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THE EFFECT OF HAPTIC INTERACTION AND LEARNER CONTROL ON STUDENT PERFORMANCE IN AN ONLINE DISTANCE EDUCATION COURSE

Marty J. Park
University of Kentucky, marty.park@uky.edu
Author ORCID Identifier:
http://orcid.org/0000-0002-9422-2936

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Marty J. Park, Student

Dr. Gary Anglin, Major Professor

Dr. Kristen Perry, Director of Graduate Studies

THE EFFECT OF HAPTIC INTERACTION AND LEARNER CONTROL ON STUDENT PERFORMANCE IN AN ONLINE DISTANCE EDUCATION COURSE

DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Education in the
College of Education
at the University of Kentucky

By
Marty J. Park

Lexington, Kentucky

Director: Gary J. Anglin, Ed.D., Associate Professor of Education and Instructional

Systems Design

Lexington, Kentucky

ABSTRACT OF DISSERTATION

THE EFFECT OF HAPTIC INTERACTION AND LEARNER CONTROL ON STUDENT PERFORMANCE IN AN ONLINE DISTANCE EDUCATION COURSE

Today’s learners are taking advantage of a whole new world of multimedia and hypermedia experiences to gain understanding and construct knowledge. While at the same time, teachers and instructional designers are producing these experiences at rapid paces. Many angles of interactivity with digital content continue to be researched, as is the case with this study.

The purpose of this study is to determine whether there is a significant difference in the performance of distance education students who exercise learner control interactivity effectively through a traditional input device versus students who exercise learner control interactivity through haptic input methods. This study asks three main questions about the relationship and potential impact touch input had on the interactivity sequence a learner chooses while participating in an online distance education course. Effects were measured by using criterion from logged assessments within one module of a distance education course.

This study concludes that learner control sequence choices did have significant effects on learner outcomes. However, input method did not. The sequence that learners chose had positive effects on scores, the number of attempts it took to pass assessments, and the overall range of scores per assessment attempts. Touch input learners performed as well as traditional input learners, and summative first sequence learners outperformed all other learners. These findings support the beliefs that new input methods are not detrimental and that learner-controlled options while participating in digital online courses are valuable for learners, under certain conditions.

KEYWORDS: Distance Education, digital learning, learner control, haptics, interactivity, cognitive theory for multimedia learning

Marty J. Park

3/20/2017

Date

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By

Marty J. Park

Dr. Gary Anglin
Director of Dissertation

Dr. Kristen Perry
Director of Graduate Studies

3/20/2017

To my wife, Leah, and my children, Neilsen, Tye, Asa, Forrest, and possibly more in the future. You are gifts from God and the driving force behind this work. You may never understand how much your daily encouragement lifts me up. This has been a journey and proof that all things work together for good to them that love God, to them who are the called according to His purpose. We are blessed.

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GLOSSARY

Adaptive Release: A characteristic (feature) and ability (function) of a system or application that targets either the release or removal of content in response to an identified or predetermined user action (i.e., a performance task completion) (Parkin, Hepplestone, Holden, Irwin, & Thorpe, 2012; Swan, 2009).

ANOVA Test: An "Analysis of Variance" (ANOVA) tests two or more groups for mean differences based on a single continuous response variable (i.e., a scale or interval dependent variable). The term "factor" in an ANOVA test refers to the variable that distinguishes the group membership (e.g., input type or learner-controlled sequence selection) (Taylor, 2014).

Assessment Attempts: The assessment attempts dependent variable is the raw number of attempts for the assessment on a quantitative scale. In this study, it is the number of attempts by a learner per assessment. Each assessment observation has at least one attempt. The number of attempts was used as a primary dependent variable in the hypotheses testing procedures.

Assessment Score Range: The score range represents the score per attempt range as a dependent ratio variable representative of a scale from the learner’s lowest score attempt to his or her highest score attempt. The score attempt range is the simplest measure of variability where the highest score minus the lowest score equals the range. The score range was used as a primary dependent variable in the hypotheses testing procedures.

Assessment Score Range Grouped: Score range grouped are dependent ordinal variables that are recoded and reported as minimal score range, low score range, moderate score range, and high score range.

Blended Learning: Blended learning is the practice of using both online (digital) and in-person (traditional classroom) learning experiences when teaching students. Blended learning is represented by the integrated combination of traditional learning with web-based online approaches, the combination of many pedagogical approaches, irrespective of learning technology use, and the combination of media and tools employed in an eLearning environment. Blended learning is also known as *hybrid* or *mixed mode learning* (McRae, 2015; Strauss, 2015; Thomas, 2010).

Chi-Square Test: The Chi-square test is used to examine whether distributions of categorical variables differ from one another. The Chi-square statistic compares the counts of categorical responses between two (or more) independent groups (Field, 2009).

Cognitive Load Theory (CLT): Cognitive load theory was developed out of the study of problem solving by John Sweller in the late 1980s. Sweller argued that instructional design can be used to reduce cognitive load in learners. CLT differentiates cognitive load into three types: intrinsic, extraneous, and germane (Chandler & Sweller, 1991).

Cognitive Theory for Multimedia Learning (CTML): CTML theory depends on three basic assumptions: dual channel processing; limited capacity; and active processing. First, the dual channel processing assumption posits that humans have distinct channels for processing visual and auditory information. Second, the human working memory system has limited capacity and is susceptible to overload. Third, for learning to be transferred and retained, the learner must actively process by attending to incoming information, organizing the information into a coherent mental representation, and integrating the current mental representation with prior information (Mayer, 2005). Based on these three assumptions, the CTML outlines principles of multimedia design and evaluates each principle in terms of student retention and transfer (Austin, 2009) (also known as multimedia learning theory).

Computer Assisted Instruction (CAI): CAI is a learning environment that supports a one-on-one interaction between a learner (or several learners) and a computer program (Lunts, 2002).

Computer Based Instruction (CBI): CBI is defined as the use of the computer in the delivery of instruction (Merrill, 1980).

Distance Education: Distance education is a method of education in which the learner is physically separate from the teacher. It may be used on its own, or in conjunction with other forms of education, including face-to-face. The teaching and learning contract requires that the student be taught, assessed, given guidance and, where appropriate, prepared for examinations that may or may not be conducted by the institution (Rumble, 1989).

Digital Learning: Digital learning is learning facilitated by technology or digital tools that can give students some element of control over time, place, path and/or pace. Digital learning tools can offer flexibility and learning supports that may not be offered in traditional formats. Using mobile devices, laptops, and networked systems, educators are able personalize and customize learning experiences to align with the needs of each student. Digital learning tools can also make it possible to modify content, such as raising or lowering the complexity level of a text or changing the presentation rate (Office of Education, n.d.).

Digital Citizenship: Digital citizenship is a concept that helps teachers, technology leaders, and parents to understand what students, children, and technology users should know to use technology appropriately. It is more than just a teaching tool; it is a way to prepare students and technology users for a society full of technology. Digital citizenship is commonly known as the *norms of appropriate, responsible technology use* (Ribble, 2015).

Digital Driver's License: A digital driver's license is a learning platform designed as a Massive Online Open Course experience for distributed and custom learning solutions (Noonoo, 2014; Ribble, 2015; Swan & Park, 2015).

eLearning (e-learning): This type of learning uses electronic technologies to access educational curriculum outside of a traditional classroom. In most cases, it refers to a course, program, or degree delivered completely online. eLearning is also known as *Distance Learning*, *Online Learning*, *Digital Learning* (Hirumi, 2013).

Formative Assessments: Formative assessments are brief practice assessments based on a targeted set of learning goals. Instead of signifying the end of the unit, however, the formative assessment's purpose is to give students information, or feedback, about their learning. It helps students identify what they have learned well to that point and what they need to learn better (Guskey, 2005).

Formative First Sequence Group: A formative first sequence group is an independent and dichotomous variable characterization that was found in the metadata for all observations who participated in a formative assessment prior to attempting the summative assessment in the research design.

General Linear Model: This model is based on a straight line and is an analysis of variance procedure in which the calculations are performed using a least squares regression approach to describe the statistical relationship between one or more predictors and a continuous response variable (Field, 2009).

Haptic Input: Using touch-based interactivity as the primary interface with a digital device and platform. Haptic input is characterized by the capabilities of the device a participant uses in the research design.

Haptic Input Group: A haptic input group is an independent and dichotomous variable characterization that was found in the metadata and used in the research design for all observations using a touch-based input.

Hypermedia Learning Environments (HLE): Hypermedia learning environments (HLE) consist of network-like information structures, where fragments of information are stored in nodes that are interconnected and can be accessed by electronic hyperlinks. Hypermedia can be seen as an augmentation of hypertext, in which multimedia elements are included and can be used in flexible ways (Gerjets, Scheiter, Opfermann, Hesse, & Eysink, 2009). HLEs are also referred to as *Interactive Learning Environments* (Scheiter & Gerjets, 2007).

Interaction Effects: Applied researchers often estimate interaction terms to infer how the effect of one independent variable on the dependent variable depends on the magnitude of another independent variable (Norton, Wang, & Ai, 2004).

Interactive Distance Education (IDE): Distance learning opportunities with interactive multimedia learning as essential components are focused on targeted, intentional and engaging interactions. Multimedia tools and capabilities represent an important part of IDE systems. Interactive multimedia learning environments in distance education can respond to learner actions and are expected to promote active construction and acquisition of new knowledge (Kalyuga, 2012).

Interactive Learning Environments (ILEs): ILEs are learning environments in which what happens depends on the actions of the learner. In short, the defining feature of interactivity is responsiveness to the learner's action during learning (Moreno & Mayer, 2007).

Interactivity: In the context of this research and in alignment with the literature, *interactivity* is a characteristic of the learning experience that enables multidirectional (two-way) communication *between* a learner and a learning platform containing content designed by an instructor, with the goal of knowledge construction consistent with the instructional goal (Kalyuga, 2012; Markus, 1987; Moreno & Mayer, 2007; Puntambekar, Stylianou, & Hübscher, 2003; Wagner, 1994). This is contrary to one-way information dumps *from* an instructor *to* a learner. Some researchers use *interactivity* and *learner control* interchangeably, but interactivity implies that the learner has control over the display of information (Hirumi, 2002; Kalyuga, 2012; Scheiter & Gerjets, 2007).

Learner-Centric Research Design: Learner- or user-centric research focuses on and is interested in finding the learning and performance results from the users who interface with the technology (Kenkre & Murthy, 2012; Wong, 2012).

Learner Control Principle: The learner control principle suggests that giving learners control over their instruction by allowing them to pace, sequence, and select information aids learning if learners possess high levels of prior knowledge and if they receive additional instructional support to orient themselves in the learning environment and to self-regulate their learning (Scheiter & Mayer, 2014).

Learning Management System (LMS): LMS is a software application for the administration, documentation, tracking, reporting, and delivery of electronic educational technology (also called eLearning) courses or training programs (Learning Management System, 2016).

Massive Online Open Course (MOOC): MOOCs are online courses that are open to participation regardless of institutional affiliation. They are considered a means for democratizing education and they address an unlimited number of participants (*massive*); are offered free of charge or impose only low participation fees (*open*); are not dependent on location as they are available via the Internet (*online*); and the content consists of instructional lectures and assessment (*courses*) (DeWaard et al., 2011; Dillahunt, Wang, & Teasley, 2014; Jordan, 2014)

Post-test: A post-test is a test or measurement taken after a service or intervention has occurred. The results of a post-test are compared with the results of a pre-test to seek evidence of change resulting from the intervention (Evaluation Toolkit, n.d.).

Pre-test: A pre-test is a test or measurement taken before a service or intervention begins. The results of a pre-test are compared with the results of post-test to assess change. A pre-test can be used to obtain baseline data (Evaluation Toolkit, n.d.).

Self-Regulated Learning: Academic self-regulation, also referred to as self-regulated learning, has been defined as an active, constructive process whereby learners set goals for their learning and then attempt to monitor and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features of the environment (Artino & Stephens, 2009).

Summative Assessments: Summative assessments are evaluation procedures that are used to appraise the outcomes of instruction and help the teacher and student know when the instruction has been effective. This type of assessment informs the student of their mastery of the subject (Bloom, 1968).

Summative First Sequence Group: A summative first sequence group is an independent and dichotomous variable characterization that was found in the metadata for all observations who participated in a summative assessment prior to attempting the formative assessment in the research design.

Techno-Centric Research Design: This type of research design focuses on the performance and understanding of the technology (Mayer, 2005).

Touch Screen: A computer device that allows a user to interact with the device and content being displayed by touching areas on the screen. In this study, login metadata from the platform captured the user agent string in the database

(Appendix C). The user agent string identified the device type and input type (touch screen or non-touch screen).

Traditional Input Group: A traditional input group is an independent and dichotomous variable characterization that was found in the metadata and used in the research design for all observations using a traditional input methods (non-touch-based input).

CHAPTER 1

INTRODUCTION AND GENERAL INFORMATION

The collective goal of education is to increase student knowledge construction and application through instructional design and effective teacher practice (Moreno & Mayer, 2007). With increased digital experiences, researchers are now asking about the entry point for the learner and how the general experience affects the cognitive load of the student while interacting in an in-depth digital landscape. Additionally, interest is rising on the prerequisites a learner should command in order to increase success.

Digital learning is a term that has become synonymous with learning facilitated by technology with the intent of giving students elements of control and choice. Through distance education courses and digital resources, students can be granted additional control over time, place, path, and pace using digital tools and implementation designs. However, digital learning does not exist as one isolated part of an equation. Digital learning is not just providing students with a device—nor is it simply providing students with access to digital content. To be implemented with quality and rigor, digital learning experiences require a recipe of technologies, digital content, and instructional design. How teachers and students alike leverage digital learning experiences to improve academic achievement is of great importance and is the purpose of this research.

Overview of the Study

A renewed interest in education reform is revitalizing classrooms across the United States (Ahn, Ames, & Myers, 2012; Burks & Hochbein, 2015; Glazer & Peurach, 2013). Scholars, researchers, and practitioners alike are turning over every rock with the goal of higher student achievement and increased access to learning content. Innovation in education is at the center of the collision of interest with public, private, family, and media stakeholders. State leaders, namely the Council of Chief State School Officers (CCSSO), a nonpartisan, nationwide, nonprofit organization of public officials who head departments of elementary and secondary education in the states, have exercised focus on testing and scaling student centered learning through innovation lab networks. Through the foci of CCSSO, state education commissioners identified and invested in the following six tenants believed to advance student centered learning: (1) world class knowledge and skills; (2) performance-based learning; (3) personalized learning; (4) comprehensive systems of learning supports; (5) anytime, everywhere opportunities; and (6) student agency (Council of Chief State, 2016). Many of these innovations are shifting the traditional emphasis away from the establishment of education environment, the instructor, and the teaching that takes place in physical classrooms. Reformers are shifting from concepts of *schooling* to *authentic learning*, while intentionally exchanging events that have a start and end time (with an assigned seat) for experiences that are driven by unique individual learners at a customized pace while having personalized, unlimited access to great content and great supports. Ysseldyke and McLeod (2007) argue that it is the difficult to imagine the diversity of instruction this design requires without the aid of education technologies (digital connectivity, digital content, and digital systems) (as cited in Karich, Burns, & Maki, 2014).

With the aforementioned education reform in the 21st century comes a resurgence of interest and value placed in education technology. Many would argue (McRae, 2015; Strauss, 2015) that educational leaders are searching for better ways to reach more students; to personalize learning for every student; to expand the reach of effective teachers; and to increase graduation rates and percentages of students who are college- and career-ready. Some are putting false beliefs in an educational digital “silver bullet” (Friedman, 2013; Herold, 2015; Shirky, 2010; Thomas, 2010; Toyama, 2015). Others are finding promise in new approaches of distance education and digital learning. The overarching frame of digital learning comfortably captures traditional concepts of online learning, distance learning, blended learning, computer based instruction (CBI), and eLearning—all of which are falling under the umbrella of today’s 21stcentury “digital learning” strategies.

The Digital Learning Landscape

Since their 2008 emergence into the already crowded distance education and eLearning and landscape (Fini, 2009), Massive Online Open Courses (MOOCs) are enjoying much attention with the launch of traditional courses in new ways from elite institutions such as Stanford, MIT, and Harvard (Jordan, 2014). The revenue opportunities are at least partially driving the excitement in MOOCs, but the open aspects of the digital movement are equally compelling. “Open” helps define this distance education strategy in two ways (Jordan, 2014). First, it ensures that anyone with interest can get access to the course, and second, that the course content must be created with open source, be copyright free, or create commons original work. With the commercial potential of MOOCs beginning to take shape, the hope is that the open aspects of how practitioners use MOOCs are not overshadowed. MOOCs also share responsibility for increased attention in how technologies create increased opportunities for connecting and improving the learning paradigm (Fini, 2009). The increased attention increases rhetoric, hype, consternation, and even panic.

Provided there is access, learners can self-select when and how they learn. Shirky (2010) and Fini (2009) both point to the use of self-selected tools in participatory social activity. While institutional systems such as learning management systems are still prevalent, Fini (2009) argues that there has been a shift from centralized, specialized, institutionally owned systems towards distributed, general-purpose, user-centered, and user-owned systems, such as social software tools.

In the context of informal distance education and MOOCs, there should be a renewed urgency placed on learning design. In other words, there cannot be a flight from quality. All that has been researched and learned informing practitioners on how students learn best cannot simply be discarded in order to satisfy the insatiable craving to put information behind a sheet of glass and onto a screen.

