Old Dominion University

ODU Digital Commons

Using Visually Disfluent Fonts for Cueing and Increased Reading

Nena Barley
Old Dominion University, nbarl001@odu.edu

Recommended Citation

USING VISUALLY DISFLUENT FONTS

FOR CUEING AND INCREASED READING COMPREHENSION

by

Nena Barley

B.S. August 1980, University of Florida
M.S. December 2002, Florida Institute of Technology

A Dissertation Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

EDUCATION

OLD DOMINION UNIVERSITY
August 2016

Approved by:

Ginger S. Watson (Director)

John W. Baaki (Member)

Philip A. Reed (Member)

ABSTRACT

USING VISUALLY DISFLUENT FONTS FOR CUEING
AND INCREASED READING COMPREHENSION

Nena S. Barley
Old Dominion University, 2016
Director: Dr. Ginger Watson

Research has shown that using hard-to-read fonts in a reading assignment is an external way to manipulate text to slow down the learner's task completion time, giving more time on task and improving the learner's ability to comprehend and retain the content (Alter & Oppenheimer, 2009b). This novelty effect interferes with the legibility of the reading material, but not the readability. This study is focused on using hard-to-read fonts, also referred to as disfluent fonts, to cue the learner to important information that may lead to more cognitive engagement and processing. Facing the visual challenge of a disfluent font, the learner's curiosity intrinsically motivates the learner to make sense of the content. Visually disfluent fonts, integrated into instructional materials can be used as an instructional intervention strategy to increase cognitive engagement, leading to deeper processing (Bjork, 1994). Deeper encodings increase time spent on task and have been associated with higher levels of achievement and better mental retrieval (Craik & Tulving, 1975). While this study did not show any significant effects for using a disfluent font for cueing on achievement score, time, cognitive load or perception of the reading task, limitations are discussed for consideration in future research.

Keywords: disfluent font, desirable difficulty, cognitive engagement, novelty effect, cues, curiosity.

Education is the foundation of our lives…

This dissertation is dedicated to

my family & friends,

who understood my tenacity for this journey.

ACKNOWLEDGEMENTS

This quest began when **Jim Shannon** said, "Hey Nena, this degree sounds like you…" and **Dr. Jim Bryant** encouraged me to "Go for it…"

Once accepted, **Dr. Gary Morrison** advised me throughout my coursework and endured my multitude of questions. He was a mentor and a friend who shared my love of the Blue Ridge Mountains and his photography reminded me of the beauty that draws us beyond the classroom.

Selfless, and by my side through coursework, projects, presentations, papers, discussion boards and the start of the ODU Instructional Design and Technology Graduate Student Organization was **Dr. Brett Cook-Snell**, who was always happy to listen and motivate me through the speed bumps. His willingness to allow data collection from his students with only a day's notice gave me a much needed burst of energy that carried me through to this end.

Knower of everything statistical, **Jeff Levy** appeared out of nowhere to agree to help me brush up on my statistical skills and freely offer his support. His persistent mentoring encouraged me to be sure I truly understood my analysis.

Stepping in to pull me under her wings when Dr. Morrison retired, **Dr. Ginger Watson** keep me working through this journey. Her patience for the many discussions, emails and reviews renewed my drive this last year. **Dr. John Baaki** and **Dr. Phil Reed**, my committee members, volunteered to add my proposal and defense to their already busy schedules bringing additional insight and guidance to my research.

And finally, **Kirk Barley**, the love of my life, who gave me the space to do this my way, sheltering my time to ensure I was successful.

Thank you all for being part of my journey….

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

Introduction and Literature Review

Introduction

Recent research suggests that presenting reading material in a font that is more difficult for a learner to decipher will take the learner longer to read and lead to better retention of the message (Alter, Oppenheimer, Epley, & Eyre, 2007; Diemand-Yauman, Oppenheimer, & Vaughan, 2011; Thompson et al., 2013). Older studies have also found that increased illegibility led to better metacomprehension, or grasp of a learner's own comprehension of the material presented (Love, 2012). This disfluency appears to operate as a "desirable difficulty," engendering deeper cognitive engagement and deeper processing strategies (Alter & Oppenheimer, 2008; Alter et al., 2007; Bjork, 1994; Corley, MacGregor, & Donaldson, 2007; Craik & Tulving, 1975; Song & Schwarz, 2008) which facilitates encoding of the information and subsequently better mental retrieval in the future (Craik & Tulving, 1975).

Fluency is defined as the metacognitive speed or ease with which a learner can read problems and/or produce an answer to a query (Thompson et al., 2013). Using a hard-to-read font is a simple, cost effective way to interfere with a learner's fluency. By creating a disfluency, or subjective experience of difficulty associated with the cognitive operation of reading the written text, the learner's retention of the information is significantly improved (Diemand-Yauman et al., 2011). Utilizing disfluency in a reading passage cues the learner to slow down their reading speed, increasing their time on task and allowing more time for the learner to process the information (Alter et al., 2007).

Reading comprehension is a complex task (Cain, Oakhill, & Bryant, 2004; van Merrienboer, Clark, & de Croock, 2002) and can be predicted by both motivational (Chapman &

Tunmer, 1995) and cognitive variables (Pressley & Harris, 2006). A learner's motivation to participate in or complete an instructional task can stem from cognitive curiosity, or a desire to bring better form to one's own knowledge structures (Malone, 1981). As a motivator for learning, curiosity can be evoked by environments that are neither too complicated, nor too simple, with respect to the learner's existing knowledge (Berlyne, 1965; Piaget, 1952).

Instructional Design of Written Materials

Historically, the goals of a graphic designer and the goals of the instructional designer have had much in common. Both strive to create visually pleasing layouts that will attract and hold the learner's attention and communicate information so that it is easily understood and remembered. However, using research on human cognitive processes is a far better guide for instructional design, than relying on intuition and standard practice (Bjork & Bjork, 2011; Bjork, 1994). Whether utilizing paper-based or digitally-based materials, instructional designers must understand the diversity of factors that influence human behavior (Fleming & Levie, 1993).

Instructional design that utilizes good graphic design principles on a computer screen, minimizes learning time, while poor use of graphic design principles leads to increased task completion time and a reduced, or lack of persistence on task. Even with these observable effects on both time and persistence, there was no detrimental effect on processing, as measured by the learner's achievement scores (Szabo & Kanuka, 1998).

Poor design may cause learners to attend to the material more carefully and process it more slowly, causing the learner to overcome their initial response and engage in more systematic reasoning (Alter et al., 2007). Recent studies found enhanced instructional effectiveness through an increased time on task by using design elements such as hard-to-read fonts or other font degradation that slows down the time the learner spent on the reading.

The focus of this study is on the use of visually disfluent fonts in instructional reading materials to cue learners to important elements. This study assesses whether time spent on the important elements of the reading task affects reading comprehension and learning achievement.

Literature Review

A review of the literature indicates that a traditional typographical cueing, such as a bolded font, is not a new approach for instructional design. However, using a disfluent, or hard-to-read font in instructional reading materials has recently been suggested as an external text manipulation that will cue the learner and also act as a metacognitive signal that the task may need more cognitive engagement in order to process. Facing a visual challenge, the learner's curiosity intrinsically motivates the learner to make sense of the content, leading to more time on task and deeper cognitive engagement, which supports deeper processing, and ultimately increased reading comprehension. This study utilized this approach by creating a desirable difficulty for cueing the learner specifically to the important content in the reading.

Desirable Difficulties and Cognitive Engagement

A desirable difficulty is a learning condition that makes encoding more difficult, but also engages a learner's processes, such as curiosity, which supports learning and improves long-term retention (Yue, Castel, & Bjork, 2013). Font manipulations, or other visual effects that vary the conditions of learning, rather than keeping them constant and predictable, adds desirable difficulty to the design of instructional materials. Manipulations such as blurred fonts (Yue et al., 2013), interleaving (Richland, Bjork, Finley, & Linn, 2005) and blocking (Chapman & Tunmer, 1995; Kornell & Bjork, 2008; Pressley & Harris, 2006; Rohrer & Taylor, 2007; Shea & Morgan, 1979; Simon & Bjork, 2001) are other ways to introduce visual difficulties during learning. Seemingly counterintuitive to the standard *keep it simple* rule of thought, these instructional

design manipulations often enhance learning. It is not the difficulty that leads to the improvements, but rather how the intervention engages processes that support learning (Alter, Oppenheimer, & Epley, 2013; Bjork, 1994). Research suggests that when learning from text or reading, instructional designers should carefully consider adding complexity that introduces desirable difficulties (McNamara, Kintsch, Songer, & Kintsch, 1996) and cognitive engagement into the learning process.

Disfluency. Neuroscientific evidence suggests that when faced with a disfluency the learner's anterior cingulate cortex (Boksman et al., 2005), triggers an alarm that activates the prefrontal cortex responsible for deliberative and effortful thought (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Goel, Buchel, Frith, & Dolan, 2000; Lieberman, Gaunt, Gilbert, & Trope, 2002). This physiological reaction activates more elaborate processing which ultimately may lead a learner to make adjusting or correcting actions in their responses (Alter et al., 2007). Research shows disfluency leads to deeper cognitive processing, independent of the objective cognitive difficulty of the task (Alter & Oppenheimer, 2009a; Craik & Tulving, 1975; Diemand-Yauman et al., 2011; Oppenheimer, 2008). However, deeper cognitive engagement does not ensure comprehension accuracy.

While theoretical justification shows that learners consistently judge less fluent items as being more difficult to remember or recognize, research has shown that actual recall for these items is often surprisingly unaffected by or is even improved by perceptual disfluency (Diemand-Yauman et al., 2011; Hirshman & Mulligan, 1991; Nairne, 1988; Rhodes & Castel, 2008; Slamecka & Graf, 1978). Conditions that create challenges and slow the rate of task completion and learning often optimize long-term retention and transfer, which is the distinction between learning and performance (Bjork & Bjork, 2011).

Perceptual cues. External visual manipulations of text, such as a bolded font, can act as a perceptual cue to direct a learner's attention (Hartley, 2004) and signal that the bolded instructional content may require deliberate, intentional processing in order to lead to meaningful learning. Human visual perception is extremely selective (Baddeley, 1992) and compared to equivalent verbal input, visual stimuli provides better processing cues to help shape the learner's perception of a message (Baggett & Ehrenteucht, 1982).

Fluency. Fluency is the difference between the expected difficulty of a task and the actual difficulty a learner experiences (Alter et al., 2013; Whittlesea & Williams, 1998, 2000). When faced with both external sensory cues and internal metacognitive cues, a learner's perceived or felt fluency, or confidence about a task can affect the learner's judgments (Alan, Castel, David, McCabe, & Henry, 2007; R.E. Mayer, 1984; Oppenheimer, 2008; Thompson et al., 2013; Yue et al., 2013). Many times the fluency of a task is not based on a straightforward external cue, but on the learner's perception for the level of effort that will be required to meet the challenge of the assigned task. When faced with information that is processed easily or fluently, a learner's intuitive processes will guide the learner's judgment (Schwarz, 2004). However, information processed with a metacognitive experience of difficulty, or disfluency, alarms the learner and serves as a cue that the task is difficult, or that the learner's intuitive response is likely to be wrong (Alter et al., 2007).

A cue's fluency, or the ease with which a cue is processed, can influence which learning strategies a learner will utilize to confront a task (Tversky & Kahneman, 1973, 1974). While learners pay equal attention to fluent and disfluent cues (Shah & Oppenheimer, 2007), if what the learner sees visually is unfamiliar, this disfluency acts as an additional metacognitive cue, warning the learner that they may lack mastery over the material (Alter & Oppenheimer, 2009a;

Tversky & Kahneman, 1973, 1974). This cautions the learner to slow down and engage in deeper, more elaborative processing (Alter et al., 2007), and leverage additional resources in order to successfully process the unfamiliar or difficult material (Jonides, 1981; Jonides & Yantis, 1988; Yantis & Jonides, 1984).

Reading Strategies

In reading tasks, a learner uses strategies to make cognitive progress and then references metacognitive strategies to monitor this progress (Flavell, 1979). Reading comprehension, or constructing meaning from text, is an intentional, deliberate, and purposeful act (Kintsch, 1998, Mokhtari & Reichard, 2002). The Metacognitive Awareness of Reading Strategies Inventory (MARSI) is a tool that was developed to assess pre-college aged students' awareness of, and their perceived use of reading strategies (Mokhtari and Reichard, 2002). See Appendix F. A metacognitive awareness occurs when information is processed with a metacognitive experience of difficulty, or disfluency, which alarms the learner and serves as a cue that the task may be difficult (Alter et al., 2007), prompting the learner to change their strategy to accomplish the task. MARSI can inform learners on their perceived use of reading strategies and help them to shape their intentional, deliberate, and purposeful actions for constructing meaning from text.

MARSI is often used for assessing readers who are fluent in one language and are receiving instruction in an unfamiliar, or foreign language. Reading text in an unfamiliar language is a similar disfluency to using hard-to-read fonts. The overall average MARSI score indicates a learner's perception on how often reading strategies are used when reading instructional materials, while the average for each MARSI subscale of the inventory shows which group of strategies (global, problem-solving, or support) the learner leverages most.

Learning Processes

While cueing may help learners extract and process essential information from static information (Tversky, Heiser, Lozano, MacKenzie, & Morrison, 2008), cueing as the primary instructional strategy may not necessarily improve learning (De Koning, Tabbers, Rikers, & Paas, 2009; Kriz & Hegarty, 2007). A critical requirement for cueing to be effective is that cues must be designed to facilitate, rather than to interfere with the processing of information (De Koning et al., 2009). For meaningful learning to be accomplished, a learner must leverage the learning processes of: 1) selecting relevant information, using the cues to guide their attention; 2) organizing that information into a coherent representation, using the cues to emphasize structure; and 3) integrating this representation into existing knowledge, (Mayer, 1992) using the cues to analyze and develop relationships between and within elements. Meaningful learning also depends on the learner's perception or individual process of selectively attending to and interpreting important detail in order to comprehend meaning (Levie, 1987; Steinberg, 1991).

Research suggests that some processing is slower and more deliberate than other processing (Kruglanski & Thompson, 1999; Osman, 2004). Even in early research, James (1890) presents the psychological suggestion that human reasoning involves two distinct processing systems for cognitive engagement: 1) one that is quick, effortless, associative and intuitive, and 2) another that is slow, effortful, analytical and deliberate (Alter et al., 2007). Cues slow down the learner's speed for processing text, which is evidence that the memory-enhancing effects of cueing are mediated by a deliberate process of attention (Lorch & Chen, 1986; Lorch, Lorch, & Klusewitz, 1995).

Cognitive Burden – More or Less

Perceptual fluency, a learner's sense of familiarity (Bjork & Bjork, 2011) or subjective feelings of ease in general (Shah & Oppenheimer, 2007) enhances comprehension in written materials (Katzir, Hershko, & Halamish, 2013). An easy to read, coherent text with cues that are familiar and comfortable has often been thought to aid a learner in recognition. Information coming readily to mind for the learner could be interpreted as evidence of learning, however, this could instead just be a product of the cues that are present in the current text. Studies have shown that for a learner to recall the same information that was cued at a later time would prove difficult, without again providing the same cues (Bjork & Bjork, 2011; Kornell, Hays, & Bjork, 2009). Therefore using cues to ease the cognitive burden, or reduce the generative processing could actually result in less effective learning (Kintsch, 1990). This study presented cues in a visually disfluent font to increase the cognitive burden. Ultimately it is a learner's active processing that facilitates learning (Healy et al., 1993; Healy & Sinclair, 1996; Kintsch, 1988, 1992; McNamara et al., 1996; Schmidt & Bjork, 1992) and improves memory for difficult tasks (Alter et al., 2007).

Hard-to-read fonts. Research has found that learner retention of material, across a wide range of subjects and difficulty levels, was significantly improved by presenting reading material in a disfluent, or slightly harder to read format. This effect appears to be driven by the visual, hard-to-read font, an external manipulation that appears to have nothing to do with semantic processing (Alter et al., 2007; Diemand-Yauman et al., 2011). Additional research suggests hard-to-read fonts are a disfluency that operates as a desirable difficulty, engendering deeper cognitive engagement and deeper processing strategies (Alter & Oppenheimer, 2008; Alter et al., 2007; Bjork, 1994; Corley et al., 2007; Craik & Tulving, 1975; Song & Schwarz, 2008).

Processing visually disfluent fonts imposes greater demands on a learner's cognitive resources than when processing fluent fonts (Alter et al., 2007). The illegibility of the text acts as a metacognitive cue for the learner to consider the words more carefully. This often requires the learner to slow down and generate relationships and meaning. This causes the learner to spend more time on the task, which leads to better meta-comprehension and a richer, deeper memory of the content. If the learner has some prior knowledge or grasp of the task, then research shows altering text presentation to a less familiar format, making it less perceptually fluent, leads to better memory of the written material (Alter & Oppenheimer, 2008; Alter et al., 2007; Bjork, 1994; Corley et al., 2007; Craik & Tulving, 1975; Diemand-Yauman et al., 2011; Kelley & Rhodes, 2002; Love, 2012; Rhodes & Castel, 2008; Song & Schwarz, 2008; Thompson et al., 2013; Zorzi et al., 2012).

Cognitive load. Cognitive Load theory centers on the fact that cognitive capacity in a learner's working memory is limited. A review of literature on cognitive load theory recommends instructional systems should be designed to optimize the use of working memory capacity and avoid cognitive overload (de Jong, 2009).

Cognitive load is multidimensional concept defined by the mental load and the mental effort a task presents to a learner. Mental load is imposed by the instructional parameters of the task, and mental effort refers to the amount of capacity that a learner must allocate to that task. Instructional manipulations to increase mental load will only be effective if a learner is motivated and invests mental effort to accomplish the task. Since mental load is determined by the task only, cognitive load is most often measured by a learner's perceived mental effort. This study utilized a 9-point rating scale to assess perceived Mental Effort (Paas, 1992).

Generative Processing

Simply reading or re-reading text has not been shown to be as significant for reading comprehension as when a learner generates information during a learning task. Generative strategies studied include: hearing the answers in memory tasks (Slamecka & Graf, 1978) or in learning tasks (Carroll & Nelson, 1993; McNamara, 1995; McNamara & Healy, 1995); providing missing letters to complete words (Hirshman & Bjork, 1988; Richland et al., 2005); interleaving (Richland et al., 2005); active inferencing (Mannes & Kintsch, 1987); or using tests as learning events (Kornell et al., 2009; Roediger & Karpicke, 2006).

Wittrock's (1974) generative model of learning supports the theory that reading comprehension is enabled when learners are able to assign prior knowledge and experiences to the material in order to generate or construct a new meaning for the text. By introducing a challenge to the learner while reading, such as a desirable difficulty, learners exert more mental effort and utilize an active process of interpretation. This mapping of disfluent information is a form of generative processing. Many studies have shown that by increasing processing at encoding, learning becomes more durable and flexible, improving long-term retention (Bjork & Bjork, 2011; McDaniel & Einstein, 2005). Illegible, hard-to-read fonts force learners to consider words more carefully, or in essence to generate them, which has been shown to cognitively lead to deeper meaning (Love, 2012), as long as the interpretation and encoding are within the limits of a learner's working memory (Yue et al., 2013).

