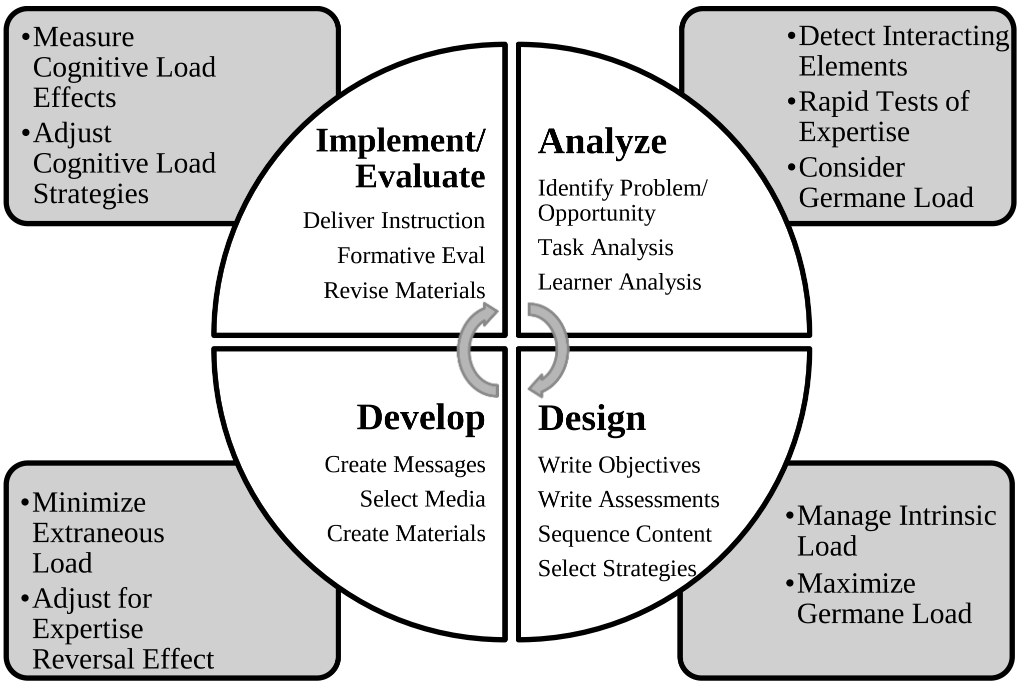

Figure 1. Cognitive load overlay model with corresponding instructional design steps.

The first heuristic resulting from the cognitive load overlay model is to incorporate the detection of interacting elements within the material to be learned during the task analysis step. Blayney et al. (2015) provide an overview of a process for listing interacting elements and having subject matter experts rank the complexity of tasks based on the number of required elements involved. This is an important step at the beginning of an instructional design project, as it helps the client or instructor begin to think about the importance of presenting material from simple-to-complex and low- to high-fidelity. The next heuristic is to use the interacting elements identified to conduct rapid tests of expertise in order to determine the relative levels of experience with the material among the learners during the analysis phase. These types of tests have been shown to provide valid assessments of a learner's understanding within a domain (Kalyuga, 2006; Kalyuga & Sweller, 2005), and they can inherently be conducted in a shorter amount of time than traditional pretests. The third and final heuristic within the analysis phase of instructional design is to consider the potential role of germane load based on the performance expectations identified in the instructional problem or opportunity. If the learners will be expected to transfer their newly acquired knowledge to different types of situations, the task analysis is an optimal time to look for specific parts of the task that could be enhanced for germane load through variability or contextual interference (Blayney et al., 2015; Lim, Reiser, & Olina, 2009).

Assuming that the intrinsic load of the material has been determined during the task analysis, the information about interacting elements will naturally flow into the writing of objectives and their corresponding assessment items. The types of objectives and order in which they are presented will depend largely upon the complexity and number of interacting elements associated with the corresponding content. In addition, this heuristic will facilitate the chunking of material relative to its complexity and the sequencing of content according to the simple-to-complex and low- to high-fidelity strategies. Beyond the management of intrinsic load, the design step of any systematic instructional design model is the point within the cognitive load overlay model in which germane load should be maximized for deeper learning. The use of generative strategies as suggested by Jonassen (1988) are an opportunity to foster germane load through prescriptive strategies such as encouraging learners to employ self-explanations.