Beyond the disruptive hype that is centered on MOOCs, educators have been structuring distance education and digital learning content for decades. The market continues to expand and evolve with Learning Management Systems (LMSs) in all shapes and sizes, which, in turn, play a significant role in blended learning strategies (McRae, 2015). Learning management systems are being called on to further accept the challenges (Rumble, 1989) to not only redefine what distance education is, but also redefine learning experiences that should be planned and accounted for. Some LMSs are "free" or open, while some are proprietary and cost money. There continues to be an aggressive, competitive market due to the growing desire for teachers wanting better ways to distribute digital content and digital learning experiences.

Studies now reveal diverse levels of preparedness for teachers and students who participate in an eLearning environment mediated by a learning management system

(Parkes, Stein, & Reading, 2015). Findings suggest that while students may be reasonably prepared to deal with the technology of eLearning for activities such as reading and writing, being clear and concise in responses, synthesizing ideas, planning strategies, making arguments, and working with others, students are not well prepared to integrate the technology into their learning. Hirumi (2013) submits that learning management systems, along with web tool creation software, make it easier for people to create and post online instructional materials. Hirumi (2013) further expresses that easy access does not necessarily mean better. There are now far more people designing online courses and course materials, with little to no formal preparation, practice, and experience in key areas such as instructional design, multimedia development, and graphic design. This results in greater variance in the quality of online course materials and, consequently, the quality of the online distance educational experience (Hirumi, 2013).

Cognitive Load

There are two linked foundational bodies of research that impact and serve as the bedrock for this study. The cognitive load theory (Chandler & Sweller, 1991) and the cognitive theory for multimedia learning (Mayer, 2005; Moreno & Valdez, 2005) both deal with the cross-section of learning and processing new information. In this study, the bodies of research on cognitive load theory and the cognitive theory for multimedia learning while interchangeable, are not an integral part of the research design. Given not everything can be researched in one study, cognitive load is only used as foundational theory but not measured in the research model.

Cognitive load is a theory of how people learn best and is finding an expanding charter in educational research literature, especially when combining multimedia in the instructional design (Cheon & Grant, 2012). De Jong (2010) postulates that the basic premise of the theory is that cognitive capacity in working memory is limited, so if a learning task requires too much capacity, learning will be hampered. The author generalizes that the recommended remedy is to design instructional systems to optimize the use of working memory capacity and avoid cognitive overload. Cognitive load theory has advanced educational research considerably and has been used to explain a large set of experimental findings (De Jong, 2010).

Kalyuga (2007) defines cognitive load as the "demand for working memory resources of a specific person that are required for achieving goals of a particular cognitive activity or learning task when the individual is fully committed to the task" (p. 513) Kalyuga further asserts:

> Invested cognitive resources may depend on motivation and other individual characteristics. Cognitive load always relates to cognitive processes of a specific person. Therefore, it depends not only on objective, depersonalized features of external information presentations or tasks, but also on cognitive characteristics of the learner. For example, the complexity of a task (e.g., the level of interactivity between its elements) is always relative to the learner knowledge base that determines what the elements are in the first place. The subjective nature of cognitive load needs to be emphasized when classifying and describing its sources and categories, especially intrinsic cognitive load (p. 513).

Both the cognitive load theory (Chandler & Sweller, 1991, 1996; Paas, Van Gog, & Sweller, 2010) and the cognitive theory for multimedia learning (Mayer, 2005; Moreno & Valdez, 2005) identify values in reducing extraneous cognitive load, managing essential or intrinsic cognitive load, and foster generative or germane cognitive load.

In the 2011 publication of *Cognitive Load Theory*, Sweller, Ayres, and Kalyuga enter into a holistic conversation that is deeply rooted in instructional design as a field of study. More recent publications (Schnotz & Kürschner, 2007) find the need to dichotomously separate our understanding of two types of knowledge, going to great length to explain that Biological Primary Knowledge (BPK) is different than Biological Secondary Knowledge (BSK). BPK is tacit. It is learnable, but not teachable. It is knowledge that we have without explicit instruction. There is no curriculum for this type of knowledge and it is key to our survival. It is comparable to the traits of an organism that survives through natural selection. It is also believed that BPK does not have any cognitive load and is not measurable. An example of BPK is talking. There are many processes that are implied in the act of speaking, lip movement, tongue placement, breathing, and so on. However, those are learned automatically in a normal, developing child, and they are not necessarily taught. However, grammatically correct speech or reading helps the authors identify BSK. Contrary to primary knowledge, BSK is all of the knowledge our culture determines to be of value. It can be explicitly taught (that is, it is learnable and teachable) and therefore it does have associated cognitive load issues, as it can be measured.

There are three major assumptions with cognitive load that are accepted in the literature and consequently used in this study. The three major assumptions are: (a) dual coding (Clark & Paivio, 1991); (b) limited working memory; and (c) active processing (meaning construction); and (Morrison & Anglin, 2005). These assumptions are in direct reprisal of misguided poor assumptions on learning in general. A poor assumption is that learners have a single channel for processing information. Mayer and Moreno (1998) counter this by using Paivio's (Morrison & Anglin, 2005) research on the respected dual code or dual channel theory. The dual channel theory is implemented in the resulting CTML principles. The second assumption cited as being poor is that learners have an unlimited capacity to process information. Baddeley and Hitch (1974) and Chandler and Sweller (1991) highlight implications that there is a limited capacity of working memory. Therefore, multimedia design should assume the learner has limited capacity and reflect as such.

The final poor assumption that CTL and CTML confront is that a learning process is passive. Mayer and Moreno (1998) attack this poor assumption with five processes that define active learning. The five processes are as follows: (1) Selecting Words; (2) Selecting Images; (3) Organizing Words; (4) Organizing Images; and (5) Integrating Words and Images with Prior Knowledge. These five interactive processes lead to the learner having control and making decisions in the learning process, either willingly or unwillingly.

Cognitive Load and Learner Control

The learner control principle of cognitive load theory (Gerjets et al., 2009; Karich et al., 2014; Kelly, 2008; Reeves, 1993; Scheiter & Mayer, 2014) suggests that giving learners control over their instruction by allowing them to pace, sequence, and select information aids learning if learners possess high levels of prior knowledge and if they receive additional instructional support to orient themselves in the learning environment and to self-regulate their learning.

There are mixed results on the effectiveness of learner control based on empirical research from a cognitive load perspective, which may be, in part, due to the differences in definitions of learner control, differences in measuring outcomes of learner control, and identifications of types of learner control. However, most do agree that learner control hinges on engagement, motivation, and self-regulation skills (Karich et al., 2014).

Opposing Views on Learner Control Effects of Cognitive Load

Learner control as a construct has been studied since the early 1960s (Mager, 1964) mainly in opposition to research and theories of programmed instruction. The research literature is inconsistent, finding either no effect at all, a positive effect, or a negative effect. This not only suggests a disagreement in the value of providing learner control in the instructional design but it also highlights inconsistent theoretical frameworks which are intended to better research the learning design principles (Reeves, 1993).

In their research, Vandewaetere and Clarebout (2013) found that learner control does not impose higher cognitive load as measured by secondary task scores and mental effort ratings. The authors hypothesize that when computer-based learning environments are more tailored or customized by the learner, via exerting control over one or more parts of the learning process, learners would be more successful and would offset extraneous cognitive load with the desired germane cognitive load. In other words, when full or partial control of the experience is granted to the learner, knowledge should be constructed with greater success and efficiencies, without overloading cognitive processes. Vandewaetere and Clarebout (2013) also further reveal that while related to higher germane load through lower difficulty, learner control is not related to extraneous load (as measured by a secondary task performance). This indicates that either a learner had sufficient cognitive resources left to deal with learner control, or that learner control as instructional strategy was authentically processed and led to higher germane load. In this research, linkages are also made between low task difficulty and low motivation based on the perception that the task did not require much effort (Paas, 1992; Paas, Tuovinen, Tabbers, & Van Gerven, 2003). Simply stated, learner control as found in this research contributed to learning by not causing a cognitive overload. It is important to note that the results of this study could have been impacted by pre-existing knowledge of the content. The majority of the research is focused on novel, to-be-learned information (Vandewaetere & Clarebout, 2013).

A 2014 meta-analysis by Karich et al. (2014) identified 85 peer reviewed articles focusing on learner control. However, only 18 of the resulting research articles met the selective criteria and were included in the meta-analysis from 1996 through 2012. Sixty-seven studies were excluded mostly because of sparse reporting of quantitative data, clear explanations, or connections to learner control, and not being published in a peer-reviewed journal. Throughout the 18 primary, peer-reviewed research articles, both academic achievement and behavior outcomes were tested, resulting in 29 total outcomes where data was collected from a total of 3,618 students. The findings suggest that the use of learner control within educational technology did not directly lead to increased outcomes for students and found near zero effects for all components of instruction (pacing, time, sequence, practice, and review). To add to the mixed results, the researchers cite previous studies, which found positive effects with mature learners (Hannafin, 1984). However, this meta-analysis suggests stronger effects with younger students (when compared to college or adult learners). Karich et al. (2014) goes as far as to suggest that learner control can likely be ruled out as a potential causal mechanism for the positive effects of educational technology. However, from the analyzed studies focusing on behavior outcomes, providing learner control within educational technology may enhance engagement, but it may not increase student skills or academic achievement (Karich et al., 2014).

Yet another study of particular interest (Gerjets et al., 2009) aims to connect learner control with hypermedia learning environments and the cognitive load theory. The researchers cite issues with previous studies in that they expose insufficient theoretical frameworks to test effects of learner control, especially in terms of hypermedia and eLearning platforms. Therefore, the authors hypothesize two imperative questions. First, the study (Gerjets et al., 2009) seeks to answer the suggested connection between cognitive load principles of multimedia and hypermedia. Second, the authors pursue identification of the effectiveness of learner control principles through a cognitive load theory perspective. While the research makes minor parallels with hypermedia and multimedia, it does find that a high level of learner control yields effective post-test performance, particularly in the area of increased intuitive knowledge. Due to a contrast from previous research (Clark, 2001; Clark & Feldon, 2005; Mayer, 2005; Moreno & Mayer, 2007; Moreno & Mayer, 2000; Moreno & Valdez, 2005; Scheiter & Gerjets, 2007; Scheiter & Mayer, 2014), of particular interest is that Gerjets et al. (2009) do not find any significant correlation with the students’ prior knowledge of the learned content and the results of the positively affected instructional design. While the research focuses on hypermedia learning environments (HLE) and the evidential connection from the literature with the principles of learner control, the initial research question leads to testing the linkage between cognitive load theory and the cognitive theory of multimedia learning. Although general differences between multimedia and hypermedia environments are expressed, researchers can formulate promising avenues to apply the basic assumptions of the cognitive theories of multimedia learning. Gerjets et al. (2009) state the following:

> It remains an open question whether learners who are more advanced not only with regard to their domain-specific prior knowledge but also with regard to their familiarity with the learning environment and their representational options might benefit from higher levels of learner control in terms of efficiency as proposed by Clark and Mayer (2003). In sum, our results indicate that designing effective hypermedia learning environments based on multimedia design theories is not as simple as it seems, but that there are nevertheless promising avenues to apply the basic assumptions of theories of multimedia learning to improve hypermedia learning designs. (p. 369)

Further, the overall question remains unanswered and unaddressed by the researchers concerning the exact characteristics of a learner that constitute great candidacy for increased levels of learner control versus that of reduced levels of learner control.

Types of Interactivity

Broadly speaking, digital interactive learning environments position a learner in the driver's seat manipulating the presentation of information through the screen. Interactivity, in general, means different things to different people in different contexts (McMillan, 2002, 2006; Moreno & Mayer, 2007). In the context of this research and in alignment with the literature, *interactivity* is a characteristic of the learning experience that enables multidirectional (two-way) communication *between* a learner and a platform containing content designed by an instructor, with the goal of knowledge construction consistent with the instructional goal (Kalyuga, 2012; Markus, 1987; Moreno & Mayer, 2007; Puntambekar, Stylianou, & Hübscher, 2003; Wagner, 1994). This is contrary to one-way information dumps *from* an instructor *to* a learner. The term *instructor* can have multiple meanings. In digital learning or distance education experiences, an instructor can take on a similar role of that in a traditional classroom, but behind a screen instead of face to face. Additionally, an instructor could be a programmed part of the experience like an avatar or character. In this scenario, the instructor is the program itself.

Five common types of interactivity are found in the literature: (1) dialoguing; (2) controlling; (3) manipulating; (4) searching; and (4) navigating (Moreno & Mayer, 2007). Navigational interactivity is the interactivity type attended to the most (Brunken, Plass, & Leutner, 2003; De Jong, 2010; Gerjets et al., 2009; Kalyuga, 2007; Moreno & Mayer, 2007; Scheiter & Gerjets, 2007; Scheiter & Mayer, 2014; Tamam & Poehling, 2014). Hirumi's (2002, 2013) three levels of planned digital learning interactions—(1) internal learner – self interactions; (2) learner-instructional interactions; and (3) learner-human and learner-nonhuman interactions—in conjunction with the five common types of interactivity, are the fundamental connections and building blocks for the remainder of this research with learner control and interactivity.

Isolated types of interactivity, such as navigation, alone would not be sufficient to make a learning environment interactive, unless navigating the environment can lead directly to the construction of knowledge or meaningful learning (Moreno & Mayer, 2007). Using a more traditional or analog tool for learning, such as a book, requires basic navigation by way of page turning. However, simple navigation alone does not define interactivity in the sense that this research refers to. Simple navigation, in reference to a book, is generally more designed for information acquisition as opposed to the aforementioned ideas on knowledge construction. Knowledge construction is building mental models by retrieving, selecting, organizing, and integrating new information with existing knowledge (Mayer, 2005).

There are two slightly opposing views of the connection of interactivity and learner control. In the literature on computer-based instruction and digital learning, learner control is distinguished slightly from interactivity. In early literature, the term *interactivity* refers to having available control options (e.g., the option to stop, start, and replay a video), whereas *learner control* refers to having control over larger units of instruction that consist of multiple, interconnected information elements (Scheiter & Mayer, 2014).

Despite the connotative differences, the two terms—*interactivity* and *learner control*—can be used interchangeably in practice, as interactivity by definition implies that the learner has control over the display of information (Scheiter & Gerjets, 2007). In the remainder of this study, the aforementioned terms will be used interchangeably. Simply stated, if interactivity types are the actions that people can do in a digital learning environment, then the learner control components are the externalized results of the experience, and therefore deeply connected.

Is Interactivity in Multimedia Different than Interactivity in Hypermedia?

Multimedia and hypermedia are deeply connected. As previously asserted, when studying the literature, hypermedia environments become synonymous or interchangeable with the ability of a learner to control the environment (i.e., learner control). A prototypical case of learner-controlled instruction is present and accounted for in hypermedia environments (Scheiter & Mayer, 2014). Therefore, the underpinning of a hypermedia environment is learner control. Likewise, the substance of learner control is interactivity. Due to the nature of hypermedia relying on a learner having full control of the environment, through navigation, searching, manipulating, controlling, dialoguing, pacing, sequencing, selection, and presentation, it has grown increasingly important to understand the theoretical and experimental frameworks by which to conduct research. The lack of a concrete framework on hypermedia learning has led many to the connections and wealth of primary research on theories of multimedia learning. While differences between hypermedia and multimedia may exist from a cognitive load perspective, the literature does highlight the role interactivity can be found within multimedia and hypermedia environments. Figure 1.1 reveals implied relationships between known types of interactivity as expressed by Moreno and Mayer (2007), with Gerjets et al. (2009) components of learner control, and one of three identified levels of planned digital interaction by Hirumi (2013).

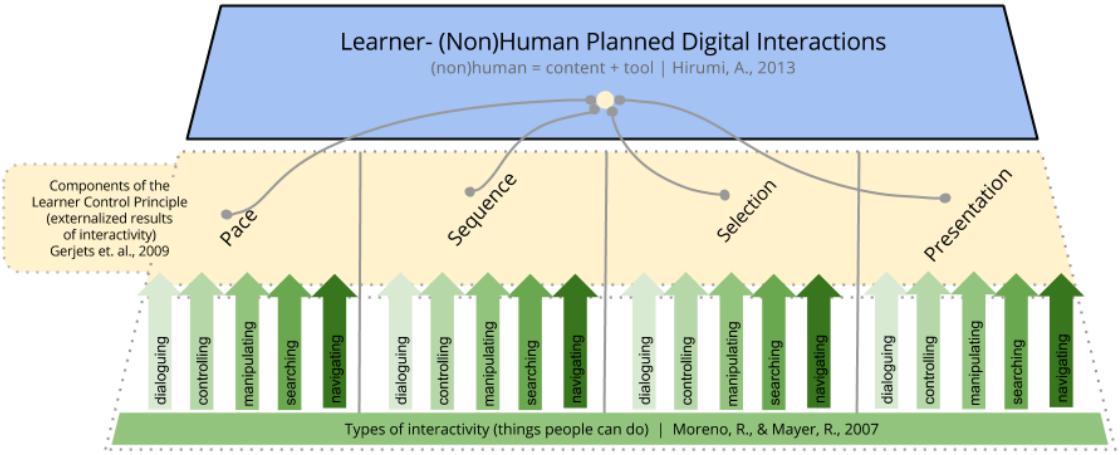

Figure 1.1: The connection between interactivity, components of learner control, and planned digital interactivity

When planning digital interactions, a designer should not only consider the type of interactivity or the result of the learner interaction (i.e., component of learner control), but also the level at which a learner engages with human (e.g., instructors, other learners) or non-human elements, such as the content and the tool(s) being used to interact with the content. In other words, the exact interactions should be planned for and designed with the appropriate learning experiences as the principal consideration. Subsequent adaptations to the Moore (1989) framework for types of interactions lead Hirumi (2002) to also highlight learner-self, and learner-instruction interactions as additional levels of interactions to plan for. When planning interactive online or digital learning experiences, Hirumi's framework (2002, 2013) continues to strengthen the role interactivity plays in both multimedia and hypermedia learning environments.