Ease of processing. Existing fluency research has shown that learners interpret stimuli depending on how easy those stimuli are to process, and that a learner's processing fluency can also influence judgment by serving as a metacognitive cue to engage in deeper reasoning. Processing fluency is an important factor that determines when the learner will overcome their

intuitive responses and engage in more systematic reasoning (Alter et al., 2013; Alter et al., 2007). Research on fluency effects indicates that the longer information is presented to the learner externally, (Bjork, 1994; Forster, Leder, & Ansorge, 2012; Jakesch, Leder, & Forster, 2013; Reber, Winkielman, & Schwarz, 1998) the more familiar or intuitive it is internally, increasing prior knowledge and improving processing. While easy to process (fluent) stimuli are most preferred by learners (Oppenheimer, 2008; Oppenheimer & Frank, 2008; Reber, Schwarz, & Winkielman, 2004; Winkielman, Piotr, & Cacioppo, 2001) and a learner's individual judgments of learning are higher for perceptually fluent items (Yue et al., 2013), it is the external, optimal instructional challenges that are experienced as self-rewarding, and lead to positive learner satisfaction (Csikszentmihalyi & Csikszentmihalyi, 1988).

Instructional Design of Written Materials to Increase Reading Comprehension

Instructional designers are faced with developing effective instruction that will challenge the learner, while maintaining an optimal balance between being too easy, offering only meager gains in learning, or being too difficult, to the point of frustration (Morrison & Anglin, 2005; Paas, Tuovinen, van Merriënboer, & Darabi, 2005). This balance is especially important when designing written materials to increase reading comprehension.

Book designers suggest that the most important part of the design of written materials is the choice of the text (Hendel, 2013). With current-day, digital approaches to instructional design, the design of the text can easily and affordably be manipulated without changing the content of the written material. Manipulations of typographical properties such as typeface are external factors that can affect legibility and can add difficulty to a reading task. Research suggests these typographical manipulations improve reading comprehension, leading to deeper processing (Bjork, 1994) which in turn facilitates encoding, and subsequently, better mental

retrieval (Craik & Tulving, 1975). Manipulations to typeface must be carefully considered as research has shown that the effects of altering text presentation should differ based on the prior knowledge and level of understanding of the learners receiving the manipulation **(**Katzir, et al., 2013). One caution for instructional designers when altering the external, typographical properties of reading material is to ensure these interventions do not go beyond disfluency, and instead become illegible.

        Text, font or typeface. Text is defined as structured letters combined to form a message that can be understood. These letters are based on a typeface (such as Times New Roman), and a specific font (based on weight and size), also referred to as a typeface sub-family (Ali, Wahid, Samsudin, & Idris, 2013; Brady, 1993; Giese & Holmes, 2002; Jamaluddin & Zaidatun, 2000). In the days of analog printing a typeface was categorized as either serif or san serif (Ambrose & Harris, 2006). In traditional typography, a serif is defined as a small line attached to the end of a stroke in an individual letter. These serifs were thought to help increase legibility as each letter is distinct, yet flows easily into the next letter helping to distinguish a complete word, similar to the visual effect of cursive hand-writing (Amdur, 2007; Bryan, 1996; Morrison & Noyes, 2003). Letters missing the serif, or categorized as san serif, are often considered for use on road signs, advertising signs and posters, as they are thought to be better for use when reading from long distances (Ambrose & Harris, 2005; Rabinowitz, 2006). But even early research suggested learners found equal legibility for both serif and san serif typeface (Paterson & Tinker, 1932). More recent studies suggest that mainstream familiarity of the font (Tinker, 1963; Zachrisson, 1965) or learner aesthetics (Bernard, Mills, Peterson & Storrer, 2001; Tinker, 1963) are the driving factors behind a learner's preference for either serif or sans serif typefaces, and not legibility.

In digital systems terminology, the typeface is still the visual design, or the letterforms; whereas the font is the how that design is delivered (Lupton, 2010). In addition to serif and san serif typefaces, a multitude of other fonts are now available based on typeface designs such as script, blackletter, Unicode and many more; all established strongly on their visual design. With the increase in online development of textual information, the design of digital typefaces and the production of fonts are fluidly linked in the digital typography. Therefore, the term font will be used for the remainder of this paper to refer to either term, typeface or font.

Visual design. Design principles offer guidelines for the visually pleasing use of text, color and graphics, to include unity, focal point and balance. These are the building blocks of any visual design (Graves, 1941). Two other elements important to instructional design are visual cognition and visual literacy. Visual cognition is the process of how a learner perceives and remembers visual information, while visual literacy is the learner's ability to interpret and make meaning from information presented in a more visual format. Both visual cognition and visual literacy rely on the appropriate use of design principles (Greenberg & Jordan, 1991; Lauer, 1979) to promote successful reading comprehension.

Reading Comprehension

Reading comprehension is a complex learning task that involves integrating sets of learning goals. The learner must read the text, process the letters, words, sentences and passages to understand their meaning and then be able to map, or integrate the new information into the learner's own current knowledge (Cain et al., 2004; van Merrienboer et al., 2002). Reading comprehension draws on many different cognitive skills and processes that do not follow a specific series of steps and is strongly predicted by a learner's lower language skills. This can impact the inference, comprehension monitoring, and knowledge about the text structure and

ultimately, shape the learner's assimilation of information across sentences to construct an integrated and coherent model of the consolidated meaning of an entire reading passage (Cain et al., 2004).

Many instructional design models approach instruction through the accomplishment of a series of simple learning tasks. However, complex learning, such as reading comprehension, usually involves mastery of integrated sets of learning goals, or multiple performance objectives. Therefore, reading tasks as a whole are clearly more than the sum of simple parts because reading comprehension requires the learner to coordinate and integrate, which has little to do with learning separate skills in isolation (van Merrienboer et al., 2002).

Legibility and readability. Reading comprehension is affected by both legibility and readability. It is important to distinguish the difference between these two terms, often used synonymously, when discussing the task of reading. Legibility is the ability to recognize individual letters or words or the factors that affect the ease and speed of reading (Tinker, 1963). Readability measures the level of mental difficulty of the reading material, or the mental effort. Readability is strongly facilitated by a learner's lower language skills – such as visually recognizing the difference between letters; prior knowledge - knowledge of the letters, order and sound (Woods, Davis, & Scharff, 2005), and a diversity of other design factors– such as type size, line length, white space, etc. that influence human behavior (Fleming & Levie, 1993; Katzir, et al., 2013).

The legibility of text influences its readability (Erdmann & Neal, 1968; Mills & Weldon, 1987; White, 2005). The ease with which a learner reads and comprehends text is measured by the level of mental difficulty or mental effort required to understand the meaning of the text (Mills & Weldon, 1987; Tinker, 1963; Woods et al., 2005).

Speed of reading. One factor that is often thought to predict a learner's reading performance is measured by the speed of accomplishing a reading task (Torgesen & Hudson, 2006). However, the speed of reading is not necessarily conducive to reading comprehension as shown in an early study which examined what the eyes do during reading. Eye tracking, psychologists observed that speed readers physically made fewer eye fixations than slower readers. These fixations are the places where a learner may focus while reading a passage. The range of text that a learner is able to discern from one fixation to the next is called perceptual span. Between fixations the reader is functionally blind while moving to the next fixation. These hops, defined as a saccade, are sections of text where a learner does not perceive letters but instead fills in information with perceptual information gleaned from fixations before and after the saccade.

While speed readers did well on general questions, they did not perform well on the minutiae of the text, possibly due to information not gained during the saccade. The speed readers showed little accuracy in the comprehension of specific details in the reading material. This suggests that the general questions were not answered from the readers' comprehension of the reading passage, but more from the fragments of text the reader had actually read in the passage combined with their preexisting knowledge about the topic. So while speed readers may complete a task before the allotted time limit, there is a reduction in the accuracy of their responses, especially in areas of reading comprehension (Rayner, 1978).

Since visually, the shape of a letter string as a whole affects the learner's perception, using odd or unfamiliar patterns, such as hard-to-read fonts will tend to slow down the learner's speed of reading. Sensing something unexpected or unfamiliar the learner utilizes a slower pace while consciously processing the unfamiliar text and integrating the new information with

existing prior knowledge before moving on to the next fixation. While some visual difficulties may not enhance reading comprehension (Katzir, et al, 2013), other research suggests unfamiliar external disfluency slows down the learner, providing more time on task and, for a short time, can act as an effective instructional strategy to increase learning (Oppenheimer, 2008; Ross & Anand, 1987).

    Novelty effect. Early research found humans have a preference for that which is familiar, but at the same time demonstrate a positive preference for an optimum level of novelty, or discrepancy between a stimulus and the learner's pre-existing representation of that stimulus (Berlyne, 1960; Dember & Earl, 1957; McCall & McGhee, 1977). When a learner encounters a strategy that has never been experienced, or a strategy that consists of a new combination of previously experienced elements (Berlyne, 1960), this novelty exposure results in a tendency for the learner's performance to initially improve when the new strategy is instituted. While any stimulus has a certain amount of arousal potential, instructional designers must also understand that repetition of this stimulus can lead to a moderation or novelty effect (Berlyne 1960, 1966, 1970, 1971). A "relatively permanent waning of a response as a result of repeated stimulation" is identified as a habituation (Thorpe, 1963, p. 61). A novelty exposure at first generates a habituation effect leading to increased liking, followed by a satiation or boredom effect once the stimulus has become familiar. This process is associated with learning accomplishment, such that the repeated exposure promotes positive feelings for learning about the stimulus, but once the stimulus has been learned, an unpleasant state of satiation, or boredom, is hypothesized to develop, causing the pleasingness of the stimulus to decline (Stang 1974; 1975).

    Similarly, it was found that while the novelty of a hard-to-read font may initially increase a learner's interest, over the course of time this novelty may wear off, reducing the impact of

distinctiveness. Eventually learners will adjust to unfamiliar, or hard-to-read fonts, by changing their expectations about what might be encountered. Even the most difficult words and manipulations get easier with repeated exposure as learners adjust to a disfluency, reducing the long-term impact of this visual distinctiveness (Diemand-Yauman et al., 2011).

Motivation

Reading comprehension and other achievement outcomes can be predicted by both motivational (Chapman & Tunmer, 1995) and cognitive variables (Pressley & Harris, 2006). Instructional designers strive to motivate learners and encourage them to want to connect newly presented information to already existing schemata (van Merrienboer et al., 2002). Motivation is an important variable to consider when optimizing instructional materials. Materials must engage the learner and enhance the learner's effort (Morrison, Ross, & Kemp, 2007; Shulman & Keislar, 1966).

Intrinsically motivating. Cognitively-oriented learning theorists argue for the importance of intrinsically motivated, play-like activities (Bruner, 1962; Piaget, 1951) and intrinsically-motivating environments which tend to arouse and satisfy a learner's curiosity by emphasizing concepts like novelty, complexity, surprisingness and incongruity (Berlyne 1960, 1965, 1968). An activity is said to be intrinsically motivating if people engage in it for its own sake (Csikszentmihalyi & Csikszentmihalyi, 1988; Malone, 1981).

An instructional design that presents a learner with instructional disfluencies or challenges supports a theory of intrinsically, motivating instruction. Often the kind of complexity or incongruity that is motivating also involves surprisingness with respect to the knowledge and expectations a learner has (Malone, 1981). Research suggests that learners are driven by a will to master a challenge and that they will seek and endure an optimal level of informational

complexity and maintain motivation to stay on task, until their cognitive structures are better formed (Berlyne, 1965; Malone, 1981; Piaget, 1951).

When students are intrinsically motivated to learn something, they may spend more time and effort in the process of learning; feeling better about what they learn, and actually utilizing the skills more in the future. Some theorists argue the instructional benefit of these feelings stem from the possibility that as more fundamental cognitive structures are modified learners experience a deeper learning (Malone, 1981; Shulman & Keislar, 1966). Only when the learner is able to attend to the important aspects of the presented material, mentally organize it into a coherent cognitive schema, and integrate it with relevant existing knowledge can meaningful learning or deep understanding commence (Morrison et al., 2007).

Additional motivation can stem from cognitive curiosity, or a desire to bring better form to one's own knowledge structures. Learners are motivated to bring three characteristics of well-formed scientific theories: completeness, consistency, and parsimony to their cognitive structures, suggesting that a learner's curiosity is engaged when there is just enough information present to make their existing knowledge seem incomplete, inconsistent, or unparsimonious (Malone, 1981). Learners will be motivated to stick with the assigned task and learn more in order to make their cognitive structures better-formed. Conceptual conflict, or a lack of consistency evoked by a stimulus situation is the principle factor in producing curiosity (Berlyne, 1965).

Curiosity. Curiosity is a motivator for learning (Malone, 1981) and can be evoked by environments that are neither too complicated nor too simple with respect to the learner's existing knowledge (Berlyne, 1965; Piaget, 1952). Curiosity is separated into sensory and cognitive components. Sensory curiosity is the interest a learner has based on sensory cues, such

as visual or graphic cues, while cognitive curiosity is more about the semantic content of the information presented. Faced with sensory curiosity and cognitive curiosity learners are interested and motivated to assimilate information using schemas they have gained from other contexts (Malone, 1981).

Perceptual visual changes in written instructional material, such as hard-to-read fonts, evoke sensory curiosity. Changes in the sensory stimuli of an environment attract the learner's attention. This interest is a precondition for learning, exploration and curiosity as it draws the learner's attention to novelties and disfluencies which increases meaningfulness to the individual learner (Silvia, 2008; Turner & Silvia, 2006).

Cognitive curiosity is aroused by making learners believe their knowledge structures are incomplete, inconsistent or unparsimonious (Malone, 1981). A learner is faced with the prospect of modifying their higher level cognitive structures when presented with an optimal level of informational complexity (Berlyne, 1965; Piaget, 1952). While motivation can stem from cognitive curiosity, additional research is required to shed more light on the boundaries between disfluent text and text that goes beyond disfluent, and actually becomes illegible, ultimately hinders learning (Diemand-Yauman, et al., 2011).

Challenge. Learning environments should be novel and surprising, however they should not be completely incomprehensible. The optimal environment would be one where the learner knows enough to have expectations about the material, but where these expectations are sometimes unmet or challenged (Malone, 1981). An environment is not challenging if the learner is certain to reach the learning goal, or for that matter, certain not to reach the learning goal.

Successfully meeting or overcoming challenges engages a learner's self-esteem, making them feel better about themselves. Based on an individual's self-rewarding mechanism, more

challenging material might actually be preferred and found to be more interesting (Csikszentmihalyi & Csikszentmihalyi, 1988; Ramachandran & Hirstein, 1999). If less confident in their ability to master the task, the learner is more likely to engage in extra effort and elaboration processing to overcome the perceived challenge (Alter et al., 2007). However, there are limits to the amount of complexity people find interesting and failure in a challenging activity will lower a learner's self-esteem, decreasing their interest in the instructional activity. (Berlyne, 1965; Hunt, 1965; Malone, 1980, 1981; Piaget, 1952; Weiner, 1980).

Not all challenges are desirable (Nelson & Narens, 1990; Yue et al., 2013) and when the task is too difficult for the learner it can lead to reduced liking (Reber et al., 1998). Using hard-to-read fonts could frustrate less motivated learners. While desirable difficulties trigger encoding and retrieval processes that support learning, comprehension and remembering, if the learner does not have the background knowledge, skills or motivation to respond to them successfully, the challenge becomes an undesirable difficulty which may over-burden the learner (Bjork & Bjork, 2011; Diemand-Yauman et al., 2011).

Research shows that poor use of design principles in instructional materials can lead to increased task completion time, and if too difficult, reduced persistence on task due to perceived complexity or doubt that the instruction has value to the learner (Szabo & Kanuka, 1998). The key to successful instructional design is to adjust the level of difficulty to the learner's level of knowledge, making the reading challenging enough to stimulate active processing but not too difficult to break down comprehension (Katzir et al., 2013; McNamara et al., 1996).

Simple and Affordable Strategy

Unlike other forms of desirable difficulties, fluency interventions on font style is an affordable and simple strategy to implement. By simply changing the visual expectations of the

font the instructional designer can create a cognitive educational intervention on digitally available instructional materials. Using word-processing software, selecting and changing fonts is an easy external change that can be made without altering the instructional content and research shows that superficial changes to learning materials yield significant improvements in educational outcomes (Diemand-Yauman et al., 2011).

Purpose of Research

The focus of this study is to compare the use of a *traditional* typographical cueing, such as a bolded font, to a visually *disfluent* font, for cueing learners to important information in an online reading assignment in order to increase reading comprehension as shown in task posttest achievement scores. The purpose of this study was to determine whether a significant difference existed between treatments (control – no cueing (N), bolded (B), or disfluent (D)) in terms of the dependent variables of achievement score, reading time, cognitive load and the participant's perception of the reading task.

The first hypothesis was that participants who are presented with a reading task using a visually disfluent font as a cue to identify important topic information will show an increase in reading comprehension, time spent on task, perceived mental effort (cognitive load) and perceived difficulty. Consistent with research using hard-to-read fonts in a reading assignment is an external way to manipulate text to slow down the learner's task completion time, giving more time on task and improving the learner's ability to comprehend and retain the content (Alter & Oppenheimer, 2009b). Visually disfluent fonts, integrated into instructional materials can be used as an instructional intervention strategy to increase cognitive engagement, leading to deeper processing (Bjork, 1994). Deeper encodings increase time spent on task and have been

associated with higher levels of achievement and better mental retrieval (Craik & Tulving, 1975).

The second hypothesis predicted that when presented with a reading task using a visually disfluent font as a cue to identify important topic information participants who perceive a higher metacognitive awareness of their reading strategies for dealing with unfamiliar or difficult text will show an increase in reading comprehension, time spent on task, perceived mental effort (cognitive load) and perceived difficulty. The metacognitive speed or ease with which a learner can read problems and/or produce an answer to a query is known as fluency (Thompson et al., 2013). Research has shown that by creating a disfluency, or subjective experience of difficulty associated with the cognitive operation of reading the written text, the learner's retention of the information is significantly improved (Diemand-Yauman et al., 2011) and can cue the learner to slow down their reading speed, increasing their time on task and allowing more time for the learner to process the information (Alter et al., 2007). Since reading comprehension, or constructing meaning from text, is an intentional, deliberate, and purposeful act (Kintsch, 1998, Mokhtari & Reichard, 2002) this study utilized the Metacognitive Awareness of Reading Strategies Inventory (MARSI) to assess the participant's awareness of, and their perceived use of reading strategies (Mokhtari and Reichard, 2002). A metacognitive awareness occurs when information is processed with a metacognitive experience of difficulty, or disfluency, which alarms the learner and serves as a cue that the task may be difficult (Alter et al., 2007), prompting the learner to adjust their strategy in order to accomplish the task.