The next heuristic in the cognitive load overlay model is to look for opportunities to minimize extraneous load during the development phase steps of creating the instructional messages, selecting delivery media, and creating all of the instructional materials. Since time and resources were identified by participants in the study as obstacles to implementing several strategies, this heuristic stresses the importance of saving any potential rework by identifying extraneous load as the instruction is developed. Existing materials can be sought to shorten the time needed to develop goal-free tasks, worked examples, and completion problems in a particular subject domain. In addition, delivery media can be selected or created that incorporates dual modality, integrated information, and the elimination of redundancy that will both benefit the learners and conserve valuable resources. The development phase is also a crucial time for addressing the expertise reversal effect, as it often relates to the point at which strategies to manage extraneous load no longer work for expert learners (Kalyuga, 2007). Since several participants perceived an obstacle that addressing expertise reversal required a prohibitive amount of additional work, it is important to note here that the strategies of integration to non-integration and dual- to single-mode presentation typically involve either the presentation of existing information in a different manner or the elimination of information. In addition, the use of scaffolding with faded guidance would entail the removal of certain instructional supports rather than the creation of unique content for learners with more expertise.

Perhaps one of the most important heuristics within the cognitive load overlay model involves the measurement of cognitive load effects during the implementation and evaluation of instructional materials. Despite the perception among many practitioners that measuring for cognitive load during formative evaluation requires resources that are rather limited during this phase of a project, this step is crucial in order to make a connection between the management of cognitive load and the attainment of superior learning outcomes among learners. Paas et al. (2003) have pointed out that the use of subjective mental effort rating scales or secondary task measures provide instructional designers with methods to measure cognitive load effects that are largely inexpensive, valid, reliable, and convenient. As various physiological measures of cognitive load become more readily available to practitioners, this heuristic will become even more powerful for connecting changes in the levels of cognitive load to learning efficiency and effectiveness. The final heuristic resulting from the cognitive load overlay model is the adjustment of strategies to manage the various types of cognitive load, which should follow the same types of modification that would be used for objectives or assessment items that are not leading to the desired learning outcomes. If the cognitive load overlay model is integrated as prescribed throughout the instructional design process, these adjustments should be possible at an acceptable level of expense and effort for the client, the instructor, and the practitioner.

Limitations

One possible limitation of the methodology for this study is that participants were self-selecting based on their interest in the research request sent to the AECT or ISPI membership, and they may have had more knowledge of the strategies of interest than the larger population of practicing instructional designers. In order to address this limitation, the description of the study did not directly mention the specific concern regarding strategies to manage cognitive load and only referenced the decision making process of instructional designers. Future studies intended to expand upon these findings could potentially include additional organizations involving practitioners such as the Association for Talent Development (ATD), or perhaps identify a sample that is not derived from membership in a professional organization.

A limitation of the questionnaire used to gather data on strategy awareness and current use in practice is that such instruments are subjective in nature due to their reliance on self-reported data (Gray et al., 2015; Rowland, 1992). As previously mentioned, the use of example statements rather than strategy names and definitions may have accounted for some of the differences in questionnaire scores when compared to a preceding study (Sentz & Watson, 2017). The observation of participant activity during a scenario and the incorporation of the debriefing interviews was used in the current study to triangulate the self-reported information from the questionnaire and address this limitation. The differences observed between self-ratings of certain strategies and the observed instances of actual strategy use during the scenario indicated that instructional designers may perceive their implementation of strategies as being more or less frequent than it actually is in practice.

A final limitation of the methods used for the study was that some participants may have felt uncomfortable using the think-aloud protocol while completing the scenario. The researcher attempted to address this issue by assuring participants throughout the activity that they were doing well with their approach to the problem, as well as prompting them to share their thoughts if they seemed reluctant to do so at times (Ericsson & Simon, 1993). None of the participants were unable to complete the scenario activity due to a lack of familiarity with the protocol.