Haptic Interactivity

If planning and designing the digital interaction for learning is important (Moore, 1989; Hirumi, 2002, 2013) for one side of the screen, then it may be as equally as important to further understand the role that interactivity plays on the student or learner side of the screen. In other words, after the information output displays on the screen through the verbal and visual or pictorial channel, how does the learner intermingle with the interface or experience all of the previously mentioned interactivity points? Traditional inputs to digital interactions are mouse and keyboard related. However, as input technology advances, new ways of interacting directly with the screen introduce new possibilities of learner engagement. The literature on touch-based interactivity shapes interesting questions on the level of interactivity that is appropriate for a learner. Prior to 2010, the research on haptic interactive devices mainly focused on output (as opposed to input) and experimenting with the performance of the technology with very few studies identifying the effects on learning or the effects on cognitive load. In 2010, Apple Inc. introduced the iPad to the consumer market, which soon penetrated the enterprise and education markets. Tablet sales and usage skyrocketed (Zickuhr, 2013). The Gartner Research Group cites the “consumerization of IT” (Niehaves, Köffer, & Ortbach, 2012), where consumer driven technologies are demanded to be used in traditional enterprise structures (businesses and schools). Soon thereafter, competing device manufacturers hustled to enter the newly defined touch screen market. There are now increasing calls for replacing desktop computers in schools with mobile devices such as tablets, but research is needed to determine the implications of this transition on student learning outcomes (Sung & Mayer, 2012). Sung and Mayer (2013) examine the rationale for improved research and instructional design for touch screen tablet devices:

> What is the rationale for investigating whether instructional techniques that are effective in learning with desktop computers (such as iMacs) also apply to handheld tablet computers (such as iPads)? Although much has been written about the potential of iPads for improving education (Geist, 2011; Peluso, 2012; Singer & Singer, 2012; Spector, Merrill, Merrienboer, & Driscoll, 2008), a review of social science databases (including PsycINFO) reveals no published experimental studies comparing learning with iPads versus learning with desktop computers. In short, although proponents propose that using iPads in college classes is a ‘‘game changer’’ (Geist, 2011, p. 758), there is a lack of published research evidence concerning the degree to which it is necessary to adapt effective instructional methods for mobile technologies such as iPads. (p. 641)

Sung and Mayer’s (2012, 2013) method-not-media research will serve as a pivotal blueprint for this research. In their study, 48 college students engaged in an interactive digital learning experience through a traditional desktop computer, while 41 students engaged in the same interactive digital learning experience through a tablet touch screen and mobile device. Regarding the instructional design, students received a continuous lesson in which the learner clicked a button to go to the next slide, followed by a post-test and a survey gauging their willingness to continue learning. The digital learning experience that students engaged in had some elements of learner control, but would not be considered by most as a *hypermedia* environment with full learner control interactivity.

While touch-based, or haptic input is deeply connected with mobile devices, this research will not address the mobility principle (Sung & Mayer, 2013). Sung and Mayer (2013) provide preliminary evidence that people may be more motivated to persevere in a learning event when they use mobile devices. The research did not find an improvement in learning outcomes, but found that learners may be more motivated to engage or initiate in a learning episode on a mobile device.

It may seem reasonable to propose that people learn a multimedia lesson better when it is delivered on a touch screen tablet due to the inherent portability, than when it is delivered on an immobile desktop computer with traditional input. This seemingly sensible declaration is based on the idea that mobile learning on a portable tablet device is more fun, and therefore students will try harder to learn than when they learn in a lab environment on traditional computers. Testing this assertion entails a media comparison study in which learning with one medium is compared to learning the same content with another medium (Sung & Mayer, 2013).

Problem Statement

The problem is that with increased ease, access, and opportunity to put instructional content online there is little understanding of the instructional design practices that should be employed for efficient knowledge construction. Teaching does not always equal learning. Further, as Sung and Mayer (2012) highlight, liking does not always equal learning either. In today's instructional design empowered by today's education technology reality, it is relatively easy for a teacher to put content on a website or any number of free or paid Learning Management Systems. However, as teachers are charged with owning the accountability of increasing achievement and growth measures, it is becoming even more important to emphasize good, research-proven learning practices when designing student experiences, which is entirely different than simply showing information on a screen or displaying a video. Learners may enjoy that, but it may not transfer into true knowledge construction or meaning making (Morrison & Anglin, 2005).

Today's technology tools can help remove the access barriers of the past. Access barriers have often been written about (Van Deursen & Van Dijk, 2014) and are most widely thought about in terms of access to content, information, and high-quality instructional guides. Synchronous digital technologies can now help unlock opportunities for learners to no longer have to physically be located inside the same four walls as their instructor. Asynchronous digital technologies can assist learners in many ways in order to leverage their instructors' thoughts and ideas at the time the learner needs it, with an "on-demand" technique. This learning can be for novel information or review.

It is generally assumed that using technology will enhance learning efficacy by improving both the efficiency and effectiveness of the learning experience (Morrison & Anglin, 2005). With the continuous advancement in education technologies (or technologies that are designed and used to enhance teaching and learning) it is incumbent upon researchers and practitioners to not only use new technologies, removing legacy barriers, but to use the tools with an effective design. This current study is aimed at providing insight into using online digital and distance education platforms effectively, when considering students who have full control over the content selection and sequence while interacting with the screen, as well as the content behind the screen, in relatively new or different ways. Previous research has identified that a full grasp of effects of learners having full or partial control of the digital learning experience while interacting with a haptic (touch) enabled input mechanism is lacking and inconsistent at best. At the time that this research was formulated, this gap in the literature was still unfilled. This research posits that to appropriately design today's digital learning experiences, an instructor must first take into consideration the types and levels of interactivity and marry that with available technologies, such as touch screen input devices. It is critical to discover if there is a difference in the planned interactivity, through a learner control lens, and the personalized and custom execution from the learner.

Purpose of the Study

The primary purpose of this study is to further uncover instructional design heuristics with the intent to produce better performance results in learners. Understanding the possible performance differentiation resulting from a learner when having absolute control during knowledge construction and performance activities in an online distance education experience proves to have design implications when learners interact with the content through modern haptic input devices. Secondarily, this study seeks to identify if there are different levels of content interactivity and advisory control based on the medium or method by which a learner receives and acts on information. Given the lack of comprehensive research on the learner-controlled method-not-media hypothesis, this experiment will specifically determine if there is a difference in interaction sequence with content from different input (touch input and non-touch input) methods.

Research Questions

This research intends to answer the following questions:

- Is there a difference in learner-controlled sequence interactivity in an online open distance education course based on the input methods being used to access the course?
- Do learner choice on sequence (a learner control element) and input type have a significant effect on score range, which is used as an indicator of performance?
- Do learner choice on sequence (a learner control element) and input type have a significant effect on the number of assessment attempts, which is used as an indicator of performance?

Need for Research

Haptic interactivity lacks a focus on human-centered learning. Further, consistent evidence on the positive or negative results of learner control and touch-base (haptic) interactivity is missing altogether. Minogue and Jones (2006) conclude that there is very little empirical research that systematically investigates the value of adding haptic elements to the complex process of teaching and learning. In other words, current technology makes the addition of touch to computer-generated digital environments possible, but the educational implications of this innovation are still largely unknown or inconsistent (Proulx, Brown, Pasqualotto, & Meijer, 2014; Roshan, 2013; Shimomura, Hvannberg, & Hafsteinsson, 2010; Wolff & Shepard, 2013; Zack, Gerhardstein, Meltzoff, & Barr, 2013).

Based on the literature review, there are very few studies on haptic touch screen input interactivity and the resulting relationship to the learner control principle of the cognitive theory for multimedia learning. This is mostly due to the short period of time and availability of the technology that make this type of input interactivity possible. However, there are four primary research articles, yielded through the literature review, where learning was studied during touch screen haptic input as an interactivity construct. Three of the four are from the education, psychology, or neuroscience fields of study. Of the four studies, only one highlights a positive effect (Sung & Mayer, 2013), two find negative effects (Krcmar & Cingel, 2014; Zack et al., 2013), and one finds no significant difference (Wang et al., 2010) in the effects with haptic touch screen input interactivity.

There is also a lack of experimental learner-centric research on haptic touch screen interactive input methods used while learning. Not only is there disagreement on the effects of the learner control principle of the cognitive theory for multimedia learning, there is also dispute in the literature on the connectedness of the principle to distance education courses. Further, there is uncertainty on whether or not the theory can transfer from multimedia to fully immersive interactive hypermedia environments. Practitioners and researchers alike have generally accepted that giving a learner more control in a digital or online environment would help motivation and engagement (Gerjets et al., 2009; Scheiter & Gerjets, 2007). However, today the empirical evidence does not conclusively project that assumption to the reduction of extraneous cognitive load or improved learning.

Couched in a broader field of study, distance education is lacking research consistency from a learning perspective. Not only are there research inconsistencies in how efficient students are in constructing new knowledge while engaged in distance education strategies or deliveries, but also in the methods and mediums being used. The journal analysis clearly underscores the lack of research on extended elements of interactivity. Further, the literature review highlights a trend that shows that most primary research in distance education, when viewed from an interactivity lens, is based on the dialoguing, where additional elements such as controlling, manipulating, searching, and navigating are not as well researched as dialoging interactivity. Additionally, as the overwhelming majority of research in this field is with graduate and undergraduate participants, there is a lack of studies conducted with primary or secondary students. This is of great importance due the unlimited and growing opportunities students in primary through secondary grade levels to interact with digital on-screen or through-screen content.

This research is necessary in order to gain a deeper understanding of the implications of touch-based interactive input methods and if they play a significant role in the levels of planned interactivity through an elevated learner control design.

Summary

Primary research literature has concentrated on disproving the general belief that giving learners control of their experience is better for increased instructional effectiveness. Inconsistencies in this research (Artino & Stephens, 2009; Gerjets et al., 2009; Kalyuga, 2012; Karich et al., 2014; Kelly, 2008; Lunts, 2002; Mager, 1964; Merrill, 1980; Reeves, 1993; Scheiter & Gerjets, 2007; Scheiter & Mayer, 2014; Vandewaetere & Clarebout, 2013) tend to circle back to self-regulation skills, motivation, as well as the age and ability or experience level of the student (Morrison & Anglin, 2005). However, there is a lack of research that addresses the impact of full or partial control of information through different types of input interactivity. Perhaps a lack of a planned interactivity framework and method by which to capture the input type (traditional or touch screen) is culpable for the lack of a consolidated approach. In isolated fields of study, there are signs indicating that more research is needed to understand more about specific tenants of interactivity and student learning.

Successfully utilizing learner-controlled instructional design requires the understanding of how students interact. However, there is a lack of research addressing the combination of the learner control principle of cognitive load theory and haptic input interactivity. Illustrated in this research study is one method to engage with instructional designers and students to further understand the implications of full or partial interactivity on different devices to improve information acquisition, with the ultimate goal of constructing new knowledge.

CHAPTER 2

LITERATURE REVIEW

Introduction and Scope

Students are accessing digital content for new learning experiences at accelerating rates. Content, devices, interactivity, and application of learning from one side of a digital screen to another parades an abundance of research implications for distance education. However, with endless opportunities to integrate how digital resources are presented to students, combined with the devices used, conclusive research on how it affects student learning is inconsistent and lacking. In other words, there is no evidence-based blueprint. Current research has narrowed the margin and identified specific cases of positive and negative effects, as well as cases with no significant difference. Of the studies that highlight positive cognitive load effects of implementing learner control practices, few cross over and deal with touch-based interactivity. Using learner control principles as a framework, this chapter will emphasize key points in the arguments for and against haptic interactivity, as well as share findings in historical distance education research. Arguments favoring program- or system-controlled content are also implied. This literature review attempts to bridge the gap in the current research, showing students who receive instructional digital content through distance education experiences with high degrees of learner control interactivity, while also showing research where students have the opportunity to interact with the content through digital touch.

To further appreciate the field of knowledge in which this study is positioned, this chapter will first provide a foundation for distance education and online learning research. Next, this chapter will include a broad overview of content interactivity and touch-enabled devices in the learning space, the connection with media technology and education, and why this matters in the successes and failures of distance education.

Next, a research journal analysis is provided to assist in uncovering a historical perspective from a highly regarded distance education journal. In this journal review, the technological advancements in distance education are highlighted as a delivery strategy that has proven to be less like climbing a ladder, and more like swimming laps in a pool. The search methodology, a definition of digital online and distance education, touch-based interactivity, and learner-controlled cognitive load issues are included. Also incorporated in the discussion are types of interactivity, a review of the experimental research studies published, a summary of the results of this research, and implications for future studies of similar focus.

Finally, a review of reviews on haptic research is followed by a primary literature review on current research as it relates to haptic or touch-based technologies in all fields of study, but focusing on education. The primary literature review on haptic input includes search methodology, a dichotomous chronological separation of the research themes, and a specific focus on touch screen input technologies as it relates to positive, negative, and no significant differences of effects on learning.

Distance Learning in Education History

It is not too far of a stretch to imagine the spreading of the gospel by the Apostle Paul as one of the first intentional and well-documented approaches of distance education. However, the turn of the 19th century, brought about by the needs and desires of people learning new skills or trades that accompanied the industrial revolution, established correspondence studies that became the *de facto* global launch pad for the future of distance education. The design of the correspondence study leveraged the use of low-cost, print-based course materials, and the postal service (mainly one-way and non-interactive). Isaac Pitman offered the first documented correspondence course in 1840, in England, with the focus of the course in teaching shorthand (Sumner, 2000; Verduin & Clark, 1991).

Three Distance Education Generations Characterized

The development of the correspondence study design, as Hamilton (1990) submits, hinges on the emergence of adult literacy, the printing press, the publishing industry, and the need for mass-produced factory models of the education system. Two World Wars, the rise of the industry, and the Great Depression were also entangled in the success of correspondence studies for well over a century of teaching and learning at a distance from 1840 to the 1950s. Countries such as the Unites States, Canada, England, and the Soviet Union all experienced increased opportunities and became distance education leaders through correspondence courses either targeted at a growing desire for education, aimed at soldiers returning from war who needed a productive place in society, combining new studies with productive adult work, or for general citizenship education for first generation immigrants to post-war countries. It is important to understand this rich history in order to understand the value as well as challenges in this research field.

Advancements in new technologies helped spur a transition or additional waves of distance education—one that shattered the general notions, implications, and resulting terminology of “correspondence education.” In fact, the second wave was so broad that the term *distance education* became the terminology of choice by authors and researchers. Many researchers (Bates, 1990; Nipper, 1989; Sumner, 2000) have now widely accepted three main generations or phases in the history of distance education. The role that technology and media play in these transitions is the focus of this researcher's critical examination and resulting detailed study.

The first generation of distance education. Within this term of reference, Nipper (1989) divides distance education into three generations: (1) correspondence study (previously highlighted); (2) multimedia distance education; and (3) computer-mediated distance education. Each generation stands on its own merits. However, there is tremendous crossover in the adoption of the generational characteristics. In other words, the characteristics of the teaching and learning experiences help identify the distance education generation, but no hard line is drawn in which one generation stops and the next begins; they can exist alongside one another for mutual support. Nipper (1989) further historically links the three generations of distance education to the development of production, distribution, and communication or media technologies.

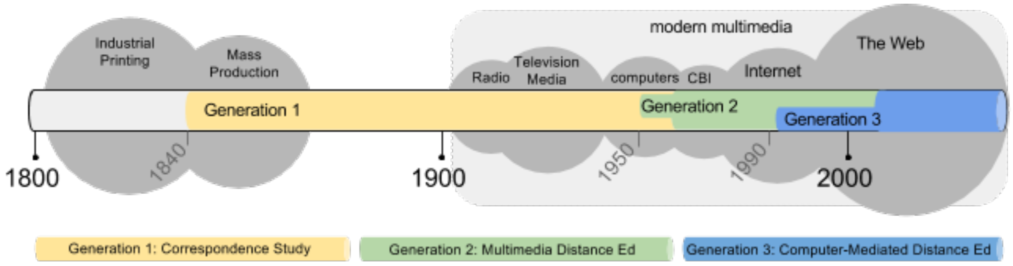

Figure 2.1: Impact of technologies on the three generations of distance education

The second generation of distance education. The second generation of distance education is commonly referred to as *multimedia distance education*. This generation was enhanced by new media technologies in print, broadcast media (such as radio and television), recordable audio, and computers. Unfortunately, this generation carried forward the goals of the previous distance education generation in that the focus was a distribution of information or a distribution of teaching and learning materials to the learner. This design, while enhanced with new technological breakthroughs, resulted in minimal potential by concentrating on one-way communication, expert knowledge, mass marketing, and student independent learning (Sumner, 2000). The multimedia distance education generation is particularly important due to research questions and theory development on the use of multimedia in learning, its cognitive dependencies, as well as the techno-centric approaches of the masses that allowed the technologies to lead the practices as opposed to the proven learning strategies. It is during this generation of distance learning that sparked the monumental research on cognitive theories of multimedia learning (CMTL) and cognitive load theory (CLT), as well as numerous researchers (Chandler & Sweller, 1991, 1996; Friesen, 2009; Kalyuga, 2012; Mayer, 2005) making the connection between media, technology, and learning (as well as extensions into distance learning). Simply put, there was a rush to use the latest and greatest technologies in the implementation of the distance learning well before research proved that it was actually good practice.