In support of these hypotheses the following research questions were posed for this study:

1. What effect did the visual cueing treatments have on the participant's achievement?

2. What effect does the visual cueing treatment have on the amount of time participants spent on each reading task?

3. What effect does the visual cueing treatment have on the participant's perceptions for each reading task?

4. What effect does the visual cueing treatment have on the participant's perceived mental effort exerted, or cognitive load, for each reading task?

5. What effect does a participant's metacognitive awareness of their reading strategies have on a participant's time spent on each reading task?

CHAPTER II

Method

Research Participants

The target sample size for this research was 60 participants which would allow for 10 students in each of the six treatment orders. The actual participants (N=77) for this research study were undergraduate students enrolled during the spring 2016 semester at a large public research university located in a mid-size southeastern city. The university's current undergraduate population is approximately 20,000 students. Participants were chosen based on a convenience sample of four sections of an undergraduate Science, Technology, Engineering and Mathematics course, STEM 110T - *Technology and Your World*. Table 1 presents the demographics for the participants in this study.

Table 1

Demographics

Gender	Frequency	Percentage
Male	42	54.5%
Female	35	45.5%
Corrective Lenses?		
No	55	71.4%
Yes	22	28.6%

Participant's gender, age, and use of corrective lenses for reading (hyperopia) were collected for demographic purposes, revealing that 54.5% were Male, 45.5% were female, and approximately 29% of the participants wore corrective lenses for close-up reading. As would be expected in a 100-level college course, the participant's ages ranged from 18 years old to 31 years old.

Age (*N*=77)
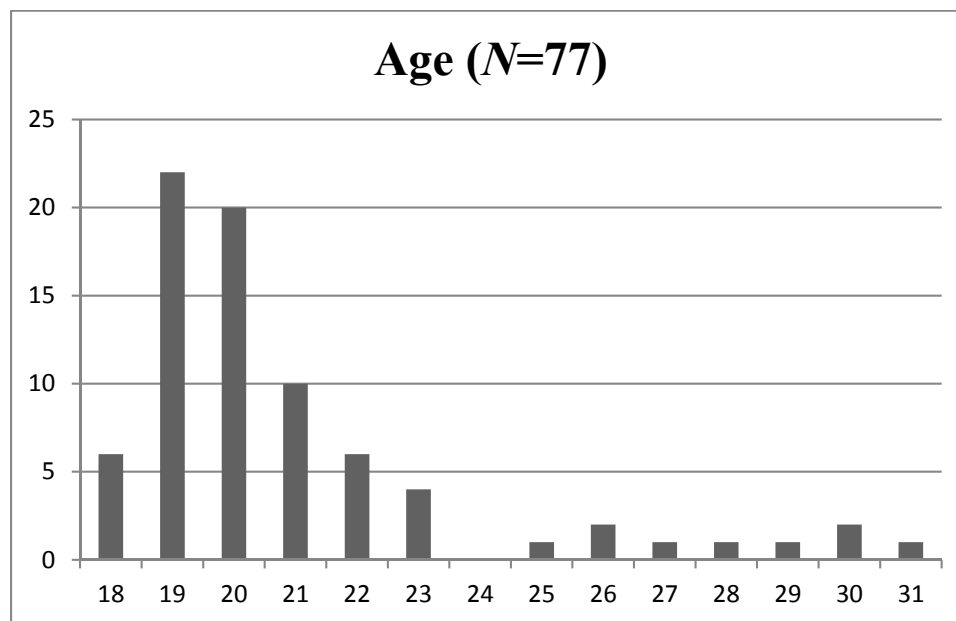
Figure 1. Participants' Ages

As shown in Figure 1, a bar chart showing the ages for the participants shows a very positive

kurtosis curve with over 50% of the participants being either 19 or 20 years old. The mean age

for the sample was 20.94 years old.

Research Design

This study utilized a within-subjects true experimental design. The independent variable

was the visual cueing (control – no cueing (N), cueing in a bolded font (B) or cueing in a visually

disfluent font (D)). Dependent variables included participant's achievement scores on task

posttests of the instructional material (SCORE), the time the participant spent on the reading task

(TIME), the participant's perception of the reading task (PERCEPTION) and the participant's

perceived mental effort or cognitive load for each reading task (LOAD). The covariate was the

participant's metacognitive awareness of their reading strategies (MARSI).

This research used three treatments of the fonts for cueing in the reading material.

Regardless of the treatment used, all text was presented in a left-justified, single-spaced, black

color format. Using a crossover design, such that each participant was exposed to all treatments

in the study, this design controls for the variation associated with hypo and hyper-responders. Because each participant completed one of each cueing treatment across their three assigned reading tasks, the inter-participant variation was reduced.

Treatment order. The presentation order of the treatments was counterbalanced using a randomized 3 X 6 within groups, crossover design, so that the order the treatments were presented to the participants would not be a factor. This design created six groups, Group A through Group F. Groups were randomly assigned as the participants entered the room.

Control – no cueing (N). The control treatment used the Times New Roman font (a commonly preferred font for instructional materials) for all text in the reading assignment, with no font manipulation and no cueing.

Bolded (B). The bolded treatment used the Times New Roman font for all text in the reading assignment, with the exception of a font manipulation bolding the **Times New Roman** font (a traditional typographical method) for cueing the participant to important information they will need for the task posttest.

Disfluent (D). The disfluent treatment used the Times New Roman font for all text in the reading assignment, with the exception of a disfluent visual font (**Impact**) used for cueing the participant to important information they will need for the task posttest. While there are many studies using hard-to-read fonts, there is not a specific group of fonts that are identified as "hard-to-read." Instead research has utilized many different fonts, color gradations, even blurring fonts to manipulate their readability, but all appeared to leverage more of a personal aversion, than a scientific reason for labeling fonts hard-to-read. In formative evaluation of the instruments, **Impact** was found by the test group to be hard-to-read.

Groups. Participants were randomly assigned to one of the six groups, Group A through Group F. Each participant was given three reading tasks, one each on the following topics:

1. RP – Rapid Prototyping

2. CM – Cellular Manufacturing

3. RFID – Radio Frequency Identification

The order of the reading tasks was always presented with the RP reading first, the CM reading second and the RFID reading last. However, each reading task randomly provided the participant exposure to one each of the cueing treatments based on their group assignment. The order tasks were presented is shown in Table 2.

Table 2

Presentation of Tasks – Order

	Reading Task		
	Rapid Prototyping (RP)	Cellular Manufacturing (CM)	Raido Frequency Identification (RFID)
Group	Treatment		
A	Disfluent	Bolded	Control - No cueing
B	Disfluent	Control - No cueing	Bolded
C	Bolded	Disfluent	Control - No cueing
D	Bolded	Control - No cueing	Disfluent
E	Control - No cueing	Disfluent	Bolded
F	Control - No cueing	Bolded	Disfluent

Measures

Metacognitive Awareness of Reading Strategies Inventory (MARSI) version 1.0. The Metacognitive Awareness of Reading Strategies Inventory (MARSI) is a self-report instrument that was developed by Mokhtari and Reichard (2002) to assess pre-college aged students'

awareness of, and their perceived use of reading strategies (see Appendix F). MARSI is used to help learners identify their intentional, deliberate, and purposeful actions for constructing meaning from text.

The inventory consists of three strategy subscales or factors: Global Reading Strategies, Problem-Solving Strategies, and Support Reading Strategies as well as an overall average MARSI score that indicates how often reading strategies are used by learners when reading instructional materials. The MARSI is often used for assessing readers who are fluent in one language and are receiving instruction in an unfamiliar or foreign language. Reading text in an unfamiliar language is a similar disfluency to using hard-to-read fonts. For this research the MARSI was used to measure participants' metacognitive awareness prior to each reading strategy (see Appendix F). These responses measured a participant's metacognitive awareness of their individual reading strategies. Participants were categorized as having mean scores that were either low (2.4 or lower), medium (2.5 to 3.4) or high (3.5 or higher). The majority of the participants in this study identified themselves as either medium (51%) or high (44%) metacognitive awareness of their reading strategies, leaving only 5% identifying themselves with low awareness.

Task posttest achievement score. Following each reading task the participant was given six task posttest questions to assess their comprehension of the instructional readings (see Appendix H). The six questions are identical for all three treatments (control – no cueing (N); bolded (B); or disfluent (D)) of that specific reading topic. All task posttests are a mixture of multiple choice and completion questions and are aimed at the important information cued by the bolded or disfluent font.

Time spent on reading task. Each reading task was designed as a separate survey in the Survey Monkey software to utilize the software's respondent metadata in which Survey Monkey captures the actual time the learner spends on that specific task (*Time Spent*). There is no specific expectation for time spent to complete reading tasks, as the participants were instructed to read at their own pace, to ensure the time spent on task was responsive to the treatment.

Perceived cognitive load. A 9-point rating scale (Paas, 1992) was presented in order to measure the participant's perceived amount of mental effort, or their cognitive load. After each reading the participants were asked to record the level of mental effort exerted for that specific reading task.

Perception of reading task. As in similar research each participant was asked to complete a four question survey specifically designed by the researcher to capture the participant's perception on each of the treatments (see Appendix H). After each reading task participants were asked to rate their responses, on a five-point Likert-type scale to the following questions:

1. How difficult did you find reading the material in this task?

   (1 = 'very easy', 5 = 'very difficult')

2. How did you feel about the fonts used in this reading task?

   (1 = 'I like them very little', 5 = 'I like them very much')

3. How difficult was it to identify the key information in this reading task?

   (1 = 'very easy', 5 = 'very difficult')

4. How frequently did you feel confused or lost during this reading task?

   (1 = 'never', 5 = 'all the time')

Instructional Materials

Instructional materials were created in conjunction with the course instructor.

Readings. In an effort to demonstrate how easily content in existing instructional material could be adapted for cueing using visually disfluent fonts, permission was requested from both the author and the publisher of one of the course's text book, *Contemporary technology: Innovations, issues and perspectives* (Markert & Backer, 2010). Permission was granted for use of the textbook's content for this research by both the author and the publisher (see Appendix A).

Content was taken from Chapter Six, "Manufacturing and Production Enterprise". This content was selected based on the instructor's expectation that most of the participants would not have had extensive prior knowledge in these subject matter areas before reading the material. Some of the content was changed slightly to remove references to other material or examples not included in the study, allowing the reading task to be independently meaningful. These changes were approved in advance by the course instructor. Three specific parts of a section in Chapter Six, Emergent Manufacturing Technologies was used:

1. "Rapid Prototyping" (RP), pages 200-202.

2. "Cellular Manufacturing" (CM), pages 202-204.

3. "Radio Frequency Identification" (RFID), pages 204-206.

The three sub-sections were edited to achieve a character count (including spaces) of between 3,663 and 3,669 to be used for the primary reading tasks. This was to ensure that the time spent for each reading task would be based on comparable character count, no matter the treatment. Because this text uses bolded font to identify key words, a cueing treatment using bolded font should be familiar to all participants.

Procedure

Participation in this research was conducted as an assignment completed during a normal class session, using reading content from a course textbook. This study was approved as "exempt from IRB review" according to federal regulations as documented in the letter of DETERMINATION OF EXMPT STATUS for Project Title # 892330-1, *Using visually disfluent fonts for cueing and increased reading comprehension* (see Appendix B).

The instructor required student participation for all registered students, making these reading tasks part of their course curriculum. Course credit was calculated on their achievement scores for the 18 questions in the three, six-question posttests. This approach provided the learners with an incentive to strive for their highest level of reading comprehension. An alternative written assignment was offered for any student who did not wish to participate in the research, however no one requested this alternative.

The participants met during normally-scheduled class time in a computer lab classroom to support the ability for data collection via computers using the Survey Monkey software (www.surveymonkey.com). The lab classrooms afforded each individual participant simultaneous access to the Internet via desktop computers. No pre-screening was performed prior to being exposed to the research study sessions.

As the participants entered the lab each was given an introductory Handout (see Appendix C) randomly assigning them to one of the six groups, Group A through Group F. This sheet included a brief description of the study, with instructions on how to begin and navigate through the session. Participants were also provided a plain white envelope and a 3X5 card (see Appendix D) with a unique three-digit participation number that was used in the creation of the participant's unique Participant ID.

To provide participant anonymity and security for the research data collected through the Survey Monkey software, participants will only be identifiable to the researcher by a unique five-digit Participant ID. A user created five-digit Participant ID was made up of the first letter of the participant's first name and the first letter of the participant's last name, followed by a consecutive three-digit number provided on the 3X5 card to each participant as they entered the room. Even though this research was part of graded coursework for a university class, the data collected and analyzed for the research must still be handled anonymously. The Participant ID was used to keep the data anonymous to the researchers but still allow the instructor the ability to match up the data with a specific student for course credit. The importance of using the same Participant ID throughout all reading tasks and measures was stressed verbally and in writing, to ensure participants understand this is how they were to receive credit and to be able to link the reading tasks for each participant.

Following all of the reading tasks, each participant placed their 3X5 card in the plain white envelope provided, sealing it closed and writing their name and course section day and time on the outside. These were given to the instructor as the participant completed the session, enabling the instructor to later match the participants to their task posttest achievement scores for course credit.

Online survey software, Survey Monkey (www.SurveyMonkey.com) was used to collect research data. A separate survey instrument was used for each of the three reading tasks in each group. While the format for these surveys is almost identical, separate links were used to isolate the data collection by treatment, for ease of analysis, verification and validation but most importantly, to record the time spent on each reading task (treatment). Since several sessions of the course were actually held in the same physical location or computer lab, the surveys were

designed to allow multiple responses from each computer. In order to obtain the participants first responses, once a page in the survey was submitted, participants could not go back and change existing responses. Once the session was complete the survey was locked down to avoid any unintentional entries added to the data. This was all done via settings in the Survey Monkey software.

The participants in the first session began by identifying an assignment in their Blackboard account for the course containing a PowerPoint file labeled "STEM 110T". This file was to act as a Graphical User Interface (GUI) to guide the participants through their Survey Monkey session for data collection (see Appendix E). Because the instructor had to launch this GUI through the Blackboard software (and not directly on the desktops as planned), some unexpected windows layering issues occurred in the first class session. This was corrected through the use of a Word document as the GUI, with embedded links for the remainder of the data collection sessions.

The first survey (see Appendix F) contained an introduction, instructions for creating the Participant ID, the Metacognitive Awareness of Reading Strategies Inventory (MARSI) (Mokhtari and Reichard, 2002) and asked for a participant's gender, age and whether the participant wore corrective lenses for reading (close-up vision). The next surveys consisted of the three reading tasks (as shown in Appendix G). To ensure the ability to link all surveys for one specific participant the first page of each survey was a registration page where participants entered their unique five-digit Participant ID number. As a washout period or distractor before each six-question task posttest the participant answered five questions on their perceptions for 1) mental effort used, 2) difficulty of the reading material, 3) fonts, 4) identify key information, and 5) confusion. A six-question posttest assessed achievement for each reading topic (RP, CM and

RFID) followed the perception survey for each reading task (as shown in Appendix H). An example of the session for each participant, regardless of group, included the following tasks:

1. Introduction / Participant ID creation / MARSI Inventory

2. Reading one

3. Perception Survey and Task Posttest

4. Reading two

5. Perception Survey and Task Posttest

6. Reading three

7. Perception Survey and Task Posttest

8. Thank you and exit

Once the participant completed the exit section they placed their 3X5 card into the white envelope, wrote their name and course information on the outside and handed the envelope to their instructor.

Analysis

Data from Survey Monkey was exported into several Microsoft Excel files. The data was then linked by the Participant ID so that each row would contain all the data for one participant. Next the data was cleaned and organized for import into the SPSS Statistics software. In the first review of this file data was assessed for duplicate, missing or misaligned data. Several "false starts" were found and eliminated. These were attributed to the PowerPoint window layering issue on the first day of data collection. For duplicate surveys the mean between the two administrations was used. For duplicate task posttest scores, the first administration data was used. There was one case [GW111] where a participant completed a incorrect reading task for their group, exposing them to two readings in the bolded treatment, and no reading in the

disfluent font. This participant's data was deleted. In another case [CW126] a participant was missing the bolded reading, but successfully completed the control – no cueing (N) and the disfluent (D) reading. In order to utilize their data, an average read time was used for the missing bolded reading. As needed, alpha and alpha-numeric values were re-coded to numeric values for input and analysis in SPSS. Responses to the perception survey question #3 was renumbered to ensure the numerical scale for all perception question responses went from positive to negative.

The resulting Master Excel file (*N*=77) was imported into SPSS for use in the statistical analysis of this data. For enhanced readability alpha numeric value labels were created for numeric data in order to indicate what the values would be referring to in the SPSS output.

For purposes of security and confidentiality, all data were stored without reference or linking to the participant's personally-identifiable information. Further, all data were stored on password-protected data storage systems accessible only to the author and dissertation director, as study investigators.

CHAPTER III

Findings / Results

This chapter presents the results of the statistical analyses used to assess the effects of a treatment using a traditional typographical cueing manipulation, such as a traditional bolded font, or a treatment using a visually disfluent font as a cue to identify important topic information on achievement scores, the participant's time spent on the reading task and the participant's perception of the task, including cognitive load (*N*=77). Participants in each treatment are in fact the same participants, with exposure to all levels of a qualitative variable (treatment) during each session. The presentation order of the tasks used a randomized 3 X 6 within groups, crossover design, to control for the order tasks were presented to the participant. The number of qualitative variables were three (control – no cueing (N), bolded (B), or disfluent (D)), equal to the number of levels of the within-subjects factor (treatment), or independent variable.

One-Way Repeated Measures Analysis of Variance (RM-ANOVA)

Because the design for this study exposes each participant to all levels of a qualitative variable and measures their performance on a qualitative variable during each exposure, the best fit for data analysis is a One-Way Repeated Measures Analysis of Variance (RM-ANOVA). This within-subjects univariate approach tests the correlation between the repeated measures when measuring each participant's performance under all three treatment conditions and then models the correlation between the repeated measures. Five assumptions that must be met include:

    three univariate assumptions

- The dependent variable is normally distributed in the population for each level of the within-subjects factor
- sphericity

- the cases represent a random sample from the population and there is no

  dependency between participants,

two multivariate assumptions

- the difference scores are multivariately normally distributed in the population

- the individual cases represent a random sample from the population and the

  difference scores for any one participant are independent from the scores for any

  other participant.

Sphericity and Mauchly's Test. Normally parametric tests based on a normal

distribution assume that the data points are independent, however in a RM-ANOVA multiple

data points can come from one participant, and therefore data from different experimental

conditions will be related. It is said that Sphericity is met when the variances of these related

differences is assumed to be roughly equal. When conducting a RM ANOVA sphericity is often

significant, or not met, resulting in an increase probability of a Type II error (failure to reject a

false null hypothesis), or loss of power in prediction. There are several multivariate tests that can

be done to correct the degrees of freedom.