Future Research

The methodology involving the use of a standardized design scenario in the current study was intended to gain further insight into the findings of a previous study that employed in-depth interviews using the Critical Incident Technique (Sugar & Luterbach, 2016). Since these two studies relied on anecdotal evidence of strategy use and the application of these strategies in a simulated instructional situation, an area for future research would be to examine the authentic work products of instructional designers to observe their use of strategies to manage cognitive load in practice. In addition to triangulating the data gathered through self-reported measures and behavioral observation, this additional research may uncover examples of strategy application within the context of specific domains that could be added to a group of heuristics that can be shared more broadly with practitioners (Winer & Vázquez-Abad, 1995).

An additional area for future research would be an examination of the cognitive load effects within the domain of instructional design itself, as it provides another opportunity to study the use of strategies within complex, ill-structured problem solving. While previous studies have examined instructional design with teachers and faculty members as the learners (Hoogveld et al., 2005; Schworm & Renkl, 2006), future research could focus on novice and expert instructional designers. Since much of the existing research involving instructional design practitioners has involved frequency counts of design activities and qualitative data explaining design rationale, the addition of cognitive load measures has the potential to provide meaningful insights into the implications of applying strategies to manage load within the preparation of instructional designers themselves.

Conclusion

The findings of the present study provide another step toward a more comprehensive understanding of the interplay between prescriptions from cognitive load theory, conditions-based instructional design, and problem solving across both well- and ill-structured domains. The results of the study indicated that instructional designers tend to think of strategies to manage cognitive load within the framework of minimizing extraneous load and managing intrinsic load. This relatively narrow view of cognitive load and potentially incomplete understanding of its prescriptive strategies did not vary according to the expertise level of practitioners, as education level and years of experience did not have a significant effect on the implementation of strategies during a standardized scenario. Despite the fact that participants self-reported an awareness of many of the strategies to manage different types of cognitive load, they also expressed a certain level of uncertainty regarding the use of strategies to address germane load and the expertise reversal effect.

This research study sheds light on the need for the identification of heuristics related to the prescriptive strategies to manage cognitive load within a broader range of content domains and more realistic problem-solving environments that practitioners work with on a daily basis. A cognitive load overlay model is proposed for use in conjunction with traditional instructional design models in order to embed heuristics for managing cognitive load into the process. These heuristics can be examined in future research studies and incorporated into the training of instructional designers in a manner that embeds strategies to manage cognitive load into context and stresses applicability to a variety of instructional environments. By addressing weak connections between prescriptive strategies and practice, those responsible for educating instructional designers can better prepare them for the field. This will, in turn, provide practitioners with a better understanding of the value of these strategies to learning outcomes and approaches to address perceived barriers to implementation. The results of this study ultimately serve to enhance our understanding of the connections between cognitive load theory and the selection and implementation of strategies in practice, as well as pointing us toward the questions that remain to be answered in order to strengthen those connections.

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Appendix A

Cognitive Load Studies and Prescribed Strategies

Authors (Year)	**Context**	**Domain**	**Cognitive Load Effects**	**Prescribed Strategies**
Sweller, Mawer, and Ward (1983)	K-12 and higher education	Kinematics and geometry	Learners who studied with reduced goal specificity were more efficient	Goal-free tasks during acquisition rather than conventional problem solving
Sweller and Cooper (1985)	K-12 and higher education	Algebra	Learners who studies worked examples took less time and made fewer errors	Worked examples rather than solution generation as learners become familiar with subject
Tarmizi and Sweller (1988)	K-12 education	Geometry	Learners who used integrated diagrams and text took less time to solve and made fewer errors	Integrate multiple sources of related information into a single element
Chi, Bassok, Lewis, Reimann, and Glaser (1989)	Higher education	Physics	Students who generated explanations of solutions had higher problem-solving scores	Prompt learners to produce self-explanations while studying worked examples and completion tasks
Jelsma and van Merriënboer (1989)	Higher education	General problem solving	Participants who used a random practice schedule took less time and made fewer errors	Present series of random tasks containing high contextual interference

van Merriënboer (1990)	K-12 education	Computer programming	Learners who studied completion problems had higher completion rates and percentage of correct feature use	Have learners complete larger portions of a solution until they are prepared to generate solutions
Chandler and Sweller (1991)	K-12 and technical education	Engineering and biology	Shorter instruction time and higher test scores when students used integrated instructions	Eliminate redundant information if material can be understood from a single element
Paas (1992)	Technical education	Statistics	Lower mental effort ratings and time on task for students using completion problems	Use completion tasks to allow learner to finish partial problem solutions
Paas and van Merriënboer (1994)	Technical education	Geometry	Better test performance, lower perceived mental effort and time on task for learners studying examples with high variability	Present a series of tasks that differ in surface features as they would in realistic situations
Sweller and Chandler (1994)	K-12 and technical education	Computer software and electrical testing	Lower time for instruction and testing, higher test scores for learners who studied with only a manual rather than a manual and equipment	Examine material for number of interacting elements to determine complexity relative to learner expertise