Parallel to the tail end of the multimedia distance education generation was the evolution and adoption of computer technology. Computer Based Instruction (CBI), also referred to as Computer Assisted Instruction (CAI), was among the first implementations of computers in education and gained validity in traditional classrooms and places of learning. Researchers (Kearsley, 2000) highlight the overall philosophy focused on electronic curriculum materials—programs that students could interact with to learn specific content. The main idea was that computers could assist in providing individualized learning experiences, including interactive content sequences consisting of problems or questions with appropriate feedback. This idea was not without critics, but there was sufficient empirical evidence to show that it worked in terms of student achievement scores and learning outcomes (Kearsley, 2000). CBI's role in drill and practice, simulations, tutorials, instructional games, and problem solving exercises is generally accepted when used appropriately. CBI applications are also generally used as supplementary, extension, enrichment, or remediation tools, and built on strong learning principles of behavioral and cognitive learning theory through programmed instruction and teaching machines (Baggaley, 2008; Mager, 1964; Pythagoras, Lin, Sampson, & Kinshuk, 2006; Reeves, 1993).

The third and current generation of distance education. A decade prior to the turn of the 21st century, CBI practices and the invention of the Internet collided to birth the third generation of distance education—known as *computer-mediated distance education*. Sumner (2000) characterizes this third generation by the potential of the personalization that new computer-mediated technologies offered. While this third generation is still in its infancy, it offers the opportunity for teachers and learners to build on the information overload brought on by the former distance education generations. The prospect for social interactivity, and public and private space computer conferencing, distributed fostering of critical skills needed for analyzing introduced or presented information. Of course, computer-mediated distance education, without the lifeblood of networks and connectedness, reverts back to more traditional multimedia-based approaches to distance education. One researcher, Joseph Pelton, submits (Bates, 1990) that this third generation of distance education, which he terms *tele-education* rather than *computer-mediated distance education*, will provide the opportunity for global networking, increased interactivity, and more control for learners, in a highly cost-effective manner. Even though his message takes a techno-centric slant, he believes that once embraced, the third generation of distance education will be the way forward for education in the future. Providing more control for learners, in this generation, based on the accessible technology versus the learning theory is an integral ingredient of the central question in this research. Interactivity, while not necessarily the kind of interaction originally conceived of in CAI/CBI, therefore, becomes very important. In this generation of distance education, research also becomes disjointed due to disagreements on what to call these strategies. Over the past two decades, researchers have jostled between terms such as *distance education*, *online education*, *online learning*, *virtual learning*, *eLearning*, *open education*, *flexible education*, and more. These terms, while descriptive in nature, force the research into a great fragmentation. Virtual learning and eLearning vocabulary, for example, are technologically advanced distribution methods, nor do they depart from, the traditional premise of distance education. They are "clicks and mortar" versus the traditional or conventional "bricks and mortar," where digital environments are established to create opportunities for distance learning to occur. eLearning is defined primarily as electronically delivered learning (Scarafiotti, 2004). They are often closely linked as synonyms for distance education. The only difference presented is that they are solely student- or learner-centered, by terminology, not necessarily by practice. The instructional design or effective teaching practice aspect may be void and leaning on the assumption that it is involved. In some cases, this could lead to unsuccessful experiences if high quality instruction is ignored.

Vital Role of the Web in Education

Again, to get a full spectrum of the research path, it is helpful to understand the role of the innovations in technologies. The Internet, created in the 1970s through collaboration between the United States government and researchers and scientists in higher education, connected computers together for the first time. The World Wide Web (the web), as we know it today, was created in 1991 by Tim Berners-Lee, who worked at a nonprofit scientific research agency in Switzerland (Draves, 2000). While the Internet linked all computers together, it neither implemented a standardized and common language recognized by all computers, nor a uniform method to distribute or locate information. Berners-Lee invented the Uniform Resource Locator (URL), or the address system we use today, which begins *http://*, often followed by *www*. Today it is commonly referred to as the website address. He created HTML, or hypertext markup language, so that files could be put into a common language where all computers could read the information, and he invented the hyperlinking system, where content can be "clicked" on and the learner can jump to another file on another computer. Through Berners-Lee's research, he essentially made the Internet usable for the masses. Shortly thereafter, an undergraduate student at the University of Illinois in Champaign-Urbana invented the first web browser, which is software designed to allow users to search and display information by interacting with websites. Thus, the creation of the Internet and the World Wide Web was largely the result of work of those in the nonprofit and education sector (Draves, 2000). At its core, the DNA and creation of the Internet and the web has less to do with commercial or business and more to do with information and knowledge that is intended to impact the general public and the majority of citizens. It is this very invention that has carried interactivity and the freedom of learner or content control into everyday life and everyday learning. But it wasn't until the web appeared in the early 1990s that this all became clear. The web also brings together all major forms of interpersonal digital interaction, such as email, chats, threaded discussions, and conferencing. Additionally, it adds previous value propositions such as multimedia (graphics, sound video) to the equation. Further, the web easily supports "classic" forms of CAI/CBI, such as drills or tutorials, again highlighting the coexistence of distance education generations.

Theoretical Issues with Haptic Interactivity, Distance Education, and Learner Control

The theoretical definitions and issues that impact the topic of haptic interactivity on learning are: the implications of cognitive load theory for multimedia learning, principles of learner control interactivity in general, and touch input in general.

Haptic interfaces. Haptics deal with touching and feeling, whether in real life or in our digital (virtual) environment. Haptic interfaces comprise hardware and software components aiming at proving computer-controlled, programmable sensations of mechanical nature, pertaining to the sense of touch (Hayward & MacLean, 2007). Theoretical views on haptic learning surfaced in the 1960s. In today's digital environment, haptic interactivity can continue to play a major role.

Cognitive load. The cognitive load theory is based on the idea that we have limited capacity for learning. Generally, the theory represents that we have three types of memory: (1) sensory memory; (2) working memory; and (3) long term memory. Our working memory is limited in some capacities, while the goal is to move learning to long-term memory as efficiently as possible. Several types of cognitive load present impact to our working memory, including extraneous, intrinsic, and germane load. Extraneous cognitive load is caused by inappropriate design that ignores the working memory limits (Mayer, 2005). Intrinsic cognitive load is determined by element interactivity and is due to the natural complexity of the information that must be processed internally. Germane cognitive load is caused by learning and moving information from working memory into long-term memory, and is exactly the type of cognitive load to be striving for (dubbed *the good cognitive load*), thus resulting in schema construction and automation (Mayer, 2005). The theory also appeals to learning through different channels, such as the auditory channel, the verbal channel, the visual channel, and the pictorial channel. The theoretical question is whether the introduction of haptic interactivity has any cognitive load impact on the other channels through the cognitive theory for multimedia learning. Haptic interactivity as a construct is a very interesting topic because it potentially could have an effect on all three cognitive load categories.

Interactivity. Moreno and Mayer (2007) define *interactivity* as a characteristic of learning environments that enable multidirectional communication, which is two-way or bidirectional. To further clarify the definition, Moreno and Mayer (2007) identify five types of interactivity: (1) dialoguing; (2) controlling; (3) manipulating; (4) searching; and (5) navigating. *Dialoguing* includes a learner’s ability to receive feedback to his or her input, as well as ask and answer questions. *Controlling* refers to the learner’s ability to control the pace or order of the presentation. *Manipulating* consists of the learner’s ability to zoom or manipulate objects on the screen. Digitally manipulating through touch, for example, could include “pinching in” or “pinching out” to increase or respectively decrease the size of the media or text on a screen. *Searching* includes the learner’s ability to find new information through a query or by selecting options. *Navigating* refers to the learner's ability to move to different content areas by selecting various available information sources. All five types of interactivity influence learner control in a distance education experience.

Researching interactivity, Hirumi (2002) proposes a framework that consists of three basic, interrelated levels of interaction. Similarly to Moore's (1989) definition, the first level consists of learner-self interactions. These interactions are the basis for the other two and include both cognitive operations and metacognitive processes.

Hirumi's second level of interactivity is learner-human and non-human interactions. This level, including elements comparable to Moreno and Mayer, is subsequently broken down into six specific interactions. The first three fall under learner-human interactions and include learner-instructor, learner-learner and learner-other interactions. The remaining three fall under learner-nonhuman interactions and are learner-content, learner-interface and learner-environment interactions.

Learner-instructor interactions can be initiated by either party and may occur before, during or after instruction. Learner-learner interactions take place between two learners either within a group setting or outside of the group without the instructor. Learner-other human interactions include exchanges with mentors, teaching assistants, or experts and can occur online or face to face. Learner-content interactions happen when the learner accesses the subject matter through media, graphics, or text. Learner-interface interaction refers to how the interface allows learners to access information, use electronic tools, and complete tasks. Learner-environment includes how the learner relates to the equipment, tools or other physical objects needed for distance learning.

Hirumi's third level is learner-instruction interactions. This level involves the intentional arrangement of tasks and events that guide the design and sequencing of level two interactions.

Learner control. Four main components of learner control are found in the literature. The four researched components of learner control are: (1) pace; (2) sequencing; (3) content; and (4) presentation. The first two components deal with a learner having the ability to control issues of timing, while the second two are forms of representation control. There is general consistency and agreement in the research on these four main components of learner control, with only slight difference.

While again citing the ambiguous results of the research on instructional effectiveness of learner control, Kalyuga (2012) proposes content control, sequencing of information, and the control of representational formats as the key ingredients of interlinked interactive web-based multimedia environments. From a cognitive load perspective, learner-controlled interactive environments may potentially impose high levels of extraneous cognitive load.

Lunts (2002) recognizes five components or variables of learner control: (1) content; (2) sequence; (3) pacing; (4) internal processing; and (5) advisory. The author highlights three of the five components as major components. The major components are content, sequence and advisory control. Lunts (2002) avoids explanation on the defining tenants that label these three as *major*, but does elude to content control, sequence control, and advisory control having a relation with optimistic findings in research (as cited in Lunts, 2002), and possibly the components that have been researched the most.

Closely related to the research on the effects of learner control is the paradigm between how much control the learner has versus program control, also known as *system control*, which employs adaptive presentation strategies (i.e., adaptive release of learning content). When leveraging technology tools and multimedia for increased learning experience, a spectrum is cultivated between the technology and the learner. At one end of the spectrum, the learner has complete control of the content and the type of interactivity with the tool or system. With the immense and ever-expanding resources in today's digital landscape (e.g., online and mobile apps), this end of the spectrum is understood in research surrounding hypermedia and learner interactivity. On the opposite end of the spectrum is a type of interactivity where the system or program owns the majority of the control. This, of course, is historically couched in the formal and well-researched programmed instruction designs of Skinner's Teaching Machines of the 1950s (Skinner, 1958). Adaptive approaches to learner interactivity with digital content are gaining generous support (Artino & Stephens, 2009; Sonwalker, 2008), due to the promise of strategically releasing just the right amount of personalized content at the perfect time. Thus, pushing learners at an individualized or custom pace based on acquisition and application of the learned content. Adaptive release designs can help remediate a student in one scenario, while helping aggressively move another student ahead in a different scenario.

While adaptive presentation strategy research is not a direct focus in the forthcoming literature review, it is worth noting that much can be learned when comparing effectiveness of the two opposite boundaries of the paradigm. While researching adaptive presentation strategies, Kelly (2008) found differences in the performance between students who have complete learner control over the learning environment and students who use an adaptive system that matches and mismatches resources with preferences. The author found that adaptive presentation strategies resulted in higher post-test and relative gain scores, though the differences were not significantly different. This research suggests that learners with certain learning characteristics types might have the most to benefit from adaptive presentation strategies. Also investigated was the activity level of the learners while in the opposing learning environments. Some students in the study only chose to use the first presented resource during the learning activity. These students were identified as having a medium activity level (the low activity level group looked at less than one resource per learning activity). Students with medium activity levels gained the most benefit by being adaptively presented with both the least and most preferred presentation strategies. Suggesting that when students are not self-motivated to explore additional learning content on their own via a learner-controlled environment, adaptive systems (more so than learner-controlled systems) can increase the effectiveness of performance with larger increases in learning gain (Kelly, 2008). Not discussed was the linkage between activity levels with engagement, self-regulation, and motivation. However, Kelly (2008) cites the importance of this linkage in future research.

A more beneficial approach for learners may be a balance between adaptive release and full learner-controlled digital learning platforms. Adaptive levels of interactivity, where the program or system responds differently based on the interactions of individual learners, could be effectively used for balancing instructional guidance. Adapting instructional procedures to levels of learner prior knowledge could provide an optimal level of instructional guidance (Kalyuga, 2012). Jackson, Krajcik, and Soloway (as cited in Najjar, 2008) expose an approach attempting to design adaptable learning environments, which offer learners guidance and helping them make decisions for themselves. However, evidence from other research into learners' use of self-selected tools in digital learning platforms indicate that less able and less knowledgeable learners are ineffective at selecting appropriate tasks and seeking appropriate quantities of support and guidance (Najjar, 2008). This further suggests that a more appropriate design may be to lean heavier on adaptive approaches with an unequal balance of learner control in the design. The adaptation level of interactivity may be best selected from a fixed pool of options and presented to the learning based on actions or behaviors. Kalyuga (2012) further highlights a perspective on adaptive interactive environments that could, in concept, also be either system-controlled (automatic adaptation) or learner-controlled (for example, advisory systems that suggest possible options for learners to select from).

Theories on cognitive load, interactivity, and learning specifically through touch interactivity are all directly relevant in this topical exploration. Therefore, the following section is dedicated to uncovering research trends in the field of distance education.

Research Trends in a Journal Analysis of the Distance Education Journal

Attempting to gain a perspective on the type and extent of research being conducted during the heart of latest transition in distance education generational characteristics (from the second generation to the third generation) a journal analysis was conducted using a prominent peer reviewed research journal, which further highlighted that design heuristics of interactivity, haptics, and input methods have not been a studied much in the vastly studied field of distance education.

There are a number of ways to capture research trends in a field of study. When analyzing keyword searches across many journals in a database, the results sometimes prove to stretch into theoretical, conceptual, and hypothetical argumentative submissions. One way to draw conclusions of research trends is to analyze a single, highly-regarded, peer-reviewed journal that mainly focuses on experimental submissions. *Distance Education* is a peer-reviewed international journal that aims to provide heightened research awareness in the academic, policy, and business communities. It publishes research and scholarly material in the fields of distance, open, and flexible education and has done so since the launch of its inaugural volume and issue in 1980. According to the publishers, the journal was one of the first journals published to focus exclusively on the area of distance-based educational practice and today it remains a primary source of original, primary, and scholarly work in the field for practitioners, teachers, and students. *Distance Education* is the official journal of the Open and Distance Learning Association of Australia, Inc. (ODLAA) and is published by the Routledge, Taylor, and Francis Group. All papers submitted for journal publication are reviewed by members of the Editorial Board with expertise in the areas(s) represented by a paper, and/or invited reviewers with special competence in the area(s) covered (ODLAA, 2015). *Distance Education* is published three times per year and examines topics in a variety of areas, such as change readiness for distance education staff, medical training through distance education, self-regulated distance language learning, new distance education technologies for interactions and collaboration, online discussions, distance education learning designs, self-paced adult learning in distance education, and developing and testing a model to understand peer interactions and learning outcomes in computer-mediated conferencing, to name a few.

This journal analysis helped solidify the foundation of the current and subsequent chapters of this paper by highlighting what is being studied and what is not being studied in distance education. The strategy employed is one attempt to construct a foundation for future research in this field of study.

Distance Education Journal Analysis Search Methodology

The analysis was implemented by performing an EBSCO electronic journal search. The journal titled *Distance Education* was used to analyze six years of work on distance learning spanning from the second generation to the third generation of distance education, chronologically from 2004 through 2009. Three volumes, spanning over six years, were reviewed to identify key terms (see Appendix A). Six constructs were identified for analysis: (1) type of article; (2) interactivity; (3) learner characteristics; (4) time and space; (5) delivery method; and (6) geographical. When reviewing common keywords, sub-constructs became apparent among the articles reviewed. Identified keywords were studied. In order to code each article per construct, individual journal articles in all issues and volumes, for the established period of time, where analyzed. Identifications were made per construct and appropriate codes per category were assigned.

Distance Education Journal Analysis

A total of 157 articles in 17 issues and six volumes were analyzed in the journal, as shown in Table 2.1. Of the resulting articles, 65 (41%) of them were identified as primary research studies. Of the yielded articles, 47 (30%) of the articles were *Talk-Talk* articles, where the author has important thoughts and information but does not really provide conceptual, theoretical, or primary research. The remaining two categories or types of peer-reviewed articles yielded in the journal were theoretical and conceptual. Of these articles, 27 (17%) were categorized as theoretical articles and 15 (12%) conceptual articles, respectively, from the publication years of 2004 through 2009. Based on the volume of published articles of the six-year span of time, in general the depth and breadth of interest in distance education topics longitudinally experienced a significant growth trend. This era or span of time was selected due to aforementioned research interests on interactivity, and the tools or devices being used by learners in formal distance education. Additionally, this era captures published research spanning two theorized generations of formal distance education, which is of multimedia distance education, as well as computer-mediated distance education.