When using SPSS to conduct a univarite Repeated-Measures ANOVA, the software also

conducts a multivariate test on the difference measures by subtracting measures associated with

one level of the within-subjects factor from the scores for an adjacent level of the within-subjects

factor. SPSS produces Mauchly's Test, which tests the hypothesis that the variances of the

differences between conditions are equal. If Mauchly's Test is significant (p < .05) then there is

significant difference between the variance of differences and it is said that the assumption of

sphericity has not been met. If Mauchly's Test is nonsignificant (p > .05) then it is reasonable to

conclude that the variances of differences are not significantly different, but roughly equal and the assumption of sphericity has been met.

The qualitative variable for this study, the treatment, is the repeated-measure or within-subjects factor. The first four research questions address the four dependent variables of achievement, reading time, perception, and cognitive load. The fifth research question addresses the dependent variable of reading time, adding the MARSI score as a covariant, or possible predictor of the participant's reading time. Unless otherwise noted, an alpha level of .05 was used for all statistical tests.

Research Question 1 – Achievement

What effect did the visual cueing treatments have on the participant's achievement?

Table 3 shows the descriptive statistics for the Dependent Variable of SCORE for the three treatments.

Table 3

Descriptive Statistics for Average Task Posttest Scores

SCORE	Descriptive Statistics		
	Mean	Standard Deviation	N
Control - No cueing	3.86	1.412	77
Bold	3.92	1.458	77
Disfluent	3.73	1.714	77

The Tests of Within-Subjects Main Effects comparing participant's task posttest scores was not significant, $F(2, 152) = .462, p = .631$ with a minimal effect size, $\eta = .006$. Since the p value is greater than .05 there is no significance. Mauchly's Test was used to test the assumption of sphericity - For achievement scores, Mauchly's Test is non-significant, $W = 0.991, \chi^2 (2) = 0.674, p = .714$. Since the significance level, $p > .05$ indicates that the assumption of sphericity has not been violated. Because

Mauchly's Test indicated that the assumption of sphericity was not violated, we can use an uncorrected RM-ANOVA F-test, and accept the null hypothesis. The conclusion is that the variances of differences in the treatment means for reading comprehension, or achievement scores, are not significantly different.

Research Question 2 – Reading Time

What effect does the visual cueing treatment have on the amount of time participants spent on each reading task?

Table 4 shows the descriptive statistics for the Dependent Variable of READ TIME for the three treatments.

Table 4

Descriptive Statistics for Average Reading Times

READ TIME	Descriptive Statistics		
	Mean	Standard Deviation	*N*
Control - No cueing	3:01	1:46	77
Bold	2:59	1:58	77
Disfluent	3:14	2:19	77

The Tests of Within-Subjects Main Effects comparing participant's reading times was not significant, $F(2, 152) = .633$, $\rho = .532$ with a minimal effect size, $\eta = .008$. Since the p value is greater than .05 there is no significance. For reading times, Mauchly's test was significant, $W = 0.793$, $\chi^2 (2) = 17.433$, $\rho = .00$. The significance level, $\rho < .05$ indicates there are significant differences between the variances. The assumption of sphericity has been violated, therefore a corrected univariate approach was taken to correct the degrees of freedom, beginning by reviewing the epsilons in Mauchly's Test. Epsilons are measures of the degree of sphericity, and both the Greenhouse-Geisser and the Huynh-Feldt epsilons were greater than 0.75, therefore statistics suggests using the Huynh-Feldt correction. With this adjustment, $F(1.689,128.344) =$

0.633, ρ = .507, which confirms the conclusion that the Within Subjects Effects of the treatments on participant's reading times are not significant.

Research Question 3 – Perception

What effect does the visual cueing treatment have on the participant's perceptions for each reading task?

Table 5 shows the descriptive statistics for the Dependent Variable of PERCEPTION for the three treatments.

Table 5

Descriptive Statistics for Average Perceptions

PERCEPTION	Descriptive Statistics		
	Mean	Standard Deviation	N
Control - No cueing	2.79	0.849	77
Bold	2.55	0.742	77
Disfluent	2.83	0.813	77

The Tests of Within-Subjects Main Effects comparing participant's perceptions of the reading tasks was not significant, $F(2, 152) = 2.903$, $\rho = .058$ with a minimal effect size, $\eta = .037$. But since $\rho = .05$, this borders on significance. For perception, Mauchly's Test of Sphericity was non-significant, $W = 0.943$, $\chi^2 (2) = 4.438$, $\rho = .109$. Because Mauchly's test indicated that the assumption of sphericity was not violated, an uncorrected RM-ANOVA F-test can be used.

Since the probability of the Within-Subjects Main Effects comparing participant's perceptions of the reading tasks was borderline post hoc tests can be run to confirm where the differences occurred between treatments. A review of the Pairwise Comparisons in Table 6 suggests that there were significant differences ($\rho = .036$) between participant's perceptions of the control – no cueing (N) reading compared to the bolded (B) reading, as well as significant

differences (ρ = .026) between participant's perceptions of the bolded reading compared to the

disfluent reading.

Table 6

Pairwise Comparisons of Participant's Perceptions

Treatment	Treatment	Mean Difference	Significance	ρ
Control - No cueing	Bold	0.234	0.036	0.036
	Disfluent	-0.036	0.791	0.791
Bold	Control - No cueing	-0.234	0.036	0.036
	Disfluent	-0.269	0.026	0.026
Disfluent	Control - No cueing	0.036	0.791	0.791
	Bold	0.269	0.026	0.026

However, because this study is using three measures control for a Type I error (rejecting the null

hypothesis while it was true) is done through a Bonferroni adjustment to adjust alpha to ρ = .017.

(α/3 =.05/3 = .017) to determine significance. However, the pairwise comparisons all remain

nonsignificant, ρ > .017. This re-affirms the conclusion that the variances of differences in the

treatment means for perception of the reading tasks are not significantly different.

Research Question 4 – Cognitive Load

What effect does the visual cueing treatment have on the participant's perceived mental effort

exerted, or cognitive load, for each reading task?

Table 7 shows the descriptive statistics for the Dependent Variable of LOAD for the three

treatments.

Table 7

Descriptive Statistics for Average Perceived Cognitive Load

| | Descriptive Statistics | | |
LOAD	Mean	Standard Deviation	N
Contol - No cueing	5.34	1.81	77
Bold	4.91	1.47	77
Disfluent	5.05	1.55	77

The Tests of Within-Subjects Main Effects comparing participant's perceptions of mental effort, or cognitive load, was not significant, $F(2, 152) = 1.742$, $\rho = .179$ with a minimal effect size, $\eta = .022$. Since the p value is greater than .05 there is no significance. Mauchly's Test of Sphericity was non-significant, $W = 0.952$, $\chi^2 (2) = 3.687$, $\rho = .158$, indicating that the assumption of sphericity has not been violated. An uncorrected RM-ANOVA F-test can be used to conclude that the Within Subjects Effects of the treatments on participant's cognitive load are not significant.

An interesting look at the means, shows that the control – no cueing (N) treatment ($M = 5.34$) and the disflutent (D) treatment ($M = 5.05$) were perceived as having the highest mental effort. The bolded treatment ($M = 4.91$), then was perceived by the participants as requiring the least amount of mental effort.

Research Question 5 – Metacognitive Awareness

What effect does a participant's metacognitive awareness of their reading strategies have on a participant's time spent on each reading task?

The Tests of Within-Subjects Main Effects comparing participant's reading times with MARSI as a covariate, was not significant, $F(2, 150) = 0.420$, $\rho = .658$ with a minimal effect size, $\eta = .006$. Since the p value is greater than .05 there is no significance. Mauchly's Test of Sphericity was significant, $W = 0.787$, $\chi^2 (2) = 17.735$, $\rho = .00$, indicating that the assumption of sphericity

has been violated. The significance level, $\rho = .00$ is less than .05 indicating there are significant differences between the variances. A corrected univariate approach was taken to correct the degrees of freedom. The epsilons, which are measures of the degree of sphericity, were both greater than 0.75, therefore the Huynh-Feldt correction was used. With this adjustment, $F(1.703,127.755) = 0.420$, $\rho = .625$, concluding that MARSI does not significantly predict the Within Subjects Effects of the treatments on participant's reading times.

Additional Analysis

During the analysis process, other relationships were reviewed. Original study design added MARSI as a covariate in the RM-ANOVA for Research Question 5. For curiosity during analysis, MARSI was added as a covariate to the other four research questions to determine if this would explain more of the variances. However, controlling for MARSI may have actually interfered with the effect size of the treatments.

Stepwise regression is a semi-automated process of building a model by successively adding or removing variables based solely on the *t*-statistics of their estimated coefficients to see if any of these variables are predictive of the participant's performance. A regression analysis was done looking at the participant's MARSI, cognitive load and perceptions of the task. A regression is a widely used statistical technique to help investigate and model relationships between variables. While not part of this research design it was interesting to note that given these three variables for a participant, the researcher would be able to predict performance.

CHAPTER IV

Discussion and Conclusion

The focus of this study was to compare the use of a *traditional* typographical cueing manipulation, such as a bolded font, to a cueing manipulation using a visually *disfluent* font, for cueing learners to important information in an online reading assignment in order to increase reading comprehension as shown in task posttest achievement scores. The purpose of this study was to determine whether a significant difference existed between treatments (control – no cueing (N), bolded (B), or disfluent (D)) in terms of the dependent variables of achievement score, reading time, cognitive load, and the participant's perception of the reading task. Participants ($N = 77$) read three different texts from their textbook. Each reading was presented in one of three treatments, control – no cueing (N), cueing in a bolded font (B) or cueing in a visually disfluent font (D), such that each participant was exposed to all three treatments. Treatment orders were varied to control for order effects.

Limitations

Limitations are influences that the researcher cannot control. They are the shortcomings, conditions or influences that cannot be controlled by the researcher that may place restrictions on the study's methodology and conclusions, or possibly explain shortcomings in the study.

MARSI. The overall MARSI scores showed that the majority of the participants felt they had Medium ($N = 39$) to High ($N = 34$) metacognitive awareness of their reading strategies. The overall averages for the MARSI sub-scores showed that the participants as a group averaged highest in the Problem-Solving Strategies. These inventory items were oriented around strategies for solving problems when text becomes difficult to read. These strategies are thought to provide participants with action plans to allow them to navigate through text skillfully.

So while there were no statistically significant effects on achievement, reading time, cognitive load or perceptions for the reading tasks, this could be explained because the participants had medium to high metacognitive awareness of their reading strategies and high problem solving strategies.

Reading from a computer screen. The design of this study presented the reading tasks through Survey Monkey and therefore reading was done on a computer screen. During data collection one student commented to the instructor that they would have preferred the readings be presented in a printed copy (paper format), saying they had a difficult time reading from computer screens. While there is a large body of research on the impact of reading from a computer screen versus from printed material, that literature was not reviewed for this study. Future studies should include these findings in the design of the instructional materials.

Reading time. Because participants were instructed to "read at your own pace" the reading times may not be an actual reflection of the time a participant actually focused on reading the text presented. Several students were observed using their cell phones and were reminded that the instructor could give another assignment if preferred. All of these participants put down their phones and completed the task, but all the while the clock was registering this as time spent on task.

The average college freshman reads 263 words per minute (Carver, 1990). Given that the data showed the reading times ranged from 4 seconds to over 14 minutes for one reading, this suggests several concerns. Most would agree that 4 seconds would not be enough time to actually read text containing approximately 570 words. This insinuates that there were participants that did not actually read the text and went straight to the task posttest. On the other end of the spectrum, a participant taking over 5 minutes for one reading suggests that the reader

may not have been focused and actually reading during the entire time. Future studies are encouraged to find techniques for validating the actual reading times more effectively, such as by the use of eye tracking software.

Control for order. Another issue with reading time may be due to the crossover design used to control for the variation associated with hypo and hyper-responders. Some participants may have realized that the task posttest questions were taken only from the cued information. This in turn would skew some of the results, especially for reading times. For example, if the first reading a participant was exposed to was the disfluent (D) treatment, when they get to the bolded (B) treatment they may just have read the cueing and then gone straight to the task posttest. An interesting approach for future research would be to see if there are differences when using a straight One-Way Analysis of Variance, such that each participant is only presented with one reading, of a much longer length.

Reading topic. The average task posttest score across the study for all treatments and all reading topics was 3.83 out of a perfect score of 6. During the analysis it was noticed that the Radio Frequency Identification (RFID) reading had an average task posttest score of 4.52, almost one point high than scores for the other two reading topics. While these readings were taken from the same chapter of the same text and are approximately the same length, for some reason the participants did much better on the RFID topic. For future research the prior knowledge of the participants with respect to the reading topics should be carefully considered. A possible solution would be to use nonsensical content, as has been done in prior research, so that there is no possible prior knowledge interference.

Amount of disfluent font. The readings in this study were designed to support the curriculum and not be too lengthy to support the participant's ability to read three readings and

answer all the surveys and task posttests within one hour's time. While this study was looking specifically at the use of a disfluent font for cueing, it may be that a reading with a higher word count and more cueing would show more distinction in reading times. Another suggestion for future research would be to use the same approach for cueing, such as bolding the important information, but to present the entire reading in the disfluent font (non-bolded).

Cueing. This study showed that cueing with either bolded or disfluent fonts didn't necessarily improve achievement, as measured by the task posttests. Since the text book used bolded font for cueing this treatment may have been too familiar and comfortable for the participants. So while the cueing may have helped the learners to extract and process essential information, long-term retention was not addressed in this study. It would be interesting for future research to study retention of participants who were exposed to visually disfluent fonts as cues to the important information in a reading.

Lack of cueing. One participant wrote in the fill in the blank response "It was harder for me to read the material and comprehend it this time…" [TT207]. This was an interesting comment given that this comment was given for the control – no cueing (N) treatment of the Cellular Manufacturing reading, a reading that contained no cueing. This suggests that maybe using a control group without cueing caused some interference in the participant's expectations and performance. Given the body of research on cueing, it may make for a stronger study if the familiar bolded font cueing was used as the control group. Without cueing the reader had to read the entire contents of the text in order to be prepared for the posttest questions, which may have explained why the highest mean for cognitive load was for the control readings.

Conclusion

As our world becomes more and more computerized, instructional designers are able to take advantage of time and cost saving approaches to adapt existing instructional materials. This study looked at one approach to take existing digitally available printed instructional materials and quickly change the visual expectations of the font to create a cognitive educational intervention. This easy, cost effective, external change can be made without altering instructional content and such superficial changes to learning materials have been shown to yield significant improvements in learning (Diemand-Yauman et al., 2011).

Even though this study did not show any significant effects for using a disfluent font for cueing, physical reactions from participants were observed during data collection. Several participants were observed leaning back as if surprised when they saw the hard to read (**Impact**) font. One participant verbally commented asking if the screen size could be increased for readability of the hard-to-read font. During the formative evaluation of the instruments, several reviewers commented on how much they disliked the **Impact** font. While there was no direct significance in the analysis, these reactions supported the research that showed by utilizing disfluency in a reading passage the learner was cued to slow (Alter et al., 2007) and embrace concepts like novelty, complexity, surprisingness and incongruity (Berlyne, 1960, 1965, 1968) as an instructional interventions.

Fluency is defined as the metacognitive speed or ease with which a learner can read problems and/or produce an answer to a query (Thompson et al., 2013). Using a hard-to-read font is a simple, cost effective way to interfere with a learner's fluency, motivating them to spend more time on task and improve comprehension and retention (Alter & Oppenheimer, 2009b). Additional research to refine these studies by creating a disfluency, or subjective experience of

difficulty associated with the cognitive operation of reading the written text may show that

simple cost effective approaches to enhance the learner's retention of important information may

be just a click away (Diemand-Yauman et al., 2011).

REFERENCES

Alan, D., Castel, David, P., McCabe, & Henry, L. R. (2007). Illusions of competence and overestimation of associative memory for identical items: Evidence from judgments of learning. *Psychonomic Bulletin & Review, 14*(1), 107-111.

Ali, A. Z. M., Wahid, R., Samsudin, K., & Idris, M. Z. (2013). Reading on the computer screen: Does font type have effects on web text readability? *International Education Studies, 6* (3), 26-35.

Alter, A. L., & Oppenheimer, D. M. (2008). Effects of fluency on psychological distance and mental construal (or why New York is a large city, but New York is a civilized jungle). *Psychological Science (Wiley-Blackwell), 19*(2), 161-167. doi:10.1111/j.1467-9280.2008.02062.x

Alter, A. L., & Oppenheimer, D. M. (2009a). Uniting the tribes of fluency to form a metacognitive nation. *Personality & Social Psychology Review (Sage Publications Inc.), 13*(3), 219-235. doi:10.1177/1088868309341564

Alter, A. L., & Oppenheimer, D. M. (2009b). Uniting the tribes of fluency to form a metacognitive nation. *Personality and Social Psychology Review, 13* (3), 219-235. doi:10.1177/1088868309341564

Alter, A. L., Oppenheimer, D. M., & Epley, N. (2013). Disfluency prompts analytic thinking--but not always greater accuracy: response to Thompson et al. (2013). *Cognition, 128*(2), 252-255. doi:10.1016/j.cognition.2013.01.006

Alter, A. L., Oppenheimer, D. M., Epley, N., & Eyre, R. N. (2007). Overcoming intuition: metacognitive difficulty activates analytic reasoning. *Journal of Experimental Psychology. General, 136*(4), 569-576. doi:10.1037/0096-3445.136.4.569

Ambrose, G., & Harris, P. (2005). *Typography*. Switzerland: AVA Publishing.

Ambrose, G., & Harris, P. (2006). *The fundamental of typography*. Switzerland: AVA Publishing.

Amdur, D. A. (2007). *Typographic design in the digital studio: Design concepts*. Clifton Park, NY: Thomson/Delmar Learning.

Baddeley, A. D. (1992). Is working memory working? The fifteenth Bartlett lecture. *Quarterly Journal of Experimental Psychology, 44*, 1–31.

Baggett, P., Ehrenfeucht, A. (1982a). How an unfamiliar thing should be called. J*ournal of Psycholinguistic Research*, 11(5), 437-445

Berlyne, D. E. (1960). *Conflict arousal and curiosity*. New York, NY: McGraw-Hill.

Berlyne, D. E. (1965). *Structure and direction in thinking*. New York, London, Sydney: John Wiley and Sons, Inc.

Berlyne, D. E. (1966). Curiosity and exploration. *Science, 153*, 25-33.

Berlyne, D. E. (1968). Curiosity and exploration. *Science, 133*, 25-33.

Berlyne, D. E. (1970). Novelty, complexity, and hedonic value. *Perception & Psychophysics, 8*, 279-286.

Berlyne, D. E. (1971). *Aesthetics and Psychobiology*. New York, NY: Appleton-Century- Crofts.