Mousavi, Low, and Sweller (1995)	K-12 education	Geometry	Less time spent studying and solving problems and better performance for learners who used dual-modality worked examples	Supplement visual information with a second mode of delivery (audio explanations)
Kalyuga, Chandler, and Sweller (1998)	Technical education	Electrical circuits	Learners with less expertise had lower mental effort ratings and higher performance scores with integrated diagrams and text; reverse effect for learners with more expertise	Replace worked examples including fully integrated information with visual-only or text-only examples as learners develop expertise
Kalyuga, Chandler, and Sweller (2000)	Technical education	Manufacturing	Students with less expertise had lower task difficulty ratings and higher performance test scores when using diagrams with auditory text; reverse effect for learners with more expertise	Replace dual modality materials with visual-only materials (no supplemental audio information) as learners gain expertise
Pollock, Chandler, and Sweller (2002)	Technical education	Electrical circuits	Lower subjective mental load and higher performance scores for learners who used isolated	Replace conventional problem solving tasks with a strategy of gradually moving from simple,

			task elements first and interacting elements second	isolated tasks to tasks of full complexity
Renkl, Atkinson, Maier, and Staley (2002)	Higher education	Probability	Learners who studied with faded worked examples had a lower number of errors and better performance in near transfer	Start learners with a larger amount of guidance and progressively fade guidance over time as they develop expertise (scaffolding)
Reisslein, Atkinson, Seeling, and Reisslein (2006)	Higher education	Engineering	Learners with low expertise had better performance scores when moving from examples to conventional problems	Fade instructional guidance over time as learners develop expertise
Schworm and Renkl (2006)	Higher education	Instructional design	Higher post-test scores for learners who used self-explanations	Prompt learners to produce self-explanations as they study worked examples and completion problems
Owens and Sweller (2008)	K-12 education	Music	More correct solutions during acquisition and higher post-test scores for learners using worked examples with spatial integration and simultaneous presentation	Integrate related information to reduce split attention

Rourke and Sweller (2009)	Higher education	Design history	Learners performed better after studying worked examples rather than problem solving	Use worked examples rather than conventional problem solving as learners become familiar with material
Oksa, Kalyuga, and Chandler (2010)	K-12 and adult education	Literary studies	Lower mental load ratings and better test performance for learners who studied worked examples; reverse effect for learners with more expertise	Fade instructional guidance over time as learners develop expertise
Stark, Kopp, and Fischer (2011)	Higher education	Medicine	Lower cognitive load scores and better performance for learners using worked examples with elaborated feedback	Prompt learners to produce self-explanations as they study worked examples and completion problems
Kyun, Kalyuga, and Sweller (2013)	Higher education	English literature	Lower mental effort ratings and higher performance for learners with less expertise studying worked examples	Move learners through a progression of tasks from worked examples to completion problems to solution generation
Nievelstein, Van Gog, Van Dijck, and Boshuizen (2013)	Higher education	Legal cases	Lower mental effort ratings and better learning outcomes for learners using worked examples	Use a high degree of task variability when presenting worked examples

Mulder, Lazonder, and de Jong (2014)	K-12 education	Physics	Improved inquiry behavior and higher quality models during learning phase for students using worked examples	Gradually move the learner from tasks of low complexity to tasks of high complexity
Si, Kim, and Na (2014)	Higher education	Computer programming	Higher efficiency for learners studying with adaptive instruction rather than fixed instruction	Have learners complete larger portions of a solution until they are prepared to generate solutions
Jung and Suzuki (2015)	Higher education	Japanese language learning	Better learning outcomes and higher student satisfaction for learners who used less comprehensive worked example templates	Use less detailed worked examples in instances where creative and independent thinking are intended outcomes
Margulieux and Catrambone (2016)	Higher education	Computer programming	Lower time on task and better performance for learners using worked examples with labeled sub-goals	Examine material for number of interacting elements to determine complexity relative to learner expertise

Appendix B

Instructional Designer Decision Making Questionnaire

Please complete this questionnaire to the best of your ability and respond to each of the questions as accurately as possible. The data gathered from the responses will be used to examine how instructional designers make decisions in practice.