Table 2.1

Volumes and Issues in *Distance Education* (2004-2009) Used in the Literature Review

Volume Number	Issue Number	Number of Articles
25	1	9
	2	8
26	1	10
	2	8
	3	10
27	1	9
	2	10
	3	8

Table 2.1, continued

28	1	9
	2	10
	3	9
29	1	9
	2	8
	3	8
30	1	13
	2	8
	3	11

After reviewing the yielded articles, it could be concluded that there was a division of major research areas of distance education. Specifically, the different types of interactivity that can be involved when teaching and learning from a distance prevailed. The major types of interactivity were broken down and articles were coded as such (see Table 2.2).

Table 2.2

Number of All Articles by Coded Type of Interactivity and by Article Publication Year

	2004-2005	2006-2007	2008-2009	Total
Interactivity				
Dialoguing	17	28	37	82
Controlling	3	9	10	22
Navigating	3	9	17	29
Manipulating	1	8	8	17
Searching	0	7	6	13
Total	24	54	78	163

There has been a dramatic but consistent longitudinal increase in the research from 2004 to 2009 conducted on dialogue interactivity. This is due to the increase of availability and ease of use of technologies such as Learning Management Systems (LMSs) to help facilitate distance education classes and this suggests the shift into the third generation of distance education, which has a deeper focus on communication, collaboration, and two-way interactivity. This also may lead to increased interests in participatory learning and traditional classroom activities.

Research that is focused on sub-construct 260, interactivity through manipulation, considerably increased from 2008-2009. This could be due to the multitude of available resources on the web. A decrease in studies regarding sub-construct 210, student-to-student dialogue, may indicate a transition from distance education as a linear approach of instruction to multifaceted approaches where teachers and students facilitate learning together.

An analysis of the 65 experimental studies reviewed reveals that the overwhelming majority of allocated research efforts were spent on dialogue interactions between learners and instructors. However, slightly different than when inspecting all types of journal articles, the experimental studies on control interactivity nudged out navigation interactivity as a research focus by nine experiments. That stated, control interactivity only appeared in 16 research experiments in all 157 peer review journal articles spanning over six years. When considering all types of journal articles, navigation interactivity was the second most attractive topic. However, that did not transfer over to published primary research. This raises a question on the interest of the topic versus the complexity of the research. As highlighted in Table 2.3, it is important to note that 28 of the 65 studies involved more than one coded interactivity type, which accounts for a greater number of coded types of interactivity than the total number of experimental studies. In other words, there is not a one-to-one match of coded interactivity types and coded studies.

Table 2.3

Number of Primary Research Articles by Coded Type of Interactivity and by Article Publication Year

	2004-2005	2006-2007	2008-2009	Total
Interactivity				
Dialoguing	16	24	20	60
Controlling	1	7	8	16
Navigating	0	3	4	7
Manipulating	0	2	2	4
Searching	0	4	1	5
N/A	3	0	1	4
Total	20	40	36	96

Also materializing from the journal analysis were the different learner profiles or demographics, as the subjects of published primary research (see Table 2.4). Increased value can be gained in understanding the types of learners participating in the published experimental research.

Table 2.4

Number of Articles by Subject Demographic by Publication Year

	2005-2005	2006-2007	2008-2009	Total
Learner Characteristic				
Home school & tutor	0	1	0	1
Primary	0	3	3	6
Secondary	0	2	7	9
Undergraduate	10	10	19	39
Graduate	13	8	13	34
Business/Private Sector	3	10	11	24
Total	26	34	53	113

While 44 journal submissions do not deal directly with people as research subjects, sub-construct 340-360 (Appendix A), the undergraduate and graduate subject demographic has consistently been studied more frequently than other sub-constructs. This may be due primarily to the availability of subjects for research at a university compared to a primary or secondary level. However, it is likely to also be a result of traditional distance education practices being geared specifically towards higher age and ability levels of learners, such as undergraduate, graduate, adult education, and professional training. As distance learning strategies in the second and third generations of distance education move into a wider spectrum of learner age and ability levels, it is increasingly important to further understand the impact distance education has as a whole on education. More studies should be conducted at the secondary and elementary level. Interesting to note is the increase of sub-construct 360, business and private sector, in this longitudinal analysis. More businesses and industries are using the online environment as a way of continuing education for their employees and researchers are responding to ensure that this method is effective and profitable.

The distribution of article categories is similar across the years 2006-2007. An experimental article published in early 2006 depicts a case study of home-schooled children receiving instruction via radio. The theoretical focus changed from a traditional information or content presentation approach to distance education, towards constructing knowledge through multiple interactions between students, the instructor(s), and the learning environment during the latter half of 2006. In 2007, the theoretical underpinnings became saturated with more suggestions of distance education as online communities of practice that use a variety of strategies and technologies to communicate multiple ways of knowing. For example, a series of studies in early 2007 focus on communication structures of online discussion boards, the strategies associated with effective discourse, and the multivariate uses of computer-mediated communication.

The shift is validated further with analysis of the experimental articles. An important component of a community of practice is the collaborative model for instruction. A majority of the articles within the specified timeframe review and support the use of collaborative and problem-based learning. Discourse analysis, conversation analysis, and other phenomenological methods were used as evaluation tools. This shift is indicative of greater learner control in the distance education experience.

In review of articles from 2008 to 2009, social networking and instructional design concerns seem to be the main points. As distance education practice fully transitioned into a digital experience, the physical environment was a surprising research variable that garnered some interest during this factor in how it impacts learning. For example, in Antarctica, students have to deal with temperatures that are -40 degrees Fahrenheit, so simple motor skills like typing become difficult and the outcome that harsh weather conditions can play havoc on equipment and electricity. The developers of online education, as well as researchers, must take all extraneous factors into considerations. The analysis of this final two-year time span, during the reviewed period of time, strongly suggest on the surface that interactivity dialogue, via social networking, could help to implement Merrill (1980) distance education principles of effectiveness, efficiency, and engagement. This discovery also aligns with Nipper's (1989) previous assertions of a characteristic shift and extended value proposition for how distance education will be most transformational in the future. Online learning will seemingly make leaps in development and delivery methods as the technology becomes faster, smarter, and capable of complex tasks. This plays a heavy load on the instructional designers for future expectations of online distance education courses.

The Need for a Micro Study in the Distance Education Field Emerges

While computer-mediated distance learning, the web, and new technologies have provided the foundation for strategies such a blended learning models and Massively Open Online Courses (MOOCs) they have also re-energized the research community. Many strategies add to the macro study of distance education and rely heavily on a learner having digital access to structured web-based content with the ability to interact with the content, as well as with instructors and other learners. Another similarity is that blended learning models and MOOCs have both the hype and criticism in the 21st century.

However, the *Distance Education* journal analysis clearly underscores the lack of research on extended elements of interactivity. In other words, while dialoguing as a type of interactivity was heavily researched, controlling, navigating, manipulating, and searching elements of interactivity were not well studied. Therefore, the remainder of this research will focus on a micro study of two common interactivity issues that are found in distance education design. The remainder of this research will focus on questions surrounding how learners interact with structured content while learning through distance and digital means. While interactivity is at the core, the issues will be broken down into opposing sides of the screen—in other words, physical interactivity with content through devices, as well as the cognitive processes that are involved in the types of control a learner has while interacting with the presented content. The ability for learners to select, control, navigate, and manipulate content on screen, as well as understand their effects, is critical for effective learning. It is also equally vital for instructors to understand the cognitive load implications during distance learning experiences, especially if the experience is deeply rooted in the characteristics prevalent in the second and third generations of distance education.

Haptic Interactivity Research

It is generally assumed that learning works best when information is absorbed from different sources and that a multisensory reinforcement learning process is probably advantageous. It is possible that we now understand the sense of touch to be very powerful and underused, in terms of today's interactivity. As early as 1960, University of Virginia Psychology Professor Frank Geldard found that cutaneous sensations, especially unusual vibrational patterns, would be highly attention-demanding and therefore provide a good source of sensory input to the body (Geldard, 1960). Most of us learn the importance of touch at an early age, even before many other language forms. Haptics have been explored for the past 50 years. However, as we continue to advance in interactive environments and with new interfaces, there have been many new experimental studies conducted within the past ten years. *Haptics*, a term which was derived from the Greek, meaning "able to touch," introduces the sense of touch and force in human-computer interaction (HCI). There are many related terms with haptics, such as *tactile*, *touch*, and *vibrotactile feedback*. Haptics enable the human operator to manipulate the environment, through touch, in a natural and effective way, enhance the sensation of "presence," and provide information such as stiffness and texture of objects, which cannot be described completely with visual or audio feedback only (Liu, Shen, Georganas, & Roth, 2005).

The purpose of this literature review is to examine the experimental research based on the types of haptic tools, possible implications, and the issues around learner results associated with interactive interfaces compounded through distance education environments. With the increased use and exploration of haptic interactivity, issues of cognitive load as it relates to the cognitive theory of multimedia learning and learner control must be considered. This review will discuss a summary of previous literature reviews conducted on the topic followed by theories and conceptual approaches to haptics and the sensory modality effect on interactivity, and the cognitive theory for multimedia learning. Finally, this review will discuss the matrix used to analyze and compare the research as well as the methodology used for selecting experimental literature. The review will conclude with suggestions for further research in the area of haptic interactivity and learning.

Haptic Interactivity Research Review of Reviews

A total of three prior literature reviews were yielded from the search process. One is from 1970, while the other two are from 2001 to present. They are comprehensive and serve as guidance in this review.

Jones, Minogue, Tretter, Negishi, and Taylor (2006) identified seven primary research articles on haptic intervention studies and four primary research articles investigating visual and haptic interactions together. An additional five studies on developmental issues with haptics were presented, as well. The authors present an everyday importance and quick review of haptic terminology, then ask how haptics might affect learning. They theoretically summarize that the use of multiple senses in learning is thought to be involved in the development of more generalized cognitive processes, that is, in moving from concrete to abstract thinking. It has been noted that "hands-on" or sensory-motor experiences are necessary elements in the development of formal operations. Minogue and Jones (2006) conclude, however, that to date there is very little empirical research that systematically investigated the value of adding haptic feedback to the complex process of teaching and learning.

Gallace, Tan, and Spence (2007) present a literature review on the body surface as a communication system over the past 50 years. This literature review provides an overview of studies that have attempted to use vibrotactile interfaces to convey information to human operators. The importance of investigating any possible central cognitive limitations (i.e., rather than the peripheral limitations, such as related to sensory masking that were typically addressed in earlier research) on tactile processing for the most effective design of body interfaces is highlighted. Gallace et al. (2007) start by taking a historical walk from the birth of the haptic research field in the 1960s through today and the potential impact of communicating through touch. Research on future possibilities of a completely new tactile language, where the body surface is successfully used as a communication device is introduced. Also explored is the published literature on tactile processing across the body surface, low-level limitations on tactile information processing, central limitations of unimodal information processing, processing of tactile information under conditions of multisensory stimulation, and the role of practice on tactile information processing. While the authors are not solely focused on primary research, this body of work will prove to be a solid basis for continued work on this topic.

Concannon (1970) presents a review of research on haptic perception that is comprehensive to Piaget's stages of development. Piaget's use of the term *haptic* usually implied the translation of tactual perceptions into visual imagery. At the time it was published, haptic perception was relatively a new concept in American education. Therefore, while being comprehensive of its time of being published, Concannon (1970) was only able to include the three main studies known to attempt verification of Piagetian stages. The known studies represented in the 1959 work by Lovell called *A Follow Up Study of Some Aspects of Piaget*, are a 1959 study on haptic perception by Page, and a 1965 study on visual and tactile-kinesthetic shape and perception by Fisher (as cited in Concannon, 1970). At this time, they concluded that haptic perception does indeed develop according to the Piagetian stages, but chronological ages differed and there was a relationship between mental age and haptic abilities. Concannon (1970) organized this literature review by the countries where haptic research was being completed, with haptic studies in England, Russia, and in the United States. Also worth noting in this review is the emphasis that Maria Montessori placed on haptic development and learning, citing her impact on educational theory and practice. Concannon (1970) makes it clear that due to the absence of conventional design, statistical analysis, and the small number of know experiments at the time, Piaget's stages of development in haptic perception showed fragmented results.

The three reviews prove to be comprehensive and valuable in the structure of the forthcoming primary literature review. Feedback or haptic output, as well as age and development level are the demonstrated themes. However, all of them highlight the lacking or inconclusive empirical research, and express the value of adding the haptic construct to the learning and research design.

Primary Literature Review of Haptic Interactivity

Interactivity is central to any educational experience and is a primary theoretical focus and key component in the constructivist theoretical framework. In a constructivist classroom, interactivity through hands-on activities and practice is at the heart of the teaching and learning experience. Haptic interactions through new technologies have become a major focus for researchers in many fields of study. The following section highlights the search methodology used, the data collection process, search results, and a summary of findings of two chronologically dichotomized periods of research on haptic interactivity. Through the research process in haptic interactivity, an argument was constructed where the second and third generations of distance education, which were principally led by advancements of technologies were cross-walked with two distinct periods of haptic technology advancements. A connection emerged between the multimedia generation of distance education (generation 2) and period 1 of haptic research. Likewise, a secondary connection materialized between the computer-mediated generation of distance education (generation 3) and the post touch-screen era or period 2 of the haptic research.

Haptic Interactivity Search Methodology and Data Collection

This study inspected many sources of information related to the construct of haptic sensory modalities, including academic journals, online journals, academic databases, Google Scholar web searches, and reference articles in primary research. Searches focused on a wide variety of article types, such as primary research articles, conceptual articles, theoretical articles, or what were labeled as *talk-talk* articles (articles that tell a story with some interesting ideas and facts consisting of evaluations, lessons learned, and/or other non-empirical writings). For this review, only experimental primary research was pulled out and dissected. All other types of literature were put aside for reinforcement purposes only. Out of the total number of journals articles found, only four (Concannon, 1970; Gallace et al., 2007; Minogue & Jones, 2006; Roth, 2001) are fully dedicated to reviewing known literature on the topic similar to the approach of this review, but are not nearly as extensive, nor solely focused on primary research.

The specific search process included investigations of the Ebscoe Host's ERIC database, Academic Search Premier, Education Full Text with Wilson Web, Web of Science, and Google Scholar. Searches were achieved using terms such as *haptics*; *touch*; *dynamic touch*; *multi-sensory information systems*; *haptic icons*; *haptic feedback*; *force feedback*; *perceptual learning through touch*; *direct learning through touch*; *haptics and* *cognitive load*; and *haptic interactivity*. Related terms such as *computer-based instruction (CBI)*; *computer-based learning*; *computer mediated communications (CMC)*; *multi touch*; *tactile feedback*; *computer mediated communications*; *human-computer interactions (HCI)*, *Virtual Interpersonal Touch (VIT)*; *Collaborative Virtual Environments (CVE*; and *Information and Communications Technology (ICT)* were also used to search the databases. Search results were dissected into two spans of time.

No preconceived categories or definitions were established prior to reviewing the haptic interactivity research. However, a profound innovation in haptic touch screen technologies hit all consumer and enterprise markets in 2010 and quickly became a factor for all instructional designers of distance education content and courses. Therefore, a hypothesis was established based on the new touch screen availability and resulting increased opportunities for new research. Peer reviewed academic journals containing primary research articles between the years of 1990 through 2009 were identified as "Period 1" and primary research articles from 2010 through 2014 were identified as "Period 2." Table 2.5 identifies the journals where primary research articles from Period 1 and Period 2 pertaining to the literature review were discovered. Period 1 was designated in the search methodology to support the search refining process for Period 2. Period 2 search results were then refined to focus on input versus output interactions, and even tighter, into study results that focused on learning outcomes when using touch screen haptic input technologies.