Bernard, M., Mills, M., Peterson, M., & Storrer, K. (2001). *A comparison of popular online fonts: Which is best and when?* Retrieved from http://psychology.wichita.edu/surl/usabilitynews/32/font.asp

Bjork, E. L., & Bjork, R. A. (2011). Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. In M. A. Gernsbacher, R. W. Pew, L. M.

Hough, & J. R. Pomerantz (Eds.), *Psychology and the real world: Essays illustrating fundamental contributions to society* (pp. 56-64). New York: Worth Publishers.

Bjork, R. A. (1994). Memory and metamemory considerations in the training of human beings. In J. M. A. Shimamura (Ed.), *Metacognition: Knowing about knowing*. Cambridge, MA: MIT Press.

Boksman, K., Theberge, J., Williamson, P., Drost, D. J., Malla, A., Densmore, M., . . . Neufeld, R. W. (2005). A 4.0-T fMRI study of brain connectivity during word fluency in first-episode schizophrenia. *Schizophrenia Research, 75*(2–3), 247-263.

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review, 108*(3), 624-652.

Brady, P. (1993). *Using type right: 121 basic no-nonsense rules for working with type*. Lincolnwood: NTC Publishing Group.

Bruner, J. S. (1962). *On knowing: Essays for the left hand*. Cambridge, MA: Belknap Press.

Bryan, M. (1996). *Digital typography sourcebook*. Canada: John Wiley & Sons, Inc.

Cain, K., Oakhill, J. V., & Bryant, P. E. (2004). Children's reading comprehension ability: Concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology, 96*(1), 31-42.

Carroll, M., & Nelson, T. O. (1993). Failure to obtain a generation effect during naturalistic learning. *Memory & Cognition, 21*(3), 361-366.

Carver, R.P. (1990). *Reading rate: A review of research and theory*. Boston: Academic Press

Chapman, J. W., & Tunmer, W. E. (1995). Development of young children's reading selfconcepts: An examination of emerging subcomponents and their relationship with reading achievement. *Journal of Educational Psychology, 87*, 154-167.

Corley, M., MacGregor, L. J., & Donaldson, D. I. (2007). It's the way that you, er, say it: Hesitations in speech affect language comprehension. *Cognition, 105*(3), 658-668. doi:10.1016/j.cognition.2006.10.010

Craik, F., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology, 104*(3), 268-294.

Csikszentmihalyi, M., & Csikszentmihalyi, I. S. (1988). *Optimal Experience: Psychological studies of flow in consciousness*. Cambridge, MA: Cambridge University Press.

de Jong, T. (2009). Cognitive load theory, educational research, and instructional design: some food for thought. *Instructional Science*, 38, 105-34, 126-127. DOI: 10.1007/s11251-009-9110-0

De Koning, B. B., Tabbers, H. K., Rikers, R., & Paas, F. (2009). Towards a framework for attention cueing in instructional animations: Guidelines for research and design. *Educational Psychology Review, 21*(2), 113-140. doi:10.1007/s10648-009-9098-7

Dember, W. N., & Earl, R. W. (1957). Analysis of exploratory, manipulatory, and curiosity behaviors. *Psychological Review, 64*(2), 91-96.

Diemand-Yauman, C., Oppenheimer, D. M., & Vaughan, E. B. (2011). Fortune favors the bold (and the italicized): Effects of disfluency on educational outcomes. *Cognition, 118*, 111–115.

Erdmann, R. L., & Neal, A. S. (1968). Word legibility as a function of letter legibility, with word size, word familiarity, and resolution as parameters. *Journal of Applied Psychology, 52*, 403-409.

Flavell, J. H. (1979). *Metacognition and monitoring: A new area of cognitive-developmental inquiry*. American Psychologist, 34, 906-911.

Fleming, M., & Levie, W. H. (1993). *Instructional message design: Principles from the behavioral and cognitive sciences* (M. Fleming, & Levie, W. H. Ed. 2nd ed.). Englewood Cliffs , NJ.

Forster, M., Leder, H., & Ansorge, U. (2012). It felt fluent, and I liked it: Subjective feeling of fluency rather than objective fluency determines liking. *Emotion, 13*(2), 280.

Giese, X., & Holmes, A. (2002). *Cisco networking academy's program: Fundamentals of web design companion guide*. Indianapolis, IN: Cisco Press.

Goel, V., Buchel, C., Frith, C., & Dolan, R. J. (2000). Dissociation of mechanisms underlying syllogistic reasoning. *NeuroImage, 12*(5), 504-514. doi:10.1006/nimg.2000.0636

Graves, M. (1941). *The art of color and design*. New York, NY: McGraw-Hill.

Greenberg, J., & Jordan, S. (1991). *The painter's eye: Learning to look at con- temporary American art*. New York, NY: Delacorte Press.

Hartley, J. (2004). Designing instructional and informational text. In *Handbook of research on educational communications and technology*, Ed. D. H. Jonassen. Mahwah, NJ: Erlbaum, pp. 917–947.

Healy, A. F., Clawson, D. M., McNamara, D. S., Marmie, W. R., Schneider, V. I., Rickard, T. C., . . . Bourne, L. E. (1993). The long- term retention of knowledge and skills. In D. Medin (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 30, pp. 135-164). New York, NY: Academic Press.

Healy, A. F., & Sinclair, G. P. (1996). The long-term retention of training and instruction. In R. A. B. E. L. Bjork (Ed.), *Memory* (pp. 525-564). San Diego, CA: Academic Press.

Hendel, R. (2013). *Aspects of Contemporary Book Design*. University of Iowa Press.

Hirshman, E., & Mulligan, N. (1991). Perceptual interference improves explicit memory but does not enhance data-driven processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17*, 507-513.

Hirshman, E. L., & Bjork, R. A. (1988). The generation effect: Support for a two-factor theory. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 14*, 484-494.

Hunt, J. M. V. (1965). *Intrinsic motivation and its role in psychological development*. Paper presented at the Nebraska Symposium on Motivation, Lincoln, NE.

Jakesch, M., Leder, H., & Forster, M. (2013). Image ambiguity and fluency. *PLoS ONE, 8*(9). doi:10.1371/journal.pone.0074084

Jamaluddin, H., & Zaidatun, T. (2000). *Pengenalan kepada multimedia (Introduction to multimedia)*. Kuala Lumpur: Venton

James, W. (1890). *The principles of psychology*. New York,NY: Holt.

Jonides, J. (1981). Voluntary versus automatic control over the mind's eye's movement. In J. B. Long & A. D. Baddeley (Eds.), *Attention and performance IX* (pp. 187–203). Hillsdale, NJ: Erlbaum.

Jonides, J., & Yantis, S. (1988). Uniqueness of abrupt visual onset in capturing attention. *Perception & Psychophysics, 43*, 346–354.

Katzir, T., Hershko, S., & Halamish, V. (2013). The effect of font size on comprehension on second and fifth grade children: Bigger is not always better. *PLoS ONE, 8*(9).

Kelley, C. M., & Rhodes, M. G. (2002). Making sense and nonsense of experience: Attributions in memory and judgment. In B. Ross (Ed.), *The Psychology of Learning & Motivation* (pp. 293-320). New York: Academic Press.

Kintsch, E. (1990). Macroprocesses and microprocesses in the development of summarization skill. *Cognition and Instruction, 7*, 161-195.

Kintsch, W. (1988). The use of knowledge in discourse processing: A construction-integration model. *Psychological Review, 95*, 63-182.

Kintsch, W. (1992). A cognitive architecture for comprehension. In H. L. Pick, P. van den Broek, & D. C. Knill (Eds.), *Cognition: conceptual and methodological issues* (pp. 143-161). Washington, DC: American Psychological Association.

Kintsch, W. (1998). *Comprehension: A paradigm for cognition.* New York, NY: Cambridge University Press.

Kornell, N., & Bjork, R. A. (2008). Learning concepts and categories: Is spacing the enemy of induction? *Psychological Science, 19*, 585–592.

Kornell, N., Hays, M. J., & Bjork, R. A. (2009). Unsuccessful retrieval attempts enhance subsequent learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35*(4), 989-998. doi:10.1037/a0015729

Kriz, S., & Hegarty, M. (2007). Top-down and bottom-up influences on learning from animations. *International Journal of Human-Computer Studies, 65*(11), 911-930. doi:10.1016/j.ijhcs.2007.06.005

Kruglanski, A. W., & Thompson, E. P. (1999). Persuasion by a single route: A view from the unimodel. *Psychological Inquiry, 10*(2), 83-109.

Lauer, D. (1979). *Design Basics.* New York: Holt, Rinehart and Winston.

Lupton, E. (2010). *Thinking with type: A critical guide for designers, writers, editors, & students* (2nd ed.). New York, NY: Princeton Architectural Press.

Levie, W. (1987). *Research on pictures: A guide to the literature* (Vol. 2). New York, NY: Springer-Verlag.

Lieberman, M. D., Gaunt, R., Gilbert, D. T., & Trope, Y. (2002). Reflection and reflexion: A social cognitive neuroscience approach to attributional inference. *Advances in Experimental Social Psychology, 34*, 199-249.

Lorch, R. F., & Chen, A. H. (1986). Effects of number signals on reading and recall. *Journal of Educational Psychology, 78*(4), 263-270. doi:10.1037/0022-0663.78.4.263

Lorch, R. F., Lorch, E. P., & Klusewitz, M. A. (1995). Effects of typographical cues on reading and recall of text. *Contemporary Educational Psychology, 20*(1), 51-64. doi:10.1006/ceps.1995.1003

Love, J. (2012). *Reading fast and slow.* Retrieved from http://theamericanscholar.org/reading-fast-and-slow/

Malone, T. W. (1980). *What makes things fun to learn? A study of an intrinsically motivating computer game*. Palo Alto, CA: Xerox Palo Alto Research Center.

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive Science, 5*, 333-370.

Mannes, S. M., & Kintsch, W. (1987). Knowledge organization and text organization. *Cognition & Instruction, 4*(2), 91-115.

Markert, L. R., & Backer, P. R. (2010). *Contemporary technology: Innovations, issues and perspectives*. Tinley Park, IL: Goodheart-Willcox Publisher.

Mayer, R. E. (1984). Aids to text comprehension. *Educational Psychologist, 19*, 30-42.

Mayer, R. E. (1992). Cognition and instruction: Their historic meeting within educational psychology. *Journal of Educational Psychology, 84*(4), 405–412.

McCall, R. B., & McGhee, P. E. (1977). The discrepancy hypothesis of attention and affect in human infants. In I. C.Uzgiris & F.Weizmann (Eds.), *The structuring of experience* (pp. 179–210). New York: Plenum.

McDaniel, M. A., & Einstein, G. O. (2005). Material appropriate difficulty: A framework for determining when difficulty is desirable for improving learning. In A. F. Healy (Ed.), *Experimental cognitive psychology and its applications* (pp. 73-85). Washington, DC: American Psychological Association.

McNamara, D. S. (1995). Effects of prior knowledge on the generation advantage: Calculators versus calculation to learn. *Journal of Educational Psychology, 87*(2), 307-318.

McNamara, D. S., & Healy, A. F. (1995). A generation advantage for multiplication skill training and nonword vocabulary acquisition. In A. F. Healy & L. E. Bourne (Eds.), *Learning and memory of knowledge and skills: Durability and specificity*. Thousand Oaks, CA: Sage.

McNamara, D. S., Kintsch, E., Songer, N. B., & Kintsch, W. (1996). Are good texts always better? Interactions of text coherence, prior knowledge, and levels of understanding in learning from text. *Cognition and Instruction, 14*, 1–43.

Mills, C. B., & Weldon, L. J. (1987). Reading text from computer screens. *ACM Computing Surveys, 19*(4), 329-357.

Mokhtari, K. & Reichard, C. A. (2002). Assessing Students' Metacognitive Awareness of Reading Strategies. *Journal of Educational Psychology, 94*(2), 249–259.

Morrison, G. R., & Anglin, G. J. (2005). Research on cognitive load theory: Application to e-Learning. *Educational Technology, Research and Development, 53*, 94-105.

Morrison, G. R., Ross, S. M., & Kemp, J. E. (2007). *Designing effective instruction*. Hoboken, NJ: John Wiley & Sons, Inc.

Morrison, S., & Noyes, J. (2003). *A comparison of two computer fonts: Serif versus ornate sans serif.* Retrieved from http://psychology.wichita.edu/surl/usabilitynews/52/UK_font.htm

Nairne, J. S. (1988). The mnemonic value of perceptual identification. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14*(2), 248-255. doi:10.1037/0278-7393.14.2.248

Nelson, T. O., & Narens, L. (1990). Metamemory: A theoretical framework and new findings. In G. H. Bower (Ed.), *The psychology of learning and motivation* (pp. 1–45). New York: Academic Press.

Oppenheimer, D. M. (2008). The secret life of fluency. *Trends in Cognitive Sciences, 12*(6), 237-241. doi:10.1016/j.tics.2008.02.014

Oppenheimer, D. M., & Frank, M. C. (2008). A rose in any other font would not smell as sweet: Effects of perceptual fluency on categorization. *Cognition, 106*(3), 1178-1194. doi:10.1016/j.cognition.2007.05.010

Osman, M. (2004). An evaluation of dual-process theories of reasoning. *Psychonomic Bulletin & Review, 11*(6), 988-1010.

Paas, F. (1992). Training strategies for attaining transfer of problem-solving skills in statistics: A Cognitive-load approach. *Journal of Educational Psycholog*y, 84, 429-434.

Paas, F., Tuovinen, J. E., van Merriënboer, J. J. G., & Darabi, A. A. (2005). A motivational perspective on the relation between mental effort and performance: Optimizing learner involvement in instruction. *Educational Technology Research & Development, 53*(3), 25-34.

Paterson, D. G., & Tinker, M. A. (1932). Studies of typographical factors influencing speed of reading. X. Style of type face. *Journal of Applied Psychology*, 16(6), 605-613.

Piaget, J. (1951). *Play, dreams, and imitation in childhood*. New York, NY: Norton.

Piaget, J. (1952). *The origins of intelligence in children*. New York, NY: International Universities Press.

Pressley, G. M., & Harris, K. H. (2006). Cognitive strategies instruction: From basic research to classroom instruction. *Handbook of educational psychology* (2nd ed., pp. 265-286). Mahwah, NJ: Erlbaum.

Rabinowitz, T. (2006). *Exploring typography*. Clifton Park, NY: Thomson Delmar Learning.

Ramachandran, V. S., & Hirstein, W. (1999). The science of art: A neurological theory of aesthetic experience. *Journal of Consciousness Studies, 6*(6/7), 15-51.

Rayner, K. (1978). Eye movements in reading and information processing. *Psychology Bulletin, 85*(3), 618-660.

Reber, R., Schwarz, N., & Winkielman, P. (2004). Processing fluency and aesthetic pleasure: Is beauty in the perceiver's processing experience? *Personality & Social Psychology Review (Lawrence Erlbaum Associates), 8*(4), 364-382.

Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of perceptual fluency on affective judgments. *Psychological Science (Wiley-Blackwell), 9*(1), 45-48.

Rhodes, M. G., & Castel, A. D. (2008). Memory predictions are influenced by perceptual information: Evidence for metacognitive illusions. *Journal of Experimental Psychology: General, 137*(4), 615–625. doi:10.1037/a0013684

Richland, L. E., Bjork, R. A., Finley, J. R., & Linn, M. C. (2005). *Linking cognitive science to education: Generation and interleaving effects.* Paper presented at the Proceedings of the twenty-seventh annual conference of the cognitive science society, Mahwah, NJ.

Roediger, H. L., & Karpicke, J. D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science, 17*, 249-255.

Rohrer, D., & Taylor, K. (2007). The shuffling of mathematics practice problems improves learning. *Instructional Science, 35*, 481–498.

Ross, S. M., & Anand, P. G. (1987). A computer-based strategy for personalizing verbal problems in teaching mathematics. *Educational Communication and Technology Journal, 35*(3), 151–162.

Schmidt, R. A., & Bjork, R. A. (1992). New conceptualization of practice: Common principles in three research paradigms suggest important new concepts for practice. *Psychological Science, 3*, 207–217.

Schwarz, N. (2004). Metacognitive experiences in consumer judgment and decision making. *Journal of Consumer Psychology, 14*, 332-348.

Shah, A. K., & Oppenheimer, D. M. (2007). Easy does it: The role of fluency in cue weighting. *Judgment and Decision Making*(2), 371–379.

Shea, J. B., & Morgan, R. L. (1979). Contextual interference effects on the acquisition, retention, and transfer of a motor skill. *Journal of Experimental Psychology: Human Learning and Memory, 5*, 179–187.

Shulman, L. S., & Keislar, E. R. (1966). *Learning by discovery: A critical appraisal*. Chicago, IL: R& McNally & Company.

Silvia, P. J. (2008). Interest—The curious emotion. *Current Directions in Psychological Science, 17*(1), 57-60. doi:10.1111/j.1467-8721.2008.00548.x

Simon, D. A., & Bjork, R. A. (2001). Metacognition in motor learning. *Journal of Experimental Psychology. Learning, Memory & Cognition, 27*(4), 907-912. Slamecka, N. J., & Graf, P.

(1978). The generation effect: Delineation of a phenomenon. Journal of Experimental

Psychology. *Human Learning and Memory, 4*, 592-604.

Song, H., & Schwarz, N. (2008). Fluency and the detection of misleading questions: Low

processing fluency attenuates the Moses illusion. *Social Cognition, 26*(6), 791-799.

Stang, D. J. (1974). Methodological factors in mere exposure research. *Psychological bulletin, 81*, 1014-1025.

Stang, D. J. (1975). Effects of 'mere exposure' on learning and affect. *Journal of Personality and Social Psychology, 31*, 7-12.

Steinberg, E. R. (1991). *Computer-assisted instruction: a synthesis of theory, practice, and technology*. Hillsdale, NJ: Lawrence Erlbaum.

Szabo, M., & Kanuka, H. (1998). Effects of violating screen design principles of balance, unity,

and focus on recall learning, study time, and completion rates. *Journal of Educational Multimedia and Hypermedia, 8*(1), 23-42

Thompson, V. A., Turner, J. A., Pennycook, G., Ball, L. J., Brack, H., Ophir, Y., & Ackerman,

R. (2013). The role of answer fluency and perceptual fluency as metacognitive cues for

initiating analytic thinking. *Cognition, 128*(2), 237-251.

doi:10.1016/j.cognition.2012.09.012

Thorpe, W. H. (1963). *Learning and Instinct in Animals* (2nd ed.). London: Methuen.

Tinker, M. A. (1963). *Legibility of print*. Ames, IA: Iowa State University Press.

Torgesen, J. K., & Hudson, R. (2006). Reading fluency: critical issues for struggling readers. In

S. J. Samuels & A. Farstrup (Eds.), *Reading fluency: The forgotten dimension of reading success*. Newark, DE: International Reading Association.

Turner, S. A., Jr., & Silvia, P. J. (2006). Must interesting things be pleasant? A test of competing appraisal structures. *Emotion, 6*, 670-674.