The questionnaire will take approximately 15 minutes to complete. Please return it to jsent003@odu.edu prior to your appointment time for the instructional design scenario activity. You may use the same email address should you have any issues or questions. Thank you for your time.

Please answer the following questions about yourself.

1. Name:

2. Job Title:

3. Email:

4. Years of Experience in Instructional Design:

	2 or less
	3-5
	6-10
	11-15
	16-20
	More than 20

5. Highest Degree Earned:

	Bachelor’s Degree (Instructional Design or related)
	Bachelor’s Degree (Other)
	Master’s Degree (Instructional Design or related)
	Master’s Degree (Other)
	Doctoral Degree (Instructional Design or related)
	Doctoral Degree (Other)

6. Primary Area of Practice:

	Business/Industry

	Higher Education
	K-12 Education
	Government
	Military
	Other (please specify)

For each of the following, please indicate the degree to which you agree with the statement:

1. I have a great deal of knowledge within the domain of instructional design.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

2. I have an ability to identify patterns within instructional problems as I solve them.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3. I solve instructional design problems quickly and with few errors.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

4. I am able to retain instructional design concepts for long periods of time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

5. I have an ability to form complex mental representations of instructional problems.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

6. I spend an extended period of time analyzing an instructional problem before solving it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

7. I am aware of my own thought processes with regard to instructional design.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

For each of the following, please indicate how often you currently use the strategy in your instructional design work:

1. I encourage the learners to generate as many solutions to a problem as they can.

Never	Not Often	Sometimes	Often	Very Often

2. I ask the learners to generate their own solutions to problems rather than examining sample solutions.

Never	Not Often	Sometimes	Often	Very Often

3. I provide partial solutions to problems and ask the learners to complete them.

Never	Not Often	Sometimes	Often	Very Often

4. I combine different pieces of information together to allow the learners to better focus their attention.

Never	Not Often	Sometimes	Often	Very Often

5. I consider the implications of using various delivery media in relation to the complexity of the content within my designs.

Never	Not Often	Sometimes	Often	Very Often

6. I provide similar information in multiple ways throughout my design to help the learner benefit from redundancy.

Never	Not Often	Sometimes	Often	Very Often

7. I present content in its full complexity from the beginning of the instruction rather than gradually working from lower to higher complexity.

Never	Not Often	Sometimes	Often	Very Often

8. I present content in increasingly more realistic contexts as the learner progresses through the instruction.

Never	Not Often	Sometimes	Often	Very Often

9. I vary the presentation of material within my designs in order to promote transfer of learning to other contexts.

Never	Not Often	Sometimes	Often	Very Often

10. When providing the learners with opportunities to practice using new concepts, I randomly order problems to encourage transfer.

Never	Not Often	Sometimes	Often	Very Often

11. I prompt the learners to explain their decision making process as they solve problems rather than providing them with an explanation of steps.

Never	Not Often	Sometimes	Often	Very Often

12. I provide learners with a significant amount of guidance early in the instruction and gradually decrease the amount of guidance over time.

Never	Not Often	Sometimes	Often	Very Often

13. I modify the instructional content for more experienced learners in order to eliminate redundant information that they do not need.

Never	Not Often	Sometimes	Often	Very Often

14. I use the same delivery media for instruction based upon the content involved, regardless of whether the learners are novices or experts in the subject area.

Never	Not Often	Sometimes	Often	Very Often

Appendix C

Instructional Design Scenario

Please review the instructional scenario below and design a solution that addresses the needs of the learners to the best of your ability. There is no correct or preferred approach to the scenario, so please do not worry about whether your approach is the "right" one. Please speak aloud as you are making your design decisions so that the researchers can follow the process you are using. The data gathered from the responses will be used to examine how instructional designers make decisions in practice.