Table 2.5

Academic Journals Used in Research Literature Review (1990-2015)

	Journal Title
1.	*Advanced Robotics*
2.	*Assembly Automation*
3.	*Current Psychology of Cognition*
4.	*Computer Animation and Virtual Worlds*
5.	*Computer-Aided Civil and Infrastructure Engineering*
6.	*Computer-Aided Design*
7.	*Computers & Education*
8.	*Computers in Industry*
9.	*Computers in Human Behavior*
10.	*Consciousness and Cognition*
11.	*Ergonomics*
12.	*EuroHaptics*
13.	*Experimental Brain Research*
14.	*Gastroenterology*
15.	*IEEE Software*
16.	*IEEE Transactions on Biomedical Engineering*
17.	*IEEE Transactions on Consumer Electronics*
18.	*IEEE Transactions on Haptics*
19.	*IEEE Transactions on Information Technology in Biomedicine*
20.	*IEEE Transactions on Instrumentation and Measurement*
21.	*IEEE Transactions on Robotics*
22.	*IEEE Transactions on Signal Processing*
23.	*IEEE Transactions on Visualizations and Computer Graphics*
24.	*IEEE Transactions on Information and Systems*

Table 2.5, continued

	Journal Title
25.	*International Journal of Human-Computer Interaction*
26.	*International Journal of Human-Computer Studies*
27.	*International Journal of Image and Graphics*
28.	*International Journal of Medical Robotics and Computer Assisted Surgery*
29.	*Journal of Consumer Psychology*
30.	*Journal of Experimental Child Psychology*
31.	*Journal of Experimental Psychology-Human Perception and Performance*
32.	*Journal Gastrointestinal Surgery*
33.	*Journal of Informational Science*
34.	*Journal of Motor Behavior*
35.	*Journal of New Music Research*
36.	*Journal of Research in Science Teaching*
37.	*Journal of Acoustical Society of America*
38.	*Journal of the American College of Radiology*
39.	*Media Psychology*
40.	*Medical Teacher*
41.	*Military Medicine*
42.	*Multimedia Tools and Applications*
43.	*Neuroscience and Biobehavioral Reviews*
44.	*Perceptions*
45.	*Perceptual and Motor Skills*
46.	*Presence*
47.	*Psychology of Learning and Motivation*
48.	*Psychological Science*
49.	*Robotica*
50.	*Scandinavian Journal of Psychology*
51.	*Science Education*

Table 2.5, continued

	Journal Title
52.	*Science in China Series F – Information Sciences*
53.	*Sports Medicine and Arthroscopy Review*
54.	*Teaching of Psychology*
55.	*Teleoperators and Virtual Environments*
56.	*Transportation Review*
57.	*Universal Access in the Information Society*
58.	*Work – A Journal of Prevention Assessment*
59.	*World Neurosurgery*

Also materializing from the literature review on haptic interactivity was the need to identify the fields of study where the research was conducted. This was not originally a planned element to identify. However, after noticing a trend in the types of experimental design, it was interesting to see if any additional trending could be revealed. Needless to say, this review identifies that not much research is currently being done in certain professional fields, in terms of haptic interactivity's effect on learning and the users' performance (see Table 2.6).

Table 2.6

Number of Period 1 and Period 2 Articles by Field of Study

	Type of Experimental Design			
	Techno-centric	Learner-centric	Both	Total
Field of Study				
General Studies	3	1	1	5
Education/ Psych/ Neuroscience	1	18	2	21
Robotics	5	0	0	5

Table 2.6, continued

	Type of Experimental Design			
	Techno-centric	Learner-centric	Both	Total
Field of Study				
Medical	9	2	0	11
Fine Arts	1	1	0	2
Engineering/Auto/ Design	6	2	1	9
Forensic	2	0	0	2
Flight Simulation	2	0	0	2
Gaming	1	0	0	1
Total	30	24	4	58

Table 2.7 underscores the type of haptic technology used in the research as well as the general research approach, being that of a learner-centered approach or that of a techno-centric approach. A techno-centric research approach focuses on how well the technology is performing under the conditions and does not study the impact on the user or operator. Given that the majority of the studies incorporated a techno-centric approach, it is evident that capturing the different interfaces or interface types in comparison with the types of experimental design is important. When combined, a growth trend towards learner-centric research is evident in Period 2, which in turn, closes the gap considerably with techno-centric research designs of Period 1. The most tested interface was the PHANToM haptic interactive device, by SensAble Technologies, but was mainly studied in Period 1. This device provides for six degrees of freedom (6DOF) through multimodal input and force feedback (haptic output) interactivity. In all, 33% (19 of 58) of the studies were conducted using the PHANToM device, while only 6 of the 19 focus on the impact of using the device for the operator. Of the 28 experimental studies in both Period 1 and

Period 2 dealing with learner-centric approaches, only four used touch screens as an input method.

Table 2.7

Period 1 and Period 2 Experimental Studies by Haptic Tool/Interface

Research Focus	Feedback/ Tactile Mouse	PHANToM/ HapticMaster	ProMIS	Planar Haptic	Sensing Glove	Multiple/ General	Haptic Joystick	FREG	Human Touch/ Sense Pad	Touch screen	Total
Techno-centric	1	13	0	1	1	4	4	1	2	3	30
Learner-centric	2	6	2	0	0	4	1	0	5	4	24
Both	2	0	0	0	0	0	0	0	1	1	4
Total	5	19	2	1	1	8	5	1	8	8	58

After reviewing the yielded articles in Period 1, it can be concluded that there is a natural division of two major types of articles. Again, like the *Distance Education* journal analysis, the primary research was either (a) techno-centric, where research focuses on the performance and understanding of the haptic technology alone; or (b) learner- or user-centric research, focusing on finding out the learning and performance results from the users interfacing with the technology. This is also sometimes referred to as *human-centered technology*, where technology serves humans, as opposed to humans serving technology (Mayer, 2005). The decision was made to focus the study on one specific type of haptic interactivity research, that of a learner-centric focus. Learner-centric research would further assist in the type of ongoing research of interest. However, learner-centric haptic interactivity can be further categorized by fields of study, specific interfaces experimented with, and the input or output of the interface. Specific categories and their significance are identified later in this review. This literature review will then examine the effects of experimental research of the haptic interactivity construct in learning, while further identifying its relationship with the cognitive theory for multimedia learning's learner control principle and distance education.

Period 1 Summary of Search Results

The previously described search process produced 83 relevant articles that were then classified as either primary, theoretical, literature review, conceptual, case study, or talk-talk. Of the total number of articles collected, 62% (58) of the 93 articles are categorized as primary research studies, while 8% (7) are theoretical, 11% (10) are conceptual in nature, 4% (4) are literature reviews, and only 2% (2) are case studies. Finally another 2% (2) of the yielded articles were evaluated as lessons learned type of talk-talk articles.

When designing the primary research matrix (Appendix B), work was also completed in order to further identify additional characteristics of the 58 primary research studies. Of the 58 identified primary research articles, only 41 meet criteria for relevance in this study. All 41 primary research articles have quantitative research data and only one takes a mixed methods approach, including some qualitative survey and satisfaction data in the findings. As previously highlighted in Table 2.6, the majority of classified primary research articles, 61% (25 of 41), are focused solely on the technology of the haptic interface. Experimental design in these studies was intended to test the performance of the technology or haptic interface in question. Of the classified primary research articles, 39% (16 of 41) were identified as being focused on the learning results from using the haptic interface (learner-centric or both). The technology was secondary to the impact, whether beneficial or detrimental, the sensory modality had on performance of the user. In further identifying the experimental designs, some studies focus on haptic input (interaction to a device), some focus on haptic output (interaction from a device to the operator), and some focus on both input and output (see Table 2.8). Of the 14 primary research studies focused on the user and learning, only two introduced cognitive load as either a dependent or independent variable. This is significantly low in terms of the interest and the impact on learner outcome.

Table 2.8

Number of Period 1 (1990-2009) Articles by Haptic Category

	Type of Haptic Category			
	Haptic Input	Haptic Output	Both Input/ Output	Total
Article Type				
Techno-centric	4	0	21	25
Learner-centric	2	7	5	14
Both	0	2	0	2
Total	6	9	26	41

The study analysis for Period 1 identifies that of the 14 studies on learning with haptic devices, some found positive significant differences (beneficial), negative significant differences (detrimental), and variables that proved to have no significant differences on interacting with haptics. Generally, most research found the introduction of haptics into an activity to have positive outcomes. More so, the addition of haptics, force, and tactile feedback greatly increases simulation realism with benefits in terms of task completion time, reduced error rates, and learning times (Burdea, Richard, & Coiffet, 1996). Furthermore, Cao, Zhou, Jones, and Schwaitzberg (2007) found that on average, subjects performed 36% faster and 97% more accurately with haptics than without, even while cognitively loaded. Haptic feedback can not only enhance performance, but also counter the effect of cognitive overload. This effect is greater for more experienced surgeons than less experienced ones, for example, indicating greater spare cognitive capacity in surgeons with more experience. This study is very significant and impactful in the medical field. However, the research only focuses on haptic output or feedback from the device. Haptic input was not part of the study and therefore not a studied variable in terms of impacting cognitive load. Several other studies find that students who receive full-haptic feedback show a positive significant difference, suggesting that the increased sensory feedback and stimulation may have made the experience more engaging and motivating (Jones et al., 2004; Jones et al., 2006).

A 2003 study on human touch reveals some significance with the haptic sensory construct. Recognition performance was significantly better when objects were learned by both visual and haptic modalities than by either of the modalities alone. Results also suggest that objects learned visually are easier to recognize than objects learned haptically. Researchers found that haptic encoding may be slower than visual encoding. While a follow up study from the same research team finds no significant differences on performance of visual or haptic learning conditions alone, the researchers did find significant differences on bimodal visual and ($p<0.05$) and haptic learning ($p<0.005$) (Newell, Bülthoff, & Ernst, 2003).

Hatwell (1995), found that the sex of participants had no significant difference while age did. The researcher was also able to conclude that intentional learning has a positive significant difference, while incidental learning showed no significance.

Still more findings suggest that haptic signals can be a *more* robust, intuitive, and a subjectively preferred way to communicate navigation information to a user in a predominantly visual task than are visual signals—all without being any more intrusive than a visual signal. Further, researchers submit that reinforcing multimodal cues should be used with caution in attention-demanding contexts given their possibly deleterious effects (Enriquez, MacLean, & Neilson, 2007). Cockburn and Brewster (2005) found that the results of a more ecologically oriented menu-selection task show the need for caution, revealing that excessive feedback can damage interaction though "noise" that interferes with the acquisition of neighboring targets.

General Summary of Period 1 Research

Period 1 research highlights studies where the introduction of haptics into an activity had positive outcomes. However, the majority of the studies focus on technology performance rather than the effects the haptic interactivity have on the learner or operator. Age and ability appear to have an impact with haptic interactivity, where the sex of the user does not. Furthermore, a strong regard of caution should have carried over into the post-touch screen era of Period 2, due to very few studies focusing on haptic input with a learner- or user-centric focus. Suggestions that haptic encoding is slower when tested separately than visual encoding surfaced, but conclusive evidence was lacking.

Period 2 Summary of Search Results

Initial search methodology produced 24 relevant articles that were then classified as either primary, theoretical, literature review, conceptual, case study, or talk-talk. Of the total number of articles collected, 71% (17) of the 24 articles were categorized as primary research studies, which show signs of increase from the 62% in Period 1.

Adding to the Period 1 primary research matrix (see Appendix B), all 17 of the primary research articles have quantitative research data. Four of the 17 studies include some survey and satisfaction data in the findings. A redirect from the 61% that were discovered in Period 1, only 30% (5 of 17), are focused solely on the technology of the haptic interface (see Table 2.9). Experimental design in these studies was intended to test the performance of the technology or haptic interface in question. There is a slight increase from 34% in Period 1 to 71% (12 of 17) in Period 2 of the studies that were identified as being focused on the learner, the user, or both the user and the technology of the haptic interface. In the "both" category, the technology was secondary to the impact, whether beneficial or detrimental, to the modality on performance of the user. Also shown in Table 2.9 is the continued categorization of the experimental designs found in the studies. Some studies focus on haptic input (interactivity to a device), some focus on haptic output (interaction from a device to the operator), and some focus on both input and output. Of the 17 primary research studies 71% (12 of 17) studied haptic input effects (haptic input or both).

Table 2.9

Number of Period 2 (2010-2014) Articles by Haptic Category

	Type of Haptic Category			
	Haptic Input	Haptic Output	Both Input/ Output	Total
Article Type				
Techno-centric	2	1	2	5
Learner-centric	5	3	2	10
Both	1	1	0	2
Total	8	9	4	17

Narrowing to Touch Screen Haptic Experimental Research in Period 2

Based on the discoveries of the Period 1 haptic literature review, the Period 2 search yielded hundreds of results but was narrowed by targeting primary experimental peer reviewed journal articles researching implications of haptic interactivity between 2010 and 2014. Based on the refinement of the Period 1 search results, the Period 2 secondary searches identified 17 articles that meet the initial requirements of being based on primary experimental research in order to be included in this secondary literature review results. Of the 17 discovered experiments, 10 consist of a learner-centric experimental design, five focus on the performance of the haptic technologies, and two studies have a design focusing on both the user and the technology. This is contrary to the findings in Period 1, where Period 1 highlights a traditional focus on technologies and tools as opposed to that of user experience.

The body of research was collected and analyzed according to the findings in the areas of studies from Period 2, primary research, learner-centric, focused in some way on haptic input (rather than output), and using touch screen input. As there were no resulting

Period 1 studies using touch screen technology meeting the original search criteria, all of the results were from Period 2. The results from the filtering process using the additional constructs identified four studies. Three of the four were from the education, psychology, or neuroscience fields of study. This was encouraging due to the primary focus of the research being that of effects on learning in the field of education. Of the four studies, one highlighted a positive effect (Sung & Mayer, 2013), two found negative effects (Krcmar & Cingel, 2014; Zack et al., 2013), and one found no significant difference (Wang et al., 2010) in the effects with haptic touch screen input interactivity.

Positive effects. In their study, Sung and Mayer (2013) cite the increasing calls for replacing desktop computers in schools with mobile devices such as tablets, but they note that research is needed to determine the implications of this transition on student learning outcomes (Sung & Mayer, 2013). A media comparison study was designed in which learning with one medium was compared to learning the same content with another medium. For example, it may seem reasonable to propose that people learn a multimedia lesson better when it is delivered on a portable, handheld haptic tablet such as an iPad, which they can hold in a comfortable environment, than when it is delivered on an immobile desktop computer in a laboratory cubicle. This seemingly reasonable assertion is based on the idea that learning on an iPad in a comfortable place is more *fun* and therefore students will try harder to learn than when they learn in a traditional setting, such as a school computer lab.

The premise for the study was to test Clark's (2001) oppositions to methods of learning and confounding research implications on new mediums. Based on an extensive review of research on instructional media, Clark (2001) came to the conclusion that instructional media do not improve learning, but instructional methods do. According to Clark (2001), “there is no evidence for a causal connection between media and learning” (p. 329). This statement includes multimedia learning: “there is no credible evidence of learning from any medium or combination of media that cannot be explained by other non-multimedia factors” (Clark & Feldon, 2005, p. 98).

The researchers’ goal was not to compare touch screen tablet devices to traditional computers, but rather to determine whether improving the design of multimedia lessons based on cognitive principles, such as the learner control principle, is as effective in conventional media (traditional computers) as with mobile media (iPads). The study predicted that improved design based on cognitive principles should be effective across media because the same cognitive processing is activated. Sung and Mayer (2013), further assert:

> However, although the choice of instructional media might not affect learning outcomes, it could affect the learner’s motivation to continue learning, which is an important educational consideration. The focus on extending cognitive design principles from desktop computers to iPads and on determining the motivational effects of iPads as compared to desktop computers represent two new contributions to research and theory on learning with technology. (p. 642)

The primary empirical finding concerning instructional method is that adding multimedia and cognitive strategies such as segmenting and signaling to an online multimedia or distance education lessons improves transfer test performance for both desktop computers and mobile devices. In short, the method effect may apply equally well to both desktop and other haptic input mobile computing environments. While the primary empirical finding concerning the instructional medium is that learning with a mobile (touch screen) device in an informal environment leads to a greater willingness to continue studying new lessons than does learning with a desktop computer in a formal environment for both standard and enhanced lessons. The media effect applies equally well to both standard and enhanced lessons. Overall, instructional methods affect learning outcomes but not motivation to continue learning, and instructional media affect motivation to continue studying but not learning outcomes. This study has direct implications on learner control issues when engaged with distance education and distance learning.

The results concluded in this study (Sung & Mayer, 2013) extend Clark's (2001) methods-not-media hypothesis to the new domain of mobile touch screen computing, by showing that instructional media do not cause learning but instructional methods do cause learning. This is a main theoretical contribution of this research for this chapter.

Negative effects. Two primary research studies found negative effects with haptic interactivity and learning or end user outcomes. Both studies indicating a negative effect on the learner for haptic touch screen interactivity were performed with infant (15 months old) or toddlers of preschool age. Krcmar and Cingel (2014), through primary research, discovered an increased extraneous cognitive load when using haptic interactive touch screen devices during reading exercises with pre-school aged children. However, of important note, the results suggested that the extraneous cognitive load may not have been between the learner and the technology, but rather introduced by parents when reading along and engaged in the experimental design. This is of significant interest since there is little question that parent-child joint reading is related to a number of positive childhood outcomes, such as vocabulary acquisition and school success. However, with the growth of tablet computers, parents are now able to read to their children using different mediums, which introduces additional constraints on this study. This study used a repeated-measures design with parents and their preschool-aged children to test the difference between reading interactions and child comprehension on two platforms: traditional books and electronic touch screen iPad books. Results indicated that in the electronic interactive reading condition, parents used more “talk about the book” format and environment than in the traditional book condition, where they used more evaluative comments about content. Children comprehended significantly more in the traditional book condition than in the haptic interactive electronic book condition. Additional analyses suggest that this finding is related to the increase in distraction talk by parents in the electronic book condition. Results suggest that it is important to consider the specific content of parent-child reading interactions and the increased cognitive load these interactions can place on children when using new technologies, such as touch interactive devices, as parent questions about the book format and the environment were related to decreases in child comprehension (Krcmar & Cingel, 2014). Zack et al. (2013) suggest that there is a negative effect on transfer tests from 2D (touch screen interaction) to 3D real-world models. The study highlights that further research should be directed to examining transfer of learning between real-world objects and 2D representations to determine why it might be difficult for young children to transfer learning on tasks requiring them to understand the functional equivalence between 3D and 2D and to act appropriately. The touch screen paradigm provides a good method for examining representational flexibility in young infants on a task that involves transferring of action across dimensions (Zack et al., 2013). The study also indicates that results are inconsistent with other similar studies using non-interactive 2D designs.