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology, 5*, 207-232.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, 185*, 1124–1131.

Tversky, B., Heiser, J., Lozano, S., MacKenzie, R., & Morrison, J. (2008). Enriching animations. In R. K. Lowe & W. Schnotz (Eds.), *Learning with animation: Research and design implications*. New York, NY: Cambridge University Press.

van Merrienboer, J. J. G., Clark, R. E., & de Croock, M. B. M. (2002). Blueprints for complex learning: The 4C/ID-model. *Educational Technology, Research and Development, 50*(2), 39-64.

Weiner, B. (1980). *Human motivation*. New York, NY: Holt, Rinehart & Winston.

White, A. W. (2005). *Thinking in type*. New York, NY: Allworth Press.

Whittlesea, B. W. A., & Williams, L. D. (1998). Why do strangers feel familiar, but friends don't? A discrepancy-attribution account of feelings of familiarity. *Acta Psychologica, 98*.

Whittlesea, B. W. A., & Williams, L. D. (2000). The source of feelings of familiarity: the discrepancy-attribution hypothesis. *The Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 547–565 doi:10.1037/0278-7393.26.3.547

Winkielman, Piotr, & Cacioppo. (2001). Mind at ease puts a smile on the face: Psychophysiological evidence that processing facilitation leads to positive affect. *Journal of Personality and Social Psychology, 81*, 989–1000.

Wittrock, M. C. (1974). Learning as a generative process. *Educational Psychologist*,11, 87–95.

Woods, R. J., Davis, K., & Scharff, L. F. V. (2005). Effects of typeface and font size on legibility for children. *American Journal of Psychological Research, 1*(1).

Yantis, S., & Jonides, J. (1984). Abrupt visual onsets and selective attention: Evidence from visual search. *Human Perception and Performance , Journal of Experimental Psychology, 10*(5), 601–621. doi:10.1037/ 0096-1523.10.5.601

Yue, C. L., Castel, A. D., & Bjork, R. A. (2013). When disfluency is—and is not—a desirable difficulty: The influence of typeface clarity on metacognitive judgments and memory. *Memory & Cognition, 41*, 229-241.

Zachrisson, B. (1965). *Studies in the Legibility of Printed Text*. Stockholm: Almqvist & Wiksell.

Zorzi, M., Barbiero, C., Facoetti, A., Lonciari, I., Carrozzi, M., Montico, M., . . . Ziegler, J. C. (2012). Extra-large letter spacing improves reading in dyslexia. *Proceedings of the National Academy of Sciences of the United States of America, 109*, 11455–11459. Retrieved from http://www.pnas.org/content/109/28/11455.full.pdf

Appendix A.

PERMISSION

From: Linda Rae Markert <lindarae.markert@oswego.edu>
Date: May 29, 2015 at 4:47:36 AM PDT
To: Nena Barley <nbarl001@odu.edu>
Cc: "custserv@g-w.com" <custserv@g-w.com>, Ginger Watson <gswatson@odu.edu>
Subject: Re: NEED AS SOON AS POSSIBLE: REQUEST to use Instructional Material

Nena,

I am on holiday, so I hope you can get a response from G-W directly.

If you can call Karen Carlyle (sp?) at the company, she can direct you to the correct person. I do not object to your use of the stated material.

Good luck! I am interested to read your dissertation.

Linda Rae Markert

Sent from my iPad

On May 28, 2015, at 5:57 PM, Nena Barley <nbarl001@odu.edu> wrote:

To whom it may concern,

I am writing to request copyright permission to use instructional material from your *Contemporary Technology* textbook for my Research in pursuit of my PhD in Instructional Design and Technology.

Markert, L. R., & Backer, P. R. (2010). Contemporary technology: Innovations, issues and perspectives. Tinley Park, IL: Goodheart-Willcox Publisher.
ISBN: 978-1-60525-281-0

My name is Nena Barley and I am a PhD Candidate at Old Dominion University in Norfolk, Virginia. I plan on using STEM 110T- *Technology and Your World* courses for data collection for my study entitled "Using Disfluent Fonts for Cueing and Increased Reading Comprehension" in the FALL 2015 semester.

One advantage of this treatment is that instructors can easily adapt already created instruction by simply changing the font. I would like to ask to use content in Chapter 6 *Manufacturing and Production Enterprise* for my instruction to be presented to students online using Survey Monkey. This instruction would be a part of the student's regular curriculum.

Please let me know as soon as possible if this would be possible. Thank you very much.

Thank you so much,
Nena Barley
757-672-3188

From: Karen Carlyle <kcarlyle@g-w.com>
Date: May 29, 2015 at 10:15:21 AM PDT
To: "nbarl001@odu.edu" <nbarl001@odu.edu>

Good Day, Nena:

Dr. Markert forwarded your request to use instructional material from Chapter 6, "Manufacturing and Production Enterprise" from her textbook *CONTEMPORARY TECHNOLOGY* for research in pursuit of your PHD in Instructional Design and Technology at Old Dominion University.

Goodheart-Willcox grants you permission to use the information and contents as described in your research.

If possible, would you share with Goodheart-Willcox the findings of your study, Using Disfluent Fonts for Cueing and Increased Reading Comprehension? This may have some application for our development and creation of easy-to-use materials. Please send to my attention at jff@g-w.com or to John F. Flanagan, Goodheart-Willcox Publisher, 18604 West Creek Drive, Tinley Park, IL 60477.

We wish you success in your research.

John F. Flanagan

President

Appendix B.

DETERMINATION OF EXEMPT STATUS

OFFICE OF THE VICE PRESIDENT FOR RESEARCH

Physical Address
4111 Monarch Way, Suite 203
Norfolk, Virginia 23508
Mailing Address
Office of Research
1 Old Dominion University
Norfolk, Virginia 23529
Phone(757) 683-3460
Fax(757) 683-5902

DATE:	April 11, 2016
TO:	Ginger Watson, Ph.D.
FROM:	Old Dominion University Education Human Subjects Review Committee
PROJECT TITLE:	[892330-1] Using visually disfluent fonts for cueing and increased reading comprehension
REFERENCE #:	
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	April 11, 2016
REVIEW CATEGORY:	Exemption category # [6.1 & 6.2]

Thank you for your submission of New Project materials for this project. The Old Dominion University Education Human Subjects Review Committee has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact Petros Katsioloudis at (757) 683-5323 or pkatsiol@odu.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Old Dominion University Education Human Subjects Review Committee's records.

Generated on IRBNet

Appendix C.

HANDOUT

Dear Student,

You are being invited to take part in a research study. It is important that you understand why the research is being done and what it will involve. Please take the time to read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information. Participation in this research is conducted as part of your normal class session; however, if you chose not to participate, your instructor will provide you another assignment. Your responses will be anonymous. Survey response data will only be associated with your unique PARTICIPANT ID number.

Title of Study: **DISFLUENT FONTS FOR CUEING**

The focus of this study is to explore the use of typographical cueing for important information in an online reading assignment.

This research is being conducted by:
Nena Barley, Old Dominion University,
Instructional Design and Technology PhD candidate,
nbarl001@odu.edu - - 757-672-3188

Dr. Ginger Watson, Old Dominion University,
Darden School of Education,
gswatson@odu.edu - - 757-683-3246

If you have any questions concerning your rights as a research participant that have not been answered by the investigator, or if you wish to report any concern about the study, you may contact:
 Dr. George Maihafer, Old Dominion University Institutional Review Board chair, at 757-683-4520.

Instructions - You will be asked to:
  1. Create a unique Participant ID Number.
  2. Complete the Metacognitive Awareness of Reading Strategies Inventory.
  3. At your normal reading pace, read three different sections from your textbook.
 4. Answer a motivational survey and six achievement questions after each reading.

To begin this session, open your internet browser - click on <u>100% zoom level</u> on the bottom right hand corner of your screen.

- Close your internet browser
- On your desktop, locate and double-click on the **STEM 110T** icon on your desktop.
- Click on the box for **GROUP A.**
- You will see a bulleted list of tasks. Click on the first bullet and complete the survey that follows.
- Every time you see the following message, click **"Yes"** to return to the bulleted list of tasks.
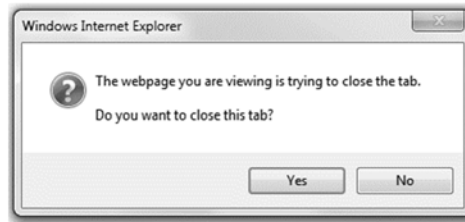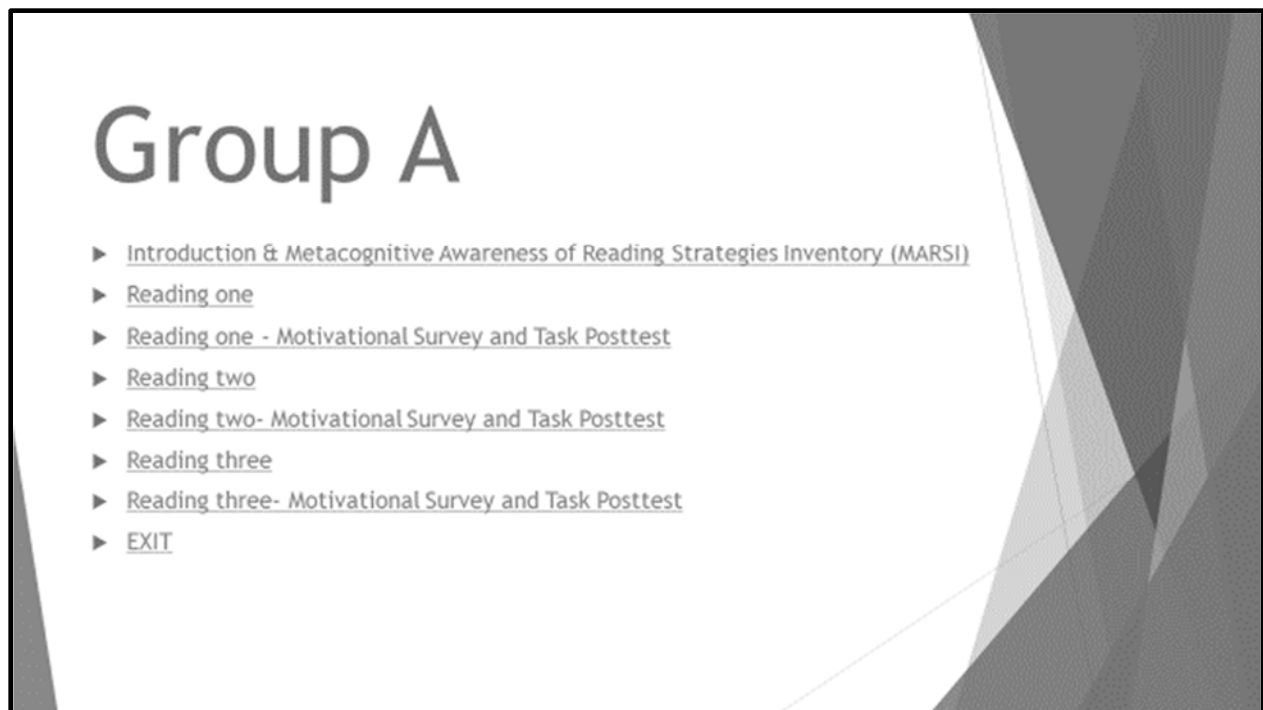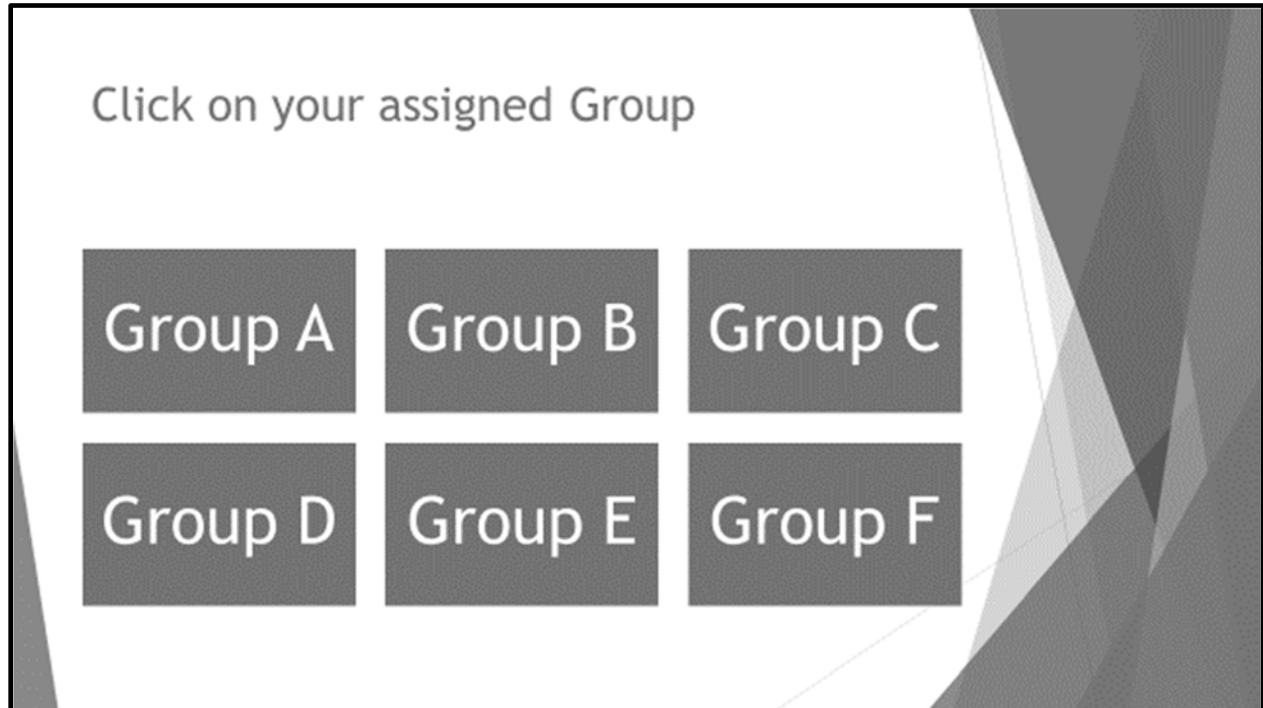
- Continue through the listing, clicking on the bullets and completing the surveys.

Thank you for your participation!

Appendix D.

3X5 CARD AND PLAIN WHITE ENVELOPE
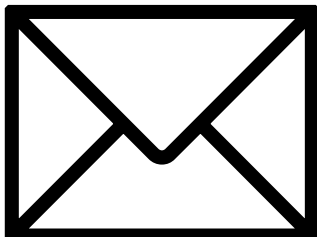
FIRST   LAST   *1 2 3*

Participant Number

Appendix E.

GRAPHICAL USER INTERFACE (GUI)

Appendix F.

INTRODUCTION / METACOGNITIVE AWARENESS

INTRODUCTION / MARSI

INTRODUCTION

Dear Student,

You are being invited to take part in a research study. It is important that you understand why the research is being done and what it will involve. Please take the time to read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information. Participation in this research is conducted as part of your normal class session; however, if you chose not to participate, your instructor will provide you another assignment. Your responses will be anonymous. Survey response data will only be associated with your unique PARTICIPANT ID number.

Title of Study: **DISFLUENT FONTS FOR CUEING**

The focus of this study is to explore the use of typographical cueing for important information in an online reading assignment.

This research is being conducted by:

Nena Barley, Old Dominion University, Instructional Design and Technology PhD candidate, nbarl001@odu.edu - - 757-672-3188

Dr. Ginger Watson, Old Dominion University, Darden School of Education, gswatson@odu.edu - - 757-683-3246

If you have any questions concerning your rights as a research participant that have not been answered by the investigator, or if you wish to report any concern about the study, you may contact:

Dr. George Maihafer, the current Old Dominion University Instructional Review Board chair, at 757-683-4520.

Instructions - You will be asked to:

1. Create a unique Participant ID Number.
2. Complete the Metacognitive Awareness of Reading Strategies Inventory.
3. Read three different sections from your textbook.
4. Answer a motivational survey and six achievement questions after each reading.

By clicking on the NEXT button below, you agree to participate in this research.

INTRODUCTION / MARSI

Create your unique PARTICIPANT ID number...

* 1. Write the first letter of your FIRST name...

* 2. Write the first letter of your LAST name...

* 3. Enter your three digit participation number...

INTRODUCTION / MARSI

Your PARTICIPANT ID...

Your unique five digit PARTICIPANT ID for all surveys will be: [Q1] [Q2] [Q3]

On the 3X5 card you were given, please add your initials in the blanks before your unique three digit number to make note of your five digit PARTICIPANT ID number.

You will need to provide this PARTICIPANT ID on the first page of each survey. You can use your 3X5 card for reference as you work through the sections.

At the end of this class, please place your 3X5 card in the plain white envelope and write your name and course section on the outside of the envelope.

Hand this to your instructor as you leave the room to ensure you receive course credit for your work today.

INTRODUCTION / MARSI

Metacognitive Awareness of Reading Strategies Inventory (MARSI)

Directions: Listed below are statements about what people do when they read academic or school-related materials such as textbooks or library books.

Five numbers follow each statement (1, 2, 3, 4, 5), and each number means the following:

- **1 means "I never or almost never do this."**
- **2 means "I do this only occasionally."**
- **3 means "I sometimes do this" (about 50% of the time).**
- **4 means "I usually do this."**
- **5 means "I always or almost always do this."**

After reading each statement, select the number (1, 2, 3, 4, or 5) that applies to you using the scale provided.

Please note that there are no right or wrong answers to the statements in this inventory, but you must select one answer for each question.

INTRODUCTION / MARSI

MARSI Questions - page 1

- 1 means "I never or almost never do this."
- 2 means "I do this only occasionally."
- 3 means "I sometimes do this" (about 50% of the time).
- 4 means "I usually do this."
- 5 means "I always or almost always do this."

* 4. I have a purpose in mind when I read.

1	2	3	4	5
○	○	○	○	○

* 5. I take notes while reading to help me understand what I read.

1	2	3	4	5
○	○	○	○	○

* 6. I think about what I know to help me understand what I read.

1	2	3	4	5
○	○	○	○	○

* 7. I preview the text to see what it's about before reading it.

1	2	3	4	5
○	○	○	○	○

* 8. When text becomes difficult, I read aloud to help me understand what I read.

1	2	3	4	5
○	○	○	○	○

INTRODUCTION / MARSI

MARSI Questions - page 2

• 1 means "I never or almost never do this."
• 2 means "I do this only occasionally."
• 3 means "I sometimes do this" (about 50% of the time).
• 4 means "I usually do this."
• 5 means "I always or almost always do this."

* 9. I summarize what I read to reflect on important information in the text.

1	2	3	4	5
◻	◻	◻	◻	◻

* 10. I think about whether the content of the text fits my reading purpose.

1	2	3	4	5
◻	◻	◻	◻	◻

* 11. I read slowly but carefully to be sure I understand what I'm reading.