The scenario will take approximately 30 minutes to complete. All of the information you will need is contained within the scenario, but please feel free to ask the researcher if you need clarification on any of the information. Thank you for your time.

Scenario

You are an instructional designer working for your current or most recent organization (K-12, higher education, industry, government, etc.), and you need to cover the creation of spreadsheets as part of the regular course of your instructional duties. The creation and use of spreadsheets is considered a basic competency within your area of practice that learners need to master in order to work with data in their particular settings. You have been asked to incorporate instruction related to the basic creation of spreadsheets within the Microsoft Excel software package as part of regular training/education activities for your learners.

Needs Assessment

Your supervisor has asked you to create an instructional module on the creation of basic spreadsheets within Microsoft Excel that will enable all learners to establish a consistent level of competency inputting and manipulating data. The instruction needs to be basic enough that learners are able to complete it with only a fundamental understanding of the mathematical operations involved in creating a spreadsheet, and the instruction needs to be flexible enough to be used by learners independently at their own pace.

Learner Analysis

Regardless of your particular practice setting, all learners are able to read English at an 8th grade level or higher, have basic proficiency in the use of computers and mathematical formulas, and are physically able to perform the tasks involved.

The majority of the learners (16 students in a class of 20) have little experience using Microsoft Excel and should be considered novices with respect to the creation and use of spreadsheet applications. Robert, shown below, is one of these learners:

Robert is a third-year undergraduate student who is majoring in studio art. He has used computers throughout his K-12 and college education but has not done much work with Microsoft Office applications other than basic word processing. He has experience viewing budget data in Excel spreadsheets during his time in the Art Club in high school, but he has not created a spreadsheet from scratch or manipulated the data in an existing spreadsheet. Robert has taken typical mathematics courses prior to enrolling in college, including two years of algebra. He is considering a minor in business due to his interest in starting his own art studio, so Robert is motivated to learn and apply the information from the unit to his area of study.

There are, however, a few learners (4 students in a class of 20) who have an intermediate understanding of Microsoft Excel and the creation of basic spreadsheets. Karen, shown below, is one of these learners:

Karen is a first-year undergraduate student who is majoring in business administration. She has used computers throughout her K-12 education and has some experience with each of the Microsoft Office applications. She has not taken any formal coursework in Excel, but she has a working knowledge of the basic functionality involved in creating a spreadsheet from tutorials within the program itself to put together simple spreadsheets for high school classes. Karen has taken business mathematics and algebra courses prior to enrolling in college. She anticipates taking a few accounting courses later in college as part of her major, so she is motivated to build upon her existing knowledge by learning the information. As with the other learners with more expertise, Karen is still required to take the instruction and meet the objectives.

Environmental Analysis

The instruction may be delivered by any means of delivery deemed appropriate, provided that the learners are able to progress through the material at their own pace. The learners have access to computers in a lab at your organization/institution, and all computers are equipped with Microsoft Office and an Internet connection. Written materials can also be made available to the learners if you determine they are needed for the instruction. An instructor station and a projector are located at the front of the lab if you find a need to use those. Learners will be given access to the desks and computers during class/working hours as needed to complete the instruction.

Task Analysis

A task analysis of basic spreadsheet creation revealed the following steps:

- Determine a practical need for a spreadsheet application.
- Sketch out the structure of the spreadsheet.
- Determine the calculations that will be needed to manipulate the data.
- Open Microsoft Excel.
- Create column headings appropriate to the application.
- Create row headings appropriate for the data.
- Input the data in the appropriate cells.
- Format cells as appropriate for the types of data included.
- Use basic math symbols (= , + , - , * , /) to create formulas as appropriate.
- Use a function to calculate totals (SUM) as appropriate.
- Use a function to calculate averages (AVERAGE) as appropriate.
- Use a function to find the highest value (MAX) in a range of numbers.
- Use a function to find the lowest value (MIN) in a range of numbers.
- Use a function to determine how many numbers (COUNT) are in a range of cells.
- Copy a function across multiple spreadsheet cells.
- Create a basic chart that displays the information graphically in a useful manner.