No significant difference. Wang et al. (2010) studied simulations and real driving protocols and found no significant difference when subjects used one of three haptic interactive input methods (keypad, touch screen, rotational controller). While finding no significant difference in learner-centric results between the input tools, the results indicate that simulations using the touch screen haptic input do indeed map to on-road study of similar protocol with usability and safety implications with high fidelity. In other words, visual attention and task measures mapped very closely between the two experiences, simulation and real-world.

General Summary of Period 2 Haptic Research

The post-touch-screen era of Period 2, 2010 to present, finds more researchers focusing on a learner-centric research on effects of using haptic input interactivity. Research designs appear to move away from publishing research focused on how well the technology works. Further, most of the targeted studies were done with infants and learners on the low end of the age and ability scale, which supports the findings from earlier, Period 1 research, that age does play a role in the positive or negative effects of haptic interactivity. Finally, in an online distance education course, both the media effect and the method effect appear to play a significant role, where the instructional methods affected learning outcomes but not motivation to continue learning, and instructional media affected motivation to continue studying but not learning outcomes. Results and research in this field remain inconsistent, therefore future studies should also examine transfer of learning.

Conclusions for Distance Education and Haptic Touch Screen Research

The literature review and research leads to several additional questions and even more assumptions. As demonstrated in this literature review, the technology tools and technology performance approach throughout many different fields of study have received the most attention. Experimental design based on how the technology is performing is the most researched area. Is it because we allow the technology to dictate to us how we do our jobs? Is it because we care more about new tools than we do the indirect cognitive load issues that could indirectly affect us? Is the field going to continue to get caught up in the tailspin of using new technologies and designing the next best thing, even if it is not the right thing for the right learner? Similarly to the past views on the characteristic shifts of emerging distance education generations being pushed along by advancements in technologies, one can certainly argue that based on the current trends in research, the field of distance education will continue to focus on the availabilities of the latest technologies.

Of all of the types of haptic interactivity that professional fields are studying, it is interesting that the primary literature review data shows that researchers are most interested in whether the equipment is working and precise. For example, in the medical field, very few studies focus on the doctors' usability and cognitive needs, as opposed to the precision of the technology, while a vast majority of the studies focus on the performance of the tool, not noting whether using this tool had an increase in performance or diverse effect on the actual user of the haptic tool. The medical field, for one, should be concerned with a user-centric approach to haptic interactivity and haptic tools.

The research and literature review also helps in the conclusion of the need for more specific research focused on cognitive load effects on touch-based input interactivity. There is not enough focused research to make a strong conclusion. In fact, there is an inherent lack of data researching multimodal input and cognitive load effects of multi-touch interfaces. There are certainly questions as to the effect on the cognitive load that this type of sensory interactivity has when combined with visual channels, auditory channels, and the user's ability to have complete control of the experience.

General research on cognitive load issues when learners have control over their distance education experience while engaging in haptic interactivity is lacking and inconclusive. There are questions about whether haptic interfaces can help more in multitasking scenarios versus performing one task at a time. In these cases, design is best based on some understanding of human multisensory attention (Hayward & MacLean, 2007; MacLean & Hayward, 2008), and more research is needed at this point. Further, more conclusive research is needed on age and ability issues, as some studies involving younger learners have found negative effects. From a distance education lens, Concannon (1970) concludes that haptic perception does develop according to the Piagetian stages but chronological ages differed and there was a relationship between mental age and haptic abilities. The vast majority of distance education and interactivity researchers focus on older students (undergraduate, graduate) or adult learners. Business and industry training further highlights this, which further highlights the need as distance education strategies are clearly being employed with students of lower age and ability levels.

Designing distance education instruction with touch interactivity explicitly in mind, should be approached from the perspective of what the user needs as opposed to what is technically possible. Standing on the Sung and Mayer (2013) research, while their study examines learning outcomes from informal mobile devices versus that of formal, seated lab devices, they also express the following:

> Future research is needed to disentangle the individual contributions of using a mobile device and learning in an informal environment to gains in motivational

> ratings. Most relevant is their assertion that it would also be useful to disentangle the effects of differences in screen size (10-in. versus 17-in.), input controls (i.e., touch screen versus mouse clicks), and mobility (i.e., hand-held versus docked). Which would lend further insight into the connection of these haptic controls with the learner control principal of the cognitive theory for multimedia learning. Further research is needed to determine whether the effects can be replicated in a more authentic learning situation involving actual students learning within an actual course and with a delayed test. Finally, it would be helpful to include better measures of motivation (i.e., beyond self-report ratings) and better measures of learning and motivational processes during learning (i.e., beyond post-tests). (p. 645)

This continued the findings of Minogue and Jones (2006), who concluded that there is very little empirical research that systematically investigated the value of adding haptic technology to the complex process of teaching and learning.

Implications from the Literature for This Research

As submitted by Bates (1990), new strategies in distance education will provide the opportunity for global networking, increased interactivity and more control for learners, in a highly cost-effective manner. However, research has identified issues to consider when designing distance education experiences. Learning through distance education cannot be focused on information presentation and information acquisition, but rather, focused on designs geared towards core knowledge construction. Dumping massive amounts of information at students does not work in traditional classrooms, nor does it work online. There are many instructional design considerations when planning digital learning experiences. Through digital or online environments, cognitive load implications with a learner's ability and desires to control their experience and cognitive load implications with haptic interactivity have emerged as being deeply connected and worthy of future study.

If more research is focused on learning and user-centric impacts, as previously addressed, results could provide a profound link between interactivity and types of control that positively and negatively impact learning through understanding.

Minogue and Jones (2006) summarize this discussion seamlessly with the following comments:

> It would be both interesting and informative if-armed with the theories and understandings of haptics built by psychologists and cognitive scientists-we could rigorously investigate the effects of using the latest technologies in the field to create haptically rich learning environments. Perhaps one day students will become immersed in a virtual animal cell, more fully exploring its structure and functioning. Perhaps physics instruction will use haptic feedback devices to teach students more effectively about invisible forces such as gravity and friction. Visually impaired students may learn math by touching data represented in a tangible graph and chemistry by feeling the attractive and repulsive forces associated with various compounds. There is a critical need for more in-school studies that pay attention to developmental, cognitive, and behavioral factors that contribute to student learning with this new technology. We need more research into how students perceive, process, store, and use haptic information in a variety of educational contexts and settings. Continued investment and research in this area have the potential to pay off not only in a more robust understanding of haptics in education but also, ultimately, in the creation of new ways to, engage learners of all types and at all levels in the active construction of more meaningful understandings. (p. 343)

It is clear that future research on distance education environments, the learner control principle, as well as haptic interactivity could help spark improvements on teaching and learning in real-world classrooms and real-world distance education experiences.

However, while current distance education practices continue to leverage the latest and greatest of new technologies, they are often void of instructional design practices centered on the cognitive theory for multimedia learning. This paper then is the first study that bridges the gap in literature touching on implications of the learner control principle as well as implications of haptic interactivity as outlined by both Sung and Mayer (2013) and Scheiter and Mayer (2014), respectively.

The purpose of this study was to determine whether there is a significant difference in the performance of distance education students who exercise learner control interactivity effectively through a traditional input device versus students who exercise learner control interactivity through haptic methods.

CHAPTER 3

METHODOLOGY

Based on the literature review, the previous chapter argues that original research is lacking in regards to implications of learner control and haptic interactivity in distance education. While general research in distance education and cognitive theories for multimedia learning is ample, there is a need to expand this line of research on the effects and comparisons between the media and methods of interactivity that learners engage in while constructing new knowledge online. The results of this study provide a perspective on middle school and high school students participating in an open online distance education course, and if their chosen interactivity methods affected their levels of learner control, as well as overall success.

As Clark and Feldon (2005) submits, the most promising approach to learning is to assume that it is caused by instructional methods that can be embedded in instruction and presented by a variety of media. Sung and Mayer (2013) express this idea as the method-not-media hypothesis, the authors further submit the need for more focused studies involving the same instructional methods delivered within different media. In terms of learning, coherent with the method-not-media hypothesis, Hattie (2013) proposes that the same instructional methods, such as learner control, which are more effective within conventional environments, are also more effective in computer-based environments.

This study has established grounds to further test the method-not-media hypothesis in the context of learners in an open online distance education course. Chapter Two provided important rationale for examining constructs on interactivity, haptic touch-based input, and learner-controlled effects. Similar to the existing methods-not-media hypothesis research from Sung & Mayer (2013), this chapter presents three key research questions, as well as aligned hypotheses that were tested. More specifically, the learning outcomes of students who learn the same lesson with the same instructional method but delivered in two different media experiences gives a foundation for the research in this chapter. The participant and subject descriptors, instrumentation, instructional materials, procedures, and study design are also presented in detail throughout this chapter.

Research Questions

Based on the literature, this study sought to answer the following research questions:

- Is there a difference in learner-controlled sequence interactivity in an online open distance education course based on the input methods being used to access the course?
- Do learner choice on sequence (a learner control element) and input type have a significant effect on score range, which is used as an indicator of performance?
- Do learner choice on sequence (a learner control element) and input type have a significant effect on the number of assessment attempts, which is used as an indicator of performance?

Hypotheses

Based on the research questions stated above, the following hypotheses were tested:

- Hypothesis 1: There is a no significant difference in the learner-controlled sequence selection of learners interacting with digital content through haptic input when compared to learners who are interacting with digital content through traditional input methods.

- Hypothesis 2: There is no significant difference in the score range on assessments in an online open distance education course when comparing the two different input groups and learner-controlled sequence groups.
- Hypothesis 3: There is no significant difference in the number of assessment attempts in an online open distance education course when comparing the two different input groups and learner-controlled sequence groups.

Participants

This research was conducted using pre-existing data from an online platform called the Digital Driver's License (DDL) and was designed and hosted by the College of Education at the University of Kentucky, a public co-educational university located in the south east of the United States. As one of only two land-grant universities in its state, it has the largest in terms of student enrollment (University of Kentucky, 2016). It is also the highest ranked research university in the state according to the Center for Measuring University Performance (Lombardi, Phillips, Abbey, & Craig, 2012).

The total platform participant count since the launch of the open online distance education course in August of the 2012-2013 school year, included 147,024 students, 1,392 administrators, and 9,584 teachers participate in the course. Participants submitted over five million assessment attempts. The course is openly distributed, where school or school district administrators can decide when to start and when to stop the course. There are currently 1,210 school districts that initiated participation, with 158,000 total accounts (students, teachers, and administrators) that logged in more than 752,000 times. School representation was from all 50 states in the United States, as well as schools from more than 20 different countries (platform data as of January 1, 2016).

This research examined students in traditional high school and middle school settings, with ages ranging from 11 to 19. Upon receiving instructions from their school, students self-registered and enrolled in an open distance education course on digital citizenship as a required and incentivized participant. Participants were required to complete the course to receive their school purchased device. For this study, one school district and one learning module was selected for research. Within the selected module and school district, there were 1,148 middle school students and 1,118 high school students for a total of 2,266 unique student participants. When registering, students selected their school district and school affiliation, which was not a required selection for account creation as this could be accomplished at any time. At the time of the study, 147 students had affiliated with their district, but not their school. Participants took 4,746 assessments and accumulated 19,365 attempts, as all assessments can be reset and attempted as many times as desired. Of the total assessments taken, 2,254 were formative assessments and 2,492 were summative assessments. Students were given full learner control (i.e., pace, content selection, sequencing, and presentation) and a natural sequencing profile was generated by each student, for each student.

Similar to other districts in the state, the population of the examined district serves a predominantly white (92%), middle-class (43.4% eligible for free lunch and 5.2% reduced-price lunch) student body, while 20% of students were identified as having special needs. The school district is also moderately sized, serving students in six schools (Kentucky Department of Ed, 2016). Students in the district are also relatively high performing, as they outperformed the state as a whole on the state assessments ranking in the 98th percentile on accountability measures.

Instrumentation

Quantitative interactivity data, as well as learner performance data, were collected via a web-based user interface and a database that serves as the backend data source for content and interactivity in the open online distance education course focused on digital citizenship. Learners in the course interacted with the digital content and took assessments to gauge their understanding. They created an account in the DDL platform, and linked with their school district and school in order to share their work with teachers and administrators.

Variables

This study included the following instrumentation or research variables: Current Score, Attempts, Attempts Grouped, Score Range, Score Results, Haptic Input, and Learner Control Sequence.

Current score. Current score is a dependent ratio variable that represents the highest or final attempt score per an individual assessment.

Attempts. The attempts variable is a dependent ratio variable that represents the raw number of attempts the learner made for each assessment on a quantitative scale.

Attempts grouped. Attempts grouped are dependent ordinal variables that are recoded and reported as minimal attempts, low attempts, moderate attempts, and high attempts.

Score range. The score range represents the score per attempt range as a dependent ratio variable representative of a scale from the learner’s lowest score attempt to his or her highest score attempt. The score attempt range is the simplest measure of variability where the highest score minus the lowest score equals the range.

Score range grouped. Score range grouped are dependent ordinal variables that are recoded and reported as minimal score range, low score range, moderate score range, and high score range.

Score result. The score result is a dependent categorical variable represented as passed or not passed, where a passing score equals or surpasses 80% on an assessment.

Input type. The haptic input variable is an independent dichotomous categorical variable reported as touch input or no touch input (no touch input can also be translated as traditional input).

Learner control sequence. Learner control sequence is a codified independent variable reported as either the summative assessment attempted first or the formative assessment attempted first, where the formative assessment attempted first represents a learner choice in a linear sequence through the module and therefore self-selecting an adaptive release approach to the module.

Instructional Materials Used

The distance education course on digital citizenship project started as an answer to a problem—more specifically, a problem where the mainstream answers only provided technical solutions. For years, the only requirement and seemingly available choice for many school leaders had been to face the threats and pressures of liabilities and block or filter access, through technical means, to many resources found on the web. As the federal and state requirements (Federal Communications Commission, 2015) transitioned to add a new requirement of educating where the instruction of new skills was compounded in the name of safety. School leaders were found once again attempting to figure out how to help students learn a set of skills that was not an established part of teacher training.

The intent had always been to only block inappropriate, non-educational, and harmful content. However, many times if a networked or firewall filtering device is honored with the task of keeping students safe, it only knows to block or filter content based on a categorical checkbox. In other words, if a site is categorized as gaming or shopping, for example, and school district leaders chose to check a box for all gaming and shopping sites to be blocked, then the site would not be accessible while inside the school district. Filters often block instructional content. The DDL concept, proposed by Ribble (2010), was an attempt to establish a priority on teaching students how to participate online as opposed to building a walled garden or isolated physical spaces of only known websites, which had set incorrect expectations (i.e., the idea that blocking some sites makes all students safer). This strategy does not help when students leave the school grounds. Their opportunity for learning has been limited or even nullified. It is well accepted now that the teaching of digital citizenship skills is paramount to the advanced participation of learners using technologies to transform experiences. This new strategy extends well beyond the school day and the school walls, especially in our hyper-connected and collaborative open online distance education courses.

Instructional Experience

The DDL is an open distance education course and platform that offers a system of exposure to content as well as a check for a base level of understanding by way of formative and summative assessments. The course is based on exposure, questioning, feedback, and basic certifications of understanding. This performance-based approach has afforded new learning experiences for students and teachers, and created a common language for conversations around digital citizenship topics. It has also created a repository of continuously growing and connected data elements to mine and make sense of. The DDL has also given school leaders the opportunity for an alternative to blocking web resources, leaning on instruction, learning, and student performance. School leaders have transitioned to leaning on students to prove that they understand appropriate from inappropriate in order to permit resources accordingly.

Anyone can register to participate in the distance education course. It is an open system for learning specific skill sets. The ideal structure is for a school administrators to register for an “Admin account,” add their schools, select which cases they will require for their custom license, and then instruct students and teachers to register and connect to their district and school. Once connected, schools and districts can monitor the progress of their registered users through the certification process of gauging base levels of understanding through the module completion assessment processes. Modules in the DDL are made up of presented material and content in the form of text, images, video, and assessments. There are two main types of assessments learners engage in, each containing four types of questions. The question types are true/false, multiple choice, fill in, and open response. A practice assessment is formative in design. It is practice, therefore, it is designed to be an intentional and direct feedback loop to the learner. In a practice assessment, learners are presented questions and given unlimited opportunities to submit answers. Once submitted, the learner is presented with feedback to the questions and can get back to this feedback at any time. If a learner is not pleased with the score, he or she can retake the practice assessment as many times as desired. The other type of assessment is an opportunity for learners to prove that they understand the content and they do not need to be presented with any more material. This second type of assessment is designed as a summative event. Similarly, to the practice assessment, learners can submit and reset the assessment as many times as they desire. However, unlike the practice assessment, in order to successfully prove that a base level of understanding has been met by the learner, a score of 80% or higher must be achieved on the summative assessment. Learners are notified in the platform and through automated emails on their progress towards the 80% benchmark. The design is for learners to review and interact with the instructional material, take a practice assessment, receive feedback that they are ready, and then retake the summative assessment until at least an 80% has been achieved. Learners do not have to stop at an 80% score; retakes and additional attempts with successful answers can help them reach a perfect score of 100%. In other words, success on a module within the course is tied to the summative event.