1	2	3	4	5
◻	◻	◻	◻	◻

* 12. I discuss what I read with others to check my understanding.

1	2	3	4	5
◻	◻	◻	◻	◻

* 13. I skim the text first by noting characteristics like length and organization.

1	2	3	4	5
◻	◻	◻	◻	◻

INTRODUCTION / MARSI

MARSI Questions - page 3

• 1 means "I never or almost never do this."
• 2 means "I do this only occasionally."
• 3 means "I sometimes do this" (about 50% of the time).
• 4 means "I usually do this."
• 5 means "I always or almost always do this."

* 14. I try to get back on track when I lose concentration.

1	2	3	4	5
◯	◯	◯	◯	◯

* 15. I underline or circle information in the text to help me remember it.

1	2	3	4	5
◯	◯	◯	◯	◯

* 16. I adjust my reading speed according to what I'm reading.

1	2	3	4	5
◯	◯	◯	◯	◯

* 17. I decide what to read closely and what to ignore.

1	2	3	4	5
◯	◯	◯	◯	◯

* 18. I use reference materials such as dictionaries to help me understand what I read.

1	2	3	4	5
◯	◯	◯	◯	◯

INTRODUCTION / MARSI

MARSI Questions - page 4

• 1 means "I never or almost never do this."
• 2 means "I do this only occasionally."
• 3 means "I sometimes do this" (about 50% of the time).
• 4 means "I usually do this."
• 5 means "I always or almost always do this."

* 19. When text becomes difficult, I pay closer attention to what I'm reading.

1	2	3	4	5
◯	◯	◯	◯	◯

* 20. I use tables, figures, and pictures in text to increase my understanding.

	1	2	3	4	5
	○	○	○	○	○

* 21. I stop from time to time and think about what I'm reading.

	1	2	3	4	5
	○	○	○	○	○

* 22. I use context clues to help me better understand what I'm reading.

	1	2	3	4	5
	○	○	○	○	○

* 23. I paraphrase (restate ideas in my own words) to better understand what I read.

	1	2	3	4	5
	○	○	○	○	○

INTRODUCTION / MARSI

MARSI Questions - page 5

• 1 means "I never or almost never do this."
• 2 means "I do this only occasionally."
• 3 means "I sometimes do this" (about 50% of the time).
• 4 means "I usually do this."
• 5 means "I always or almost always do this."

* 24. I try to picture or visualize information to help remember what I read.

	1	2	3	4	5
	○	○	○	○	○

* 25. I use typographical aids like boldface and italics to identify key information.

	1	2	3	4	5
	○	○	○	○	○

* 26. I critically analyze and evaluate the information presented in the text.

	1	2	3	4	5

<table>
<tr><td>○</td><td>○</td><td>○</td><td>○</td><td>○</td></tr>
</table>

* 27. I go back and forth in the text to find relationships among ideas in it.

1	2	3	4	5
○	○	○	○	○

* 28. I check my understanding when I come across conflicting information.

1	2	3	4	5
○	○	○	○	○

INTRODUCTION / MARSI

MARSI Questions - page 6

- 1 means "I never or almost never do this."
- 2 means "I do this only occasionally."
- 3 means "I sometimes do this" (about 50% of the time).
- 4 means "I usually do this."
- 5 means "I always or almost always do this."

* 29. I try to guess what the material is about when I read.

1	2	3	4	5
○	○	○	○	○

* 30. When text becomes difficult, I reread to increase my understanding.

1	2	3	4	5
○	○	○	○	○

* 31. I ask myself questions I like to have answered in the text.

1	2	3	4	5
○	○	○	○	○

* 32. I check to see if my guesses about the text are right or wrong.

1	2	3	4	5

○	○	○	○	○

* 33. I try to guess the meaning of unknown words or phrases.

1	2	3	4	5
○	○	○	○	○

INTRODUCTION / MARSI

ADDITIONAL INFORMATION...

* 34. What is your gender?

○ Female

○ Male

* 35. What is your age?

[   ]

* 36. Do you currently wear corrective lenses for reading (close-up vision)?

○ YES

NO

Appendix G.

READING ASSIGNMENTS

Rapid Prototyping **(RP) – 3,669 character count**

RP-C

* PARTICIPANT ID - please refer to your 3X5 card

RP-C

Rapid Prototyping (RP)

Contemporary manufacturing is moving toward an era of mass customization. The entire suite of sciences and technologies we refer to as rapid prototyping (RP) provides the foundation to this developing approach to manufacturing. This is indeed new territory. RP is ground where US R&D teams have already established solid footing. Researchers are experimenting with and creating intelligent materials that can anticipate failure, repair themselves, and adapt immediately to changes in the environment.

Before any firm commits to the mass production of a new item, it builds different prototypes for design, ergonomics, safety, ease of assembly, and fitness for use (quality). In recent years, RP has emerged as a well-regarded manufacturing technology in the Concurrent Engineering (CE) design environment. The aim of RP systems is to make full use of prototypes early in the development stage to identify errors in design and make necessary modifications. This expanding technology has the potential to allow designers to produce a prototype within minutes of completing a Computer-aided Design (CAD) drawing of the part, thus obtaining a physical model of a proposed design, while avoiding the lengthy and costly use of conventional tooling and casting processes.

RP systems use data from a 3-D CAD file to construct a model. Charles Hull patented one of the first RP systems in the mid-1980s, with the founding of 3-D Systems, Inc., to develop commercial applications for the process he called stereolithography. The number of commercially available RP systems has increased considerably to include laser modeling systems, solid ground curing, fused deposition modeling, fast casting, and laminated-object manufacturing. The purchase of these highly sophisticated systems exclusively for internal use is often prohibitively expensive for many companies. For this reason, a large number of companies outsource their rapid-prototype manufacturing requirements. In an example of the use of prototyping to replace a motorcycle part using

fused deposition modeling, a machine tool receives a geometric description of the broken part from the CAD file on the disk. The program then divides the model into evenly spaced layers. Each layer is as small as a few thousandths of an inch. The model is built layer by layer from the bottom up. The program instructs the tool to deposit thin layers of liquid, one layer at a time. These layers subsequently fuse together to build a complete part.

A new, and cheaper, RP technology has recently emerged on the market-3-D printing. 3-D printers work by printing new layers on top of existing layers to create a 3-D object. Unlike stereolithography, 3-D printing is faster, cheaper, and easier to use. This printing is particularly useful for companies in the conceptual stages of engineering design. In these stages, they develop prototypes of new products. Timberland, a designer and manufacturer of footwear, used a 3-D printer Z Corporation developed to create new prototype shoes from CAD files. Prototypes that previously cost $1200 and took one week to carve now cost $35 and take 90 minutes to create.

Almost every issue of Machine Design, a trade weekly, contains an advertisement for new and improved types of product prototyping. There is no denying the benefits of this technology. Prototype parts can save costs because they allow the engineer and manufacturer to see the final product early in the design stage. This saves expensive revisions and rework. RP itself has expanded into two additional areas: rapid tooling and rapid manufacturing. Rapid tooling refers to the use of RP to develop molds for use in production.

RP-B

* PARTICIPANT ID - please refer to your 3X5 card

RP-B

Rapid Prototyping (RP)

Contemporary manufacturing is moving toward an era of **mass customization**. The entire suite of sciences and technologies we refer to as rapid prototyping (RP) provides the foundation to this developing approach to manufacturing. This is indeed new territory. RP is ground where US R&D teams have already established solid footing. Researchers are experimenting with and creating intelligent materials that can anticipate failure, repair themselves, and adapt immediately to changes in the environment.

Before any firm commits to the mass production of a new item, it builds different prototypes for design, ergonomics, safety, ease of assembly, and fitness for use (quality). In recent years, RP has emerged as a well-regarded manufacturing technology in the Concurrent Engineering (CE) design environment. The aim of RP systems is to make full use of prototypes early in the development stage to identify errors in design and make necessary

modifications. This expanding technology has the potential to allow designers to produce a prototype within minutes of completing a Computer-aided Design (CAD) drawing of the part, thus obtaining a physical model of a proposed design, while avoiding the lengthy and costly use of conventional tooling and casting processes.

RP systems use data from a 3-D CAD file to construct a model. Charles Hull patented one of the first RP systems in the mid-1980s, with the founding of 3-D Systems, Inc., to develop commercial applications for the process he called stereolithography. **The number of commercially available RP systems has increased considerably to include laser modeling systems, solid ground curing, fused deposition modeling, fast casting, and laminated-object manufacturing.** The purchase of these highly sophisticated systems exclusively for internal use is often prohibitively expensive for many companies. For this reason, a large number of companies outsource their rapid-prototype manufacturing requirements. In an example of the use of prototyping to replace a motorcycle part using fused deposition modeling, a machine tool receives a geometric description of the broken part from the CAD file on the disk. The program then divides the model into evenly spaced layers. Each layer is as small as a few thousandths of an inch. The model is built layer by layer from the bottom up. The program instructs the tool to deposit thin layers of liquid, one layer at a time. These layers subsequently fuse together to build a complete part.

A new, and cheaper, RP technology has recently emerged on the market-3-D printing. 3-D printers work by printing new layers on top of existing layers to create a 3-D object. Unlike stereolithography, 3-D printing is faster, cheaper, and easier to use. This printing is particularly useful for companies in the conceptual stages of engineering design. In these stages, they develop prototypes of new products. Timberland, a designer and manufacturer of footwear, used a 3-D printer Z Corporation developed to create new prototype shoes from CAD files. Prototypes that previously cost $1200 and took one week to carve now cost $35 and take 90 minutes to create.

Almost every issue of Machine Design, a trade weekly, contains an advertisement for new and improved types of product prototyping. There is no denying the benefits of this technology. Prototype parts can save costs because they allow the engineer and manufacturer to see the final product early in the design stage. This saves expensive revisions and rework. RP itself has expanded into two additional areas: rapid tooling and rapid manufacturing. **Rapid tooling refers to the use of RP to develop molds for use in production.**

RP-D

* PARTICIPANT ID - please refer to your 3X5 card

[ ]

RP-D

Rapid Prototyping (RP)

Contemporary manufacturing is moving toward an era of **mass customization**. The entire suite of sciences and technologies we refer to as rapid prototyping (RP) provides the foundation to this developing approach to manufacturing. This is indeed new territory. RP is ground where US R&D teams have already established solid footing. Researchers are experimenting with and creating intelligent materials that can anticipate failure, repair themselves, and adapt immediately to changes in the environment.

Before any firm commits to the mass production of a new item, it builds different prototypes for design, ergonomics, safety, ease of assembly, and fitness for use (quality). In recent years, RP has emerged as a well-regarded manufacturing technology in the Concurrent Engineering (CE) design environment. The aim of RP systems is to make full use of prototypes early in the development stage to identify errors in design and make necessary modifications. This expanding technology has the potential to allow designers to produce a prototype within minutes of completing a Computer-aided Design (CAD) drawing of the part, thus obtaining a physical model of a proposed design, while avoiding the lengthy and costly use of conventional tooling and casting processes.

RP systems use data from a 3-D CAD file to construct a model. Charles Hull patented one of the first RP systems in the mid-1980s, with the founding of 3-D Systems, Inc., to develop commercial applications for the process he called stereolithography. **The number of commercially available RP systems has increased considerably to include laser modeling systems, solid ground curing, fused deposition modeling, fast casting, and laminated-object manufacturing.**

The purchase of these highly sophisticated systems exclusively for internal use is often prohibitively expensive for many companies. For this reason, a large number of companies outsource their rapid-prototype manufacturing requirements. In an example of the use of prototyping to replace a motorcycle part using fused deposition modeling, a machine tool receives a geometric description of the broken part from the CAD file on the disk. The program then divides the model into evenly spaced layers. Each layer is as small as a few

thousandths of an inch. The model is built layer by layer from the bottom up. The program instructs the tool to deposit thin layers of liquid, one layer at a time.

These layers subsequently fuse together to build a complete part.

A new, and cheaper, RP technology has recently emerged on the market-3-D printing. 3-D printers work by printing new layers on top of existing layers to create a 3-D object. Unlike stereolithography, 3-D printing is faster, cheaper, and easier to use. This printing is particularly useful for companies in the conceptual stages of engineering design. In these stages, they develop prototypes of new products. Timberland, a designer and manufacturer of footwear, used a 3-D printer Z Corporation developed to create new prototype shoes from CAD files. Prototypes that previously cost $1200 and took one week to carve now cost $35 and take 90 minutes to create.

Almost every issue of Machine Design, a trade weekly, contains an advertisement for new and improved types of product prototyping. There is no denying the benefits of this technology. Prototype parts can save costs because they allow the engineer and manufacturer to see the final product early in the design stage. This saves expensive revisions and rework. RP itself has expanded into two additional areas: rapid tooling and rapid manufacturing. **Rapid tooling refers to the use of RP to develop molds for use in production.**

Cellular Manufacturing (CM) – 3,663 character count

* PARTICIPANT ID - please refer to your 3X5 card

CM-C

Cellular Manufacturing (CM)

Cellular manufacturing is a type of equipment layout in which the machines are grouped into cells, rather than being placed on an assembly line or divided into different functions (for example, all drills together or all lathes together). The parts produced in a particular cell determine the layout of the cell. In order to have an effective cellular arrangement, a company has to group its products that use similar manufacturing processes. All parts in one group (called a family) follow the same route in the cell, although individual products might spend more time at a particular machine than other products in the same family.

Historically, the layout of manufacturing facilities was classified as a job shop, flow shop, or fixed layout. Cellular manufacturing is a new type of production layout. Group technology (GT) is used in order to achieve cellular manufacturing. GT is an approach to manufacturing that seeks to maximize production efficiency by grouping together similar and recurring tasks, procedures, problems, and bottlenecks. A key feature of GT is the segregation of parts according to their designs, manufacturing features, or a combination of these. When similar parts are grouped together, each collection can ultimately share setups and machine tools. This sharing reduces production costs. GT is applicable to both automated and nonautomated manufacturing.

The GT approach is a marked improvement over traditional batch-processing methods because of its proven capacity to simplify material flow on the production floor. Experts estimate that most manufacturing is still done in small batches, ranging from a single workpiece to several thousand pieces. In many cases, these parts cannot flow smoothly through the manufacturing process since different parts require different setups or must be transferred to another machine. The application of computerization to manufacturing has enabled managers to improve the production of both small and large batches using software and MRP systems. It also became feasible for companies to identify and track the thousands of different parts being produced through the use of GT methods. Design engineers have found they can use GT systems to determine whether or not an existing part can be used in a new application, thus eliminating the need to design a new part. This potential to eliminate design duplication and the parallel need to build a new jig or fixture

can yield significant economic benefits. One of the salient benefits of GT is a direct result of using a formal coding system. In this system, each part receives a numeric code or an alphanumeric code describing specific characteristics or attributes.

A more sophisticated approach to GT entails the creation of manufacturing cells. A manufacturing cell is a collection of machine tools and material-handling equipment grouped together to process one or several part families. Transfer of the piece from one process step to another within the cell and possibly on to a different cell can be automated. The development and application of manufacturing cells are dependent on the type of manufacturing operations performed, the life cycle of products fabricated, the product mix, and projected customer demand. Cells are a blend of job shops producing a large variety of parts and flow shops dedicated to the mass production of one product. A fully operational flexible manufacturing cell speeds up the manufacturing process faster, since parts are moved quickly and systematically from one workstation to the next, allowing the manufacturer to reduce inventories of partially finished parts, representing significant cost savings.

CM-B

* PARTICIPANT ID - please refer to your 3X5 card

☐

CM-B

Cellular Manufacturing

Cellular manufacturing is a type of equipment layout in which the machines are grouped into cells, rather than being placed on an assembly line or divided into different functions (for example, all drills together or all lathes together). The parts produced in a particular cell determine the layout of the cell. In order to have an effective cellular arrangement, a company has to group its products that use similar manufacturing processes. All parts in one group (called a family) follow the same route in the cell, although individual products might spend more time at a particular machine than other products in the same family.

Historically, the layout of manufacturing facilities was classified as a job shop, flow shop, or fixed layout. Cellular manufacturing is a new type of production layout. **Group technology (GT) is used in order to achieve cellular manufacturing**. GT is an approach to manufacturing that seeks to maximize production efficiency by grouping together similar and recurring tasks, procedures, problems, and bottlenecks. A key feature of GT is the segregation of parts according to their designs, manufacturing features, or a combination of these. When similar parts are grouped together, each collection can ultimately share setups

and machine tools. This sharing reduces production costs. GT is applicable to both automated and nonautomated manufacturing.

The GT approach is a marked improvement over traditional batch-processing methods because of its proven capacity to simplify material flow on the production floor. Experts estimate that most manufacturing is still done in small batches, ranging from a single workpiece to several thousand pieces. In many cases, these parts cannot flow smoothly through the manufacturing process since different parts require different setups or must be transferred to another machine. The application of computerization to manufacturing has enabled managers to improve the production of both small and large batches using software and MRP systems. It also became feasible for companies to identify and track the thousands of different parts being produced through the use of GT methods. Design engineers have found they can use GT systems to determine whether or not an existing part can be used in a new application, thus eliminating the need to design a new part. This potential to eliminate design duplication and the parallel need to build a new jig or fixture can yield significant economic benefits. One of the salient benefits of GT is a direct result of using a formal coding system. In this system, each part receives a numeric code or an alphanumeric code describing specific characteristics or attributes.

A more sophisticated approach to GT entails the creation of manufacturing cells. **A manufacturing cell is a collection of machine tools and material-handling equipment grouped together to process one or several part families.** Transfer of the piece from one process step to another within the cell and possibly on to a different cell can be automated. The development and application of manufacturing cells are dependent on the type of manufacturing operations performed, the life cycle of products fabricated, the product mix, and projected customer demand. Cells are a blend of job shops producing a large variety of parts and flow shops dedicated to the mass production of one product. A fully operational flexible manufacturing cell speeds up the manufacturing process faster, since parts are moved quickly and systematically from one workstation to the next, allowing the manufacturer to reduce inventories of partially finished parts, representing significant cost savings.

CM-D

* **PARTICIPANT ID - please refer to your 3X5 card**

CM-D

Cellular Manufacturing

Cellular manufacturing is a type of equipment layout in which the machines are grouped into cells, rather than being placed on an assembly line or divided into different functions (for

example, all drills together or all lathes together). The parts produced in a particular cell determine the layout of the cell. In order to have an effective cellular arrangement, a company has to group its products that use similar manufacturing processes. All parts in one group (called a family) follow the same route in the cell, although individual products might spend more time at a particular machine than other products in the same family.

Historically, the layout of manufacturing facilities was classified as a job shop, flow shop, or fixed layout. Cellular manufacturing is a new type of production layout. **Group technology (GT) is used in order to achieve cellular manufacturing.** GT is an approach to manufacturing that seeks to maximize production efficiency by grouping together similar and recurring tasks, procedures, problems, and bottlenecks. A key feature of GT is the segregation of parts according to their designs, manufacturing features, or a combination of these. When similar parts are grouped together, each collection can ultimately share setups and machine tools. This sharing reduces production costs. GT is applicable to both automated and nonautomated manufacturing.