Instructional Objectives

Upon completion of the instruction:

1. The learners will create a spreadsheet application that addresses a real-world problem of either personal or professional significance.
2. The learners will structure the spreadsheet in a logical manner that lends itself to solving the problem.
3. The learners will create column and row headings that sufficiently explain the data.
4. The learners will input data as appropriate for the spreadsheet structure created.
5. The learners will format the cells as appropriate for the type(s) of data involved.
6. The learners will use three or more math symbols to create formulas to manipulate the data.
7. The learners will use at least three functions to manipulate the data in the process of solving the problem.
8. The learners will create a basic chart that presents the data graphically in order to solve the practical problem they have identified.

You have approximately 30 minutes to design and explain your solution to this instructional scenario. Please describe aloud to the researcher the steps you are taking throughout the process and the reasons you are making those decisions. This study is primarily concerned with the decision making process you use and the reasons you are taking specific steps to design a solution.

Appendix D

Instructional Design Scenario Observation Sheet

Date: Time:

Participant Name: Observer Name:

Strategy Used	**Time(s) Observed**	**Description**	**Code(s) Assigned**
Extraneous Load			
Goal-free tasks *Example phrases: "non-specific goals", "as many solutions as possible"*			
Worked examples *Example phrases: "full solution", "provide a model answer"*			
Completion tasks *Example phrases: "partial solution", "learner finishes the task"*			
Integrated information *Example phrases: "one combined source of information", "prevent split attention"*			
Dual modality *Example phrases: "audio narration", "text and audio"*			
Eliminate redundancy *Example phrases: "present information once", "remove duplicate content"*			
Intrinsic Load			

Simple-to-complex presentation *Example phrases: "gradually present information", "start with basic information and move to complex"*			
Low- to high-fidelity presentation *Example phrases: "present increasingly realistic material", "present concepts first without context"*			
Germane Load			
Variability *Example phrases: "use different surface features", "present problems as they are in the real world"*			
Contextual interference *Example phrases: "order tasks randomly", "break up related blocks of problems"*			
Self-explanations *Example phrases: "prompt learners to give information", "ask learners to explain examples"*			
Expertise Reversal			
Scaffolding *Example phrases: "decrease learner guidance gradually", "hold their hand at first and slowly remove assistance"*			
Integration to non-integration			

Example phrases: "give pictures and text to novices", "remove text instructions for experts"			
Dual- to single-mode presentation *Example phrases: "use audio instructions with novices", "remove narration for experts"*			

Overall SOLO rating (circle):

0	Respondent did not apply any strategies to manage cognitive load. (pre-structural)
1	Respondent primarily considered a single source of cognitive load. (uni-structural)
2	Respondent considered multiple sources of cognitive load. (multi-structural)
3	Respondent considered the interaction of multiple sources of cognitive load. (relational)
4	Respondent considered cognitive load holistically and displayed a comprehensive understanding of its implications. (extended abstract)

Comments:

Appendix E

Debriefing Interview Protocol

Date: Time:

Participant Name: Interviewer Name:

Thank you for taking the time to complete the instructional design scenario and for discussing the steps you took during the process in more detail. This discussion should take no longer than 15 minutes.

Questions:

1. (If the participant was observed using strategies to manage cognitive load during the scenario) Could you describe your rationale for addressing different aspects of cognitive load as you designed your solution to the instructional scenario? [*Cite specific examples from scenario: "You used worked examples in your design. Why did you choose that strategy?"]*

2. How likely are you to use various strategies to manage cognitive load within the specific subject domains and practice setting that you design for on a daily basis?

3. What barriers within your practice setting, if any, do you think might prevent you from using various strategies to manage cognitive load?

4. Which strategies to manage cognitive load, if any, do you feel might not be applicable to the particular subject matter you work with on a regular basis?

5. You only had 30 minutes to complete this instructional design scenario. If you had all the time in the world you needed to design the instruction, what would you have done differently?

6. Are there any other aspects of the instructional design scenario that you'd like to discuss in further detail?

Thank you very much for your participation in this study. Please be assured that your responses will be kept confidential.

VITA

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PROFESSIONAL EXPERIENCE

Executive Director of Web Technologies, Campus Media Support, and Instructional Design, 9/2007 – Present
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Manager of Web Services, 11/2004 – 9/2007
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