The GT approach is a marked improvement over traditional batch-processing methods because of its proven capacity to simplify material flow on the production floor. Experts estimate that most manufacturing is still done in small batches, ranging from a single workpiece to several thousand pieces. In many cases, these parts cannot flow smoothly through the manufacturing process since different parts require different setups or must be transferred to another machine. The application of computerization to manufacturing has enabled managers to improve the production of both small and large batches using software and MRP systems. It also became feasible for companies to identify and track the thousands of different parts being produced through the use of GT methods. Design engineers have found they can use GT systems to determine whether or not an existing part can be used in a new application, thus eliminating the need to design a new part. This potential to eliminate design duplication and the parallel need to build a new jig or fixture can yield significant economic benefits. One of the salient benefits of GT is a direct result of using a formal coding system. In this system, each part receives a numeric code or an alphanumeric code describing specific characteristics or attributes.

A more sophisticated approach to GT entails the creation of manufacturing cells. **A manufacturing cell is a collection of machine tools and material-handling equipment grouped together to process one or several part families.** Transfer of the piece from one process step to another within the cell and possibly on to a different cell can be automated. The development and application of manufacturing cells are dependent on the type of manufacturing operations performed, the life cycle of products fabricated, the product mix, and projected customer demand. Cells are a blend of job shops producing a large variety of parts and flow shops dedicated to the mass production of one product. A fully operational flexible manufacturing cell speeds up the manufacturing process faster, since parts are moved quickly and systematically from one workstation to the next, allowing the manufacturer to reduce inventories of partially finished parts, representing significant cost savings.

Radio Frequency Identification (RFID) – 3,666 characters

Radio Frequency Identification (RFID)

Radio frequency identification (RFID) is an automatic Identification (ID) technology that uses tags or transponders to identify objects, collect data, and most importantly, enter the data into a computer system using a wireless network. Most RFID tags are attached to a product, an animal, or a person and have two parts. These parts are an integrated circuit for storing and processing information and an antenna to receive and send signals to the wireless network. There are also simpler RFID tags without integrated circuits that can be printed directly on the product.

Most early use of RFID was in supply chain management. One of the early adopters of this technology was Walmart. As the largest retailer in the U.S., Walmart uses RFID to read product information from tags as products are moved from Walmart's distribution centers into their stores.

Walmart uses passive RFID tags. These tags do not emit a wireless signal. Instead, a special reader reads the tags. The use of RFID tags allows

Walmart to replace its stock faster and reduce excess inventory. In the last few years, other companies including Audi, Sony, Dole Food, and

Boeing have followed Walmart's lead and set up RFID systems to track products. Boeing uses RFID tags to manage incoming parts for its planes. Today, using RFID tags, the supplies are automatically scanned when they enter the building. Boeing's computer system is notified. This notification dramatically reduces labor costs for both Boeing and its suppliers.

The Department of Defense (DOD) began using RFID to track cargo and vehicles during the 1991 Persian Gulf War. Today, the DOD requires all suppliers, excluding those of bulk goods, to include RFID tags on their DOD supplies when they are delivered. Currently, all new passports the U.S. government issues contain an RFID chip with the passport holder's name, nationality, gender, date of birth, place of birth, and digitized photo. The chip also contains the passport number, issue date, expiration date, and type of passport.

RFID tags are not restricted to products and supplies. In the last two decades, millions of household pets have been implanted with RFID tags. The USDA has a new voluntary

initiative. This initiative is the National Animal Identification System (NAIS). The NAIS identifies individual animals through imbedded RFID tags. The Department of Agriculture plans on using this animal tracking feature to trace an animal-related disease back to its source within 24 hours, thereby reducing any further health threat to the U.S. public. Xmark® software's RFID system for tracking and monitoring patients is used both for infants and in nursing homes for elderly patients. In hospital nurseries, both the mother and the child are given wearable RFID tags. If a baby is removed from the newborn ward, an alarm is triggered. Nursing home systems allow wandering older residents to be monitored. Not all the uses are for medical purposes, however. The Baja Beach Club in Barcelona, Spain, offers regular customers the option of implanting RFID tags under their skin, in order to provide quicker entry and payment for drinks.

As the prices of RFID tags continue to drop, more companies will use them to manage their inventory and supply chains. The use of these tags in animals and people is more fraught with controversy. Although an implanted RFID can quicken entry into nightclubs and secured facilities, activists point to the possibility of RFID tags being used to monitor citizens. When tags are imbedded in expensive products such as clothing or electronics, will these tags continue to monitor these products after the consumer brings them home?

RFID-B

* PARTICIPANT ID - please refer to your 3X5 card

[   ]

RFID-B

Radio Frequency Identification (RFID)

Radio frequency identification (RFID) is an automatic Identification (ID) technology that uses tags or transponders to identify objects, collect data, and most importantly, enter the data into a computer system using a wireless network. Most RFID tags are attached to a product, an animal, or a person and have two parts. These parts are an integrated circuit for storing and processing information and an antenna to receive and send signals to the wireless network. There are also simpler RFID tags without integrated circuits that can be printed directly on the product.

Most early use of RFID was in supply chain management. One of the early adopters of this technology was Walmart. As the largest retailer in the U.S., Walmart uses RFID to read product information from tags as products are moved from Walmart's distribution centers into their stores. Walmart uses passive RFID tags. These tags do not emit a wireless signal.

Instead, a special reader reads the tags. The use of RFID tags allows Walmart to replace its stock faster and reduce excess inventory. In the last few years, other companies including Audi, Sony, Dole Food, and Boeing have followed Walmart's lead and set up RFID systems to track products. Boeing uses RFID tags to manage incoming parts for its planes. Today, using RFID tags, the supplies are automatically scanned when they enter the building. Boeing's computer system is notified. This notification dramatically reduces labor costs for both Boeing and its suppliers.

The Department of Defense (DOD) began using RFID to track cargo and vehicles during the 1991 Persian Gulf War. Today, the DOD requires all suppliers, excluding those of bulk goods, to include RFID tags on their DOD supplies when they are delivered. Currently, all new passports the U.S. government issues contain an RFID chip with the passport holder's name, nationality, gender, date of birth, place of birth, and digitized photo. The chip also contains the passport number, issue date, expiration date, and type of passport.

RFID tags are not restricted to products and supplies. In the last two decades, millions of household pets have been implanted with RFID tags. The USDA has a new voluntary initiative. This initiative is the National Animal

Identification System (NAIS). The NAIS identifies individual animals through imbedded RFID tags. The Department of Agriculture plans on using this animal tracking feature to trace an animal-related disease back to its source within 24 hours, thereby reducing any further health threat to the U.S. public. Xmark® software's RFID system for tracking and monitoring patients is used both for infants and in nursing homes for elderly patients. In hospital nurseries, both the mother and the child are given wearable RFID tags. If a baby is removed from the newborn ward, an alarm is triggered. Nursing home systems allow wandering older residents to be monitored. Not all the uses are for medical purposes, however. The Baja Beach Club in Barcelona, Spain, offers regular customers the option of implanting RFID tags under their skin, in order to provide quicker entry and payment for drinks.

As the prices of RFID tags continue to drop, more companies will use them to manage their inventory and supply chains. The use of these tags in animals and people is more fraught with controversy. Although an implanted RFID can quicken entry into nightclubs and secured facilities, activists point to the possibility of RFID tags being used to monitor citizens. When tags are imbedded in expensive products such as clothing or electronics, will these tags continue to monitor these products after the consumer brings them home?

RFID-D

* PARTICIPANT ID - please refer to your 3X5 card

RFID-D

Radio Frequency Identification (RFID)

Radio frequency identification (RFID) is an automatic Identification (ID) technology that uses tags or transponders to identify objects, collect data, and most importantly, enter the data into a computer system using a wireless network. Most RFID tags are attached to a product, an animal, or a person and have two parts. These parts are an integrated circuit for storing and processing information and an antenna to receive and send signals to the wireless network.

There are also simpler RFID tags without integrated circuits that can be printed directly on the product.

Most early use of RFID was in supply chain management. One of the early adopters of this technology was Walmart. As the largest retailer in the U.S., Walmart uses RFID to read product information from tags as products are moved from Walmart's distribution centers into their stores. Walmart uses passive RFID tags. These tags do not emit a wireless signal. Instead, a special reader reads the tags. The use of RFID tags allows Walmart to replace its stock faster and reduce excess inventory. In the last few years, other companies including Audi, Sony, Dole Food, and Boeing have followed Walmart's lead and set up RFID systems to track products. Boeing uses RFID tags to manage incoming parts for its planes. Today, using RFID tags, the supplies are automatically scanned when they enter the building. Boeing's computer system is notified. This notification dramatically reduces labor costs for both Boeing and its suppliers.

The Department of Defense (DOD) began using RFID to track cargo and vehicles during the 1991 Persian Gulf War. Today, the DOD requires all suppliers, excluding those of bulk goods, to include RFID tags on their DOD supplies when they are delivered. Currently, all new passports the U.S. government issues contain an RFID chip with the passport holder's name, nationality, gender, date of birth, place of birth, and digitized photo. The chip also contains the passport number, issue date, expiration date, and type of passport.

RFID tags are not restricted to products and supplies. In the last two decades, millions of household pets have been implanted with RFID tags. The USDA has a new voluntary initiative. This initiative is the National Animal

Identification System (NAIS). The NAIS identifies individual animals through imbedded RFID tags. The Department of Agriculture plans on using this animal tracking feature to trace an animal-related disease back to its source within 24 hours, thereby reducing any further health threat to the U.S. public. Xmark® software's RFID system for tracking and monitoring patients is used both for infants and in nursing homes for elderly patients. In hospital nurseries, both the mother and the child are given wearable RFID tags. If a baby is removed from the newborn ward, an alarm is triggered. Nursing home systems allow wandering older residents to be monitored. Not all the uses are for medical purposes, however. The Baja Beach Club in Barcelona, Spain, offers regular customers the option of implanting RFID tags under their skin, in order to provide quicker entry and payment for drinks.

As the prices of RFID tags continue to drop, more companies will use them to manage their inventory and supply chains. The use of these tags in animals and people is more fraught with controversy. Although an implanted RFID can quicken entry into nightclubs and secured facilities, activists point to the possibility of RFID tags being used to monitor

citizens. When tags are imbedded in expensive products such as clothing or electronics, will these tags continue to monitor these products after the consumer brings them home?

Appendix H.

COGNITIVE LOAD / PERCEPTION SURVEY / READING TASK POSTTESTS

Rapid Prototyping **(RP)** *Posttest*

RP-Q

* **PARTICIPANT ID - please refer to your 3X5 card**

RP-Q

Cognitive Load

* [1] Please choose the category (1, 2, 3, 4, 5, 6, 7, 8 or 9) that applies to you:

In the reading that I just finished I invested:

⬜ 1. very, very low mental effort

⬜ 2. very low mental effort

⬜ 3. low mental effort

⬜ 4. rather low mental effort

⬜ 5. neither low nor high mental effort

⬜ 6. rather high mental effort

⬜ 7. high mental effort

⬜ 8. very high mental effort

⬜ 9. very, very high mental effort

RP-Q

MOTIVATIONAL SURVEY

* How difficult did you find reading the material in this reading task?

very easy	easy	neither easy or difficult	difficult	very difficult
○	○	○	○	○

* How did you feel about the fonts used in this reading task?

I disliked them very much	I disliked them	neither liked or disliked	I liked them	I liked them very much
○	○	○	○	○

* How difficult was it to identify the key information
  in this reading task?

very easy	easy	neither easy or difficult	difficult	very difficult
○	○	○	○	○

* How frequently did you feel confused or lost
  during this reading task?

never	once	a few times	many times	all the time
○	○	○	○	○

RP-Q

QUESTION 1

* Commercially available Rapid Prototyping systems include:

○ laser modeling systems.

○ solid ground curing.

○ fast casting.

○ all of the above.

RP-Q

QUESTION 2

* 3-D printers are a type of:

◯ stereolithography.

◯ inkjet printers.

◯ cellular manufacturing.

◯ cost saving prototyping technology.

RP-Q

QUESTION 3

* **The use of rapid prototyping to develop molds for use in production is referred to as:**

◯ Rapid Manufacturing

◯ Rapid Tooling

◯ Rapid Molding

◯ Rapid Design

RP-Q

QUESTION 4

* Contemporary manufacturing is moving towards an era of:

◯ generic product design

◯ rapid production

◯ mass customization

◯ conventional tooling and casting

RP-Q

QUESTION 5

* 3-D printers:

◯ work by printing out the architecture for a new part.

◯ are very slow and should only be used for complex prototypes.

◯ are laser printers used to print designs on the surface of shoes.

◯ print a three dimensional prototype.

RP-Q

QUESTION 6

* Explain how 3-D printing works.

Cellular Manufacturing **(CM)** *Posttest*

CM-Q

* **PARTICIPANT ID - please refer to your 3X5 card**

CM-Q

Cognitive Load

* [1] Please choose the category (1, 2, 3, 4, 5, 6, 7, 8 or 9) that applies to you:

In the reading that I just finished I invested:

◯ 1. very, very low mental effort

◯ 2. very low mental effort

◯ 3. low mental effort

◯ 4. rather low mental effort

◯ 5. neither low nor high mental effort

◯ 6. rather high mental effort

◯ 7. high mental effort

◯ 8. very high mental effort

◯ 9. very, very high mental effort

CM-Q

MOTIVATIONAL SURVEY

* How difficult did you find reading the material in this reading task?

very easy	easy	neither easy or difficult	difficult	very difficult
○	○	○	○	○

* How did you feel about the fonts used in this reading task?

I disliked them very much	I disliked them	neither liked or disliked	I liked them	I liked them very much
○	○	○	○	○

* How difficult was it to identify the key information in this reading task?

very easy	easy	neither easy or difficult	difficult	very difficult
○	○	○	○	○

* How frequently did you feel confused or lost during this reading task?

never	once	a few times	many times	all the time
○	○	○	○	○

CM-Q

QUESTION 1

* Cellular Manufacturing:

☐ groups parts by function.

☐ is a type of equipment layout in which the machines are grouped into cells based on manufacturing processes.

☐ divides each factory into cells called jobs.

☐ is defined as an assembly line.

CM-Q

QUESTION 2

* Group Technology:

⬭ is different than cellular manufacturing.

⬭ can only be used by automated technology.

⬭ can simplify material flow on the production floor.

⬭ is an expensive approach for manufacturing.

CM-Q

QUESTION 3

* A manufacturing cell:

⬭ is a group of team members.

⬭ is a collection of machine tools and material-handling equipment grouped together.

⬭ is a traditional batch-processing method.

⬭ is a standardized manufacturing facility.

CM-Q

QUESTION 4

* Group technology is an approach to manufacturing:

⬭ that utilizes a fixed layout.

⬭ that creates bottlenecks.

⬭ used to achieve cellular manufacturing.

⬭ used instead of cellular manufacturing.

CM-Q

QUESTION 5

Group technology has a proven capacity:

⬭ to manufacture in small batches.

⬭ to simplify material flow on the production floor.

⬭ as a traditional batch-processing method.

⬭ for only automated manufacturing.

CM-Q

QUESTION 6

* Explain the Group Technology approach to manufacturing.

Radio Frequency Identification **(RFID)** *Posttest*

RFID-Q

* **PARTICIPANT ID - please refer to your 3X5 card**

RFID-Q

Cognitive Load

* [1] Please choose the category (1, 2, 3, 4, 5, 6, 7, 8 or 9) that applies to you:

In the reading that I just finished I invested:

☐ 1. very, very low mental effort

◯ 2. very low mental effort

☐ 3. low mental effort

☐ 4. rather low mental effort

☐ 5. neither low nor high mental effort

◯ 6. rather high mental effort

◯ 7. high mental effort

◯ 8. very high mental effort

☐ 9. very, very high mental effort

RFID-Q

MOTIVATIONAL SURVEY

* How difficult did you find reading the material in this reading task?

very easy	easy	neither easy or difficult	difficult	very difficult
○	○	○	○	○

* How did you feel about the fonts used in this reading task?

I disliked them very much	I disliked them	neither liked or disliked	I liked them	I liked them very much
○	○	○	○	○

* How difficult was it to identify the key information in this reading task?

very easy	easy	neither easy or difficult	difficult	very difficult
○	○	○	○	○

* How frequently did you feel confused or lost during this reading task?

never	once	a few times	many times	all the time
○	○	○	○	○

RFID-Q

QUESTION 1

* Radio frequency identification:

⬜ uses 3-D printers for ID Technology.

⬜ must contain integrated circuits and therefore cannot be printed directly on the product.

⬜ cannot be used in supply chain management.

⬜ uses tags to identify objects, collect data and to enter data into a computer system using a wireless network.

RFID-Q

QUESTION 2

* For an RFID tag to receive and send signals to the network, it must have:

○ a dial-up connection.

○ a printer.

○ an antenna.

○ a wired connection.

RFID-Q

QUESTION 3

* RFID tags

○ can have an integrated circuit for storing and processing information.

○ can have an antenna to receive and send signals.

○ can be printed directly on the product.

○ All of the above.

RFID-Q

QUESTION 4

* RFID stands for:

○ Rapid frequency identification.

○ Radio frequency information domain.

○ Radio frequency identification.

○ Radio frequency information data.

RFID-Q

QUESTION 5

* RFID tags can attach to:

◯ manufactured products and supplies.

◯ only paper products.

◯ bulk goods.

◯ a product, an animal or a human.

◯ printers.

RFID-Q

QUESTION 6

* Explain how hospitals might use RFID.

VITA

Nena S. Barley

Department of STEM & Professional Studies
Old Dominion University, Norfolk, VA

EDUCATIONAL BACKGROUND

Old Dominion University, PhD. Instructional Design & Technology, 2016

Florida Institute of Technology, Master of Science / Systems Management / Information

Systems, Summa cum laude, 2002

University of Florida, Bachelor of Science / Business Administration / Computer & Information

Sciences, 1980

PROFESSIONAL EXPERIENCE

Senior Program Manager – East Coast	12/2007 – current
Senior Engineer (Navy)	12/2006 – 05/2010
Acquisition Analyst (Navy)	05/2006 – 12/2006
Operational Analyst (Joint)	05/2005 – 05/2006
Operational Architect (Army)	11/2003 – 05/2005
Military Analyst- Strategic Plans (Army)	01/2002 – 11/2003
Exploring Executive (Learning for Life)	03/2000 – 12/2001
Instructor	08/1998 – 03/2000
Supervisor, In-Store Sales Representatives	08/1997 – 01/1999
Talent Agent/Owner Operator	03/1992 – 02/1995
Instructor	09/1988 – 06/1996
Computer Programmer/Analyst	08/1981 – 08/1982
Computer Programmer II	06/1980 – 06/1981