Currently, in the distance education course, there are six fundamental modules that contain concepts and skills of digital citizenship instruction for grades 6-12 and three fundamental modules for students in grades 3-8. The digital citizenship modules are designed to build skills and capture the nine elements of digital citizenship identified by Ribble (2010, 2011, 2015). During the design phase, concepts were chunked together to reduce the number of cases when and where it made sense. In the high school category, the sixth and final digital citizenship module is designed as a comprehensive or cumulative case containing five summative assessments of all nine elements of digital citizenship captured in the other five individual modules (see Table 3.1). Module 4, titled *Digital Law, Rights, & Responsibilities* is the sole module germane to this study.

Table 3.1

Module Breakdown Indicating the One Module Used in This Study

Module	
Module 1	Digital Access, Health, & Wellness
Module 2	Digital Commerce
Module 3	Digital Communication, Etiquette, & Security
Module 4	Digital Law, Rights, & Responsibility
Module 5	Digital Media Fluency
Module 6	The Cumulative DDL Exam

One of the foundational concepts in the course is for learners to retain the opportunity, decision, and ownership to try the summative assessment at any point in time. This sequencing decision moment is highlighted in Appendix E and was a key opportunity for the design of this research, which also included the opportunity for a learner to pass the summative DDL assessment without ever completing the other five skill building cases. While flexibility existed in the tool, an explicit theory of assessment, instruction, and learner control shapes how a user interacts with the tool. It is this scaffolding that has defined it as a repurposed and sharpened tool (Swan, 2009). This distance education course and platform proved to also be a fundamental design to explore additional theories on learner control and the impacts of how students interact in the learning environment. Presented are several different scenarios where schools and districts are setting different requirements for students. One example is a district that requires all students to successfully certify and complete all six cases while another district only requires learners to successfully complete the final cumulative case. A second example provides a scenario where students are instructed to focus on the cumulative case, but go back to skill building cases when needed. This proved to be the impetus for trying to understand designs that helped achieve success in learning while at the same time understand how control and interactivity directly affected the process. This open online distance education course is an iteration of the original *CaseMate* project as presented in TechTrends (Swan, 2009).

Procedures

The data sample in this study identified explicit types or profiles of participants using the distance learning platform. This study became an extension of one of the original observations from the course. In the initial pilot of the distance education course with approximately 60 students, the module designers saw two different student performance profiles take shape. One performance profile identified students who had multiple attempts with very low scores in the initial attempts, before eventually passing the assessments. The second performance profile identified student who had very few attempts before passing a summative assessment. Through additional observations and anecdotal data collections, it was evident that one class of students had very little agency or buy-in to the purpose of the distance education course. The teacher had not engaged in the point of the activity (short term or long term) and simply instructed students to “go to a hyperlink and answer some questions.” The second class was introduced to the purpose of successful completion (which was incentivized), as well as the overall point of having a good base understanding of digital citizenship concepts and skills for future online interactions. Class two had high teacher engagement and high student agency in the process. The profiles that emerged became the catalyst for many questions of learning efficiency and effectiveness of open online courses in a learning experience.

Research Sequence

Each learner gained access to the course, which involved a device, Internet access, and instructions on the location of the course (see Figure 3.1). The learner created an account in the platform and the platform began mining user-level data, including interactivity, participation, and login-specific metadata. As learners began working through the course they inherently chose the pace, sequencing, and representational control (learner control characteristics). The learners completed the course and data were archived for research procedures.

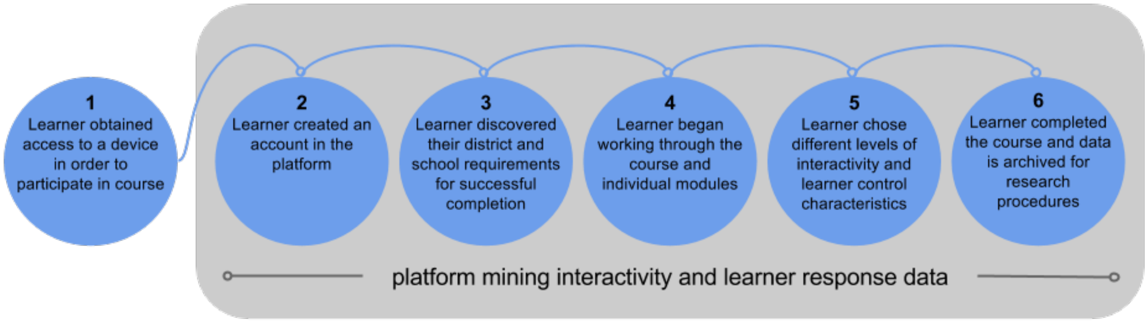

Figure 3.1: A diagram illustrating the research sequence

The research questions presented in this study are an expansion of the original observation, but with well over five million assessments submitted by learners. To quantitatively gauge student and teacher success, data were extracted, mined, and codified (see Table 3.2) to fit the association and independence study as well as the linear regression study with what was observed alongside what was expected. Table 3.2 identifies a subset of the independent and criterion variables by which this study was structured. The comprehensive data extraction process can be found in Appendix C.

Table 3.2

Variables Used and Analyzed (IV = Independent Variable; DV = Dependent Variable)

Variable	Variable Type	Definition
Current Score	Ratio (DV)	The current highest or final attempt score.
Attempts	Ratio (DV)	The raw number of attempts for the assessment on a quantitative scale.
Attempts Grouped	Ordinal (DV)	Reported as: minimal attempts, low attempts, moderate attempts, high attempts (minimal = 1 login, low = 2-5, moderate = 6 – 10, high ≥ 11 attempts)
Score Range	Ratio (DV)	The scale from lowest score per attempt to highest score per attempt. Simplest measure of variability. Max score – Min Score (score attempt per assessment)
Score Results	Nominal/ Categorical (DV)	Assessment attempts that meet 80% or above success score. Reported as 1 = Passed; 0 = Not Passed.
Total Logins	Ratio (DV)	Total number of times the learner logged into the DDL site (visits/ re-visits)
Score Range Grouped	Ordinal (DV)	Reported as = minimal attempts, low attempts, moderate attempts, high attempts. (minimal = 0, low = 1-20, moderate = 21-50, high ≥ 51 attempts)
Input Type	Nominal/ Categorical (IV)	Reported as: 0 = no touch input and 1 = touch input
Learner Control Sequence	Nominal/ Categorical (IV)	Reported as 0 = learners who worked through the formative assessments first, and 1= learners who jumped to the summative assessments first.

All of the website and user data were managed in a MySQL Database. Learner interactions and graphical interface were coded and displayed through PHP, AJAX, and JavaScript. Table 3.3 identifies the database table structure and was developed to enable systematic exploration of the educational database. It is important to understand the contents of each table and the relationship of all variables within the database when thinking through interesting questions and running data queries. Without an understanding of the data structure it would be difficult to match up variables in order to ask the informed questions for this study. With this understanding it allows for the identification of variables of interest for future study similar to that of other studies while mining education data from big data systems (Hartley & Almuhaidib, 2007).

Table 3.3

Database Table Structure

Database Table Name	Implementation Purpose
archives	General case definitions as created and designed by case builders. Also contains case ID numbers and categories. Cases = archives.
attachments	Also known as *elements*. Used by case designers to organize case content. Elements fall within (under) case categories.
attempts_archived	All individual user assessment attempt activity (including timestamp). A record is added every time a user hits the “Submit” button on either a formative or summative assessment. The user “Login ID” is also copied from the “logins” table for every record in the table.

Table 3.3, continued

Database Table Name	Implementation Purpose
case_completion	A record is added to this table every time a user successfully completes a case their district has marked as a requirement. This table is used for requirement checks and reporting.
comments	Not currently being used.
courses	This table is where assessments are located. Contains formative and summative questions, answer choices, question types, and feedback. There is one assessment ID per course (group of like assessments) that can contain multiple individual assessment ID.
districts	Includes the District ID and Name that can be found in the user registration drop down menu. This is only populated by Site Administrators.
fileuploads	Used by case designers to store content (images, videos, etc.) for case materials and assessments.
license_archived	Records in this table are user generated. Users manually click to "Get their license" based on the requirements set by the school or district. This is used when districts run reports.
license_requirements	This table stores the records for each district custom license (e.g., which cases have been marked as requirements to complete before getting license). This is only populated by district administrators.

Table 3.3, continued

Database Table Name	Implementation Purpose
logins	General metadata are stored in this table. Records are added every time a user logs in. Username, date, time, user level, browser type, device type, and IP address is captured. A key element in this table is the “LoginID.” This element is the linkage between records stored in other tables which connects the metadata with the user submitted data.
profiles	Site user registration information. Name, email address, password, user level, district, school, teacher are captured. Records are added to this table every time a user registers to use the DDL. Records can be updated after initial registration (e.g., school changed, etc.).
reflections	Not currently being used.
schools	Includes the School ID, Name, and District Number the school belongs to. The school name can be found in the user registration drop down menu. This is only populated by District Administrators.
summativereports	Calculated user responses to assessments. Attempts and score per attempts are calculated, from the “attempts_archived” table and used to display in reports.

The specific modules researched were initiated in the archives table of the database, but also spread through many other relational database tables. All other components of the modules are connected via the Case ID found in the archives table. Table 3.4 identifies the case IDs for each digital citizenship case that learners interacted with and data were collected in.

Table 3.4

Digital Citizenship Cases

Case ID	Case Name
117	Digital Law, Rights, & Responsibilities
122	Digital Commerce
141	Digital Media Fluency
142	Digital Access, Health, & Wellness
143	Digital Communications, Etiquette, and Security
185	The Cumulative DDL Exam

Module Design

Before looking at any data in the archived database it was important to fully understand how the module components were connected. The core design of the platform was built as a case builder for learning scenarios. For the purpose of this study, cases will be referred to as *instructional modules*, or simply, *modules*. Figure 3.2 presents a visualization example of how assessments were tied to module elements; module elements were tied to module categories; and module categories were tied to case ID's. This understanding was paramount as a module builder or designer, but also needed when attempting to mine data from the database. An example, highlighted in Figure 3.2, is a sample module containing four total assessments. They are organized in three categories. Within the three categories, there are two with three elements, and one with two elements. Of the categories with three elements, one contains two assessments. The other two assessments can be found in the additional categories. This figure illustrates the overall structure of a typical module in the DDL.

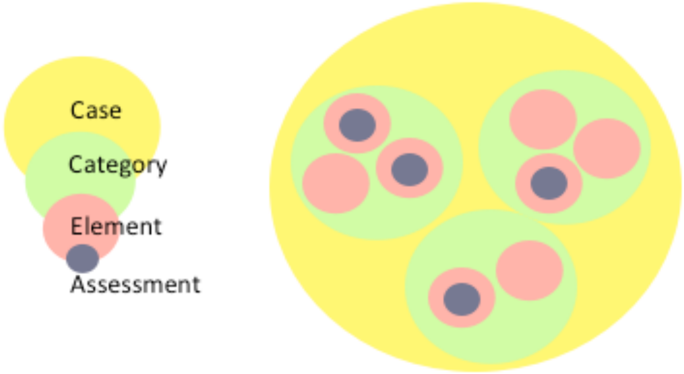

Figure 3.2: Digital Driver's License (DDL) module components

Within the database table structure, there were 13 usable tables. To assist in the disaggregation, database tables were codified as system data or user generated data (see Figure 3.3). User data are either willingly submitted by end user participation or automatically capture by the distance education course. Data submitted by the user include registering for an account with an email address, connecting with a school or district, and the submission of assessments. Metadata automatically captured by the course are placed in the database for future analysis. Figure 3.3 illustrates the individual database tables and the type of data each table collects.

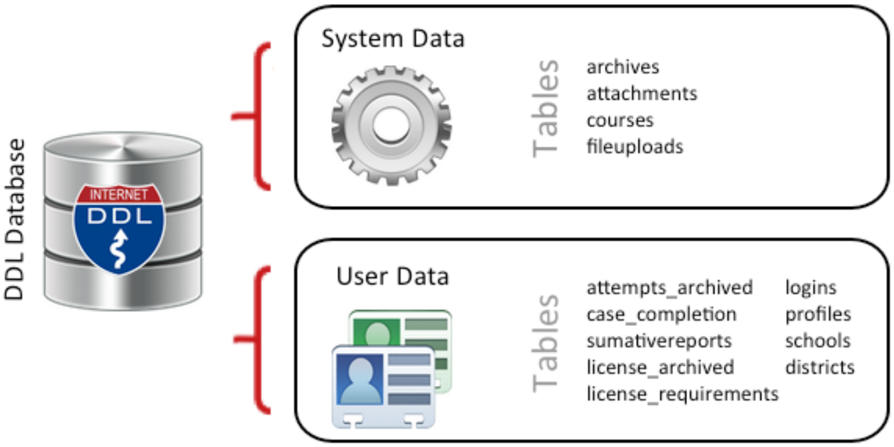

Figure 3.3: Database table structure separated by system data and user generated data

Data Retrieval from the Database and Forming the Data Set

Users enter all of the data needed to research the question into the database via a web browser-based graphical interface or application. In order to extract the data needed to run statistical regressions, a database query string was designed. The query string used was:

> *select * from summativereports LEFT JOIN profiles ON summativereports.user = profiles.user where profiles.district_ID = 10 AND summativereports.course = 117*

Breaking the query down (see Figure C.1, Appendix C), the "select" tells the query what data fields to present in the resulting output. The database query symbol * tells the output to present all fields in the table. In this particular query, and question, data from two different tables is needed. Assessment attempts and scores are needed from the summativereports table and user information, such as district is needed from the profile table. As presented earlier, the summativereports table of the database contains only one record per user, upon submission of an assessment. This unique field is updated every time a learner resets and submits an assessment (in order to get a higher score). The LEFT JOIN statement tells the query to check the secondary table and only present results that have the same username in both fields of each table and have the district identification number of 10 in the profile table of the database. The district identification number 10, is coded for a specific school district in the "districts" table of the database and is used by users when they created their account. The district_ID number correlates to a district_name which is what users see when creating their accounts and on their account information page. The last statement in the query tells the output to only present results from module number 117. As presented earlier, this module contains an instructional content as well as performance assessments featuring digital law, rights, and responsibilities.

Within the cumulative case, there were five different assessment IDs presented in the output. Table 3.5 identifies the assessments, identified as 280, 286, and 452, found in module number 117. Each assessment identification number correlated to a section of the case and an individual case topic. It is important to break this down, as some of the statistical analysis required a review one case at a time or possibly one assessment at a time.

Table 3.5

Module Assessment Identification Table

Module	Assessment ID	Topic
117	280	Connecting with legal scenarios (practice)
117	286	Introduction to rights and responsibilities (practice)
117	452	Cumulative Prove-It! (module summative)

To complete the initial data set, in order to meet the additional requirements of the study, a secondary query was designed and implemented also capture the number of logins for each individual participant. Assumptions could be made for the amount of time and attention that was placed on the content based on the number of times the participant went back to the site, however, the data needed to be representative. For this element a multiple step process was constructed. In doing so some important validation concerns were discovered.

To get the login details per user, an additional query was executed from the database on the logins table. The following query was designed and implemented:

```
SELECT user, COUNT(*) FROM logins GROUP BY user
```

The output of the query resulted in a login count for every participant in the DDL. The next step, which was using SPSS to run a data variable merge, was not only to match login counts with the correct users, but also to exclude records from participants from other schools not in this sample. Using an SPSS process, variables were excluded and matched from the new data source to the existing data source. Data were matched based on the username variable used as the keyed table. If the username existed, the login count (raw number) was added to the new variable in the data set. Coleman (2008) outlines this merge procedure in his article on merging data sets in SPSS.

Sample data were extracted January 1, 2016. It is important to make that distinction since the data source is live and continuously added to by participants. After data extract, the next step was to identify the variables in question, then import them into the SPSS software for regression analysis. Some variables (previously highlighted in Table 3.2) were transformed and recoded into categorical and ordinal variable types to run additional regressions.

Design

This study employed an observational descriptive research design with multiple models designed to answer each respective question formulated by the study hypotheses. Descriptive statistics (means, standard deviations, frequencies and cross-tabulations) were also reported for all variables.

An ex post facto research design was used to explore the input type and its relationship to several dependent variables. Data were collected using the aforementioned platform for learner interaction in an online open distance education course. After the data were collected, descriptive statistics were generated, and a 2x2 Chi-square tests were calculated. A Chi-square test of association and independence determined whether one variable was associated with another variable.

Linear regression models were also generated to answer research hypotheses 2 and 3. Regression estimates were used to describe the data and to explain the relationship between one dependent variable and one or more independent variables. Central to the regression model was the task of analyzing the correlation and directionality of the data, estimating the model fit, and evaluating the validity and usefulness of the model. The model for hypotheses 2 and 3 also included interaction terms with the dependent variables. Interactions occur when the relationship among two or more variables was considered. The interaction terms also helped describe situations in which the simultaneous influence of two variables on a third proved to not be additive. The presence of a significant interaction could have indicated that the effect of one predictor variable (i.e., input method) on the response variables (i.e., attempts, average score, score range) was different at different values of the other predictor variable (i.e., learner control level). Adding a term to the linear regression model in which the predictor variables were multiplied tested this assumption.

Group Characteristics

This research focused on two primary groups: haptic interactivity group and the comparison group of traditional interactivity. Both groups had access to the course equally by all measures and both groups displayed different levels of learner control. All instruments in the course were used with both groups. Through the data retrieval process several learner profiles or groups emerged and were coded as such (see Figure 3.4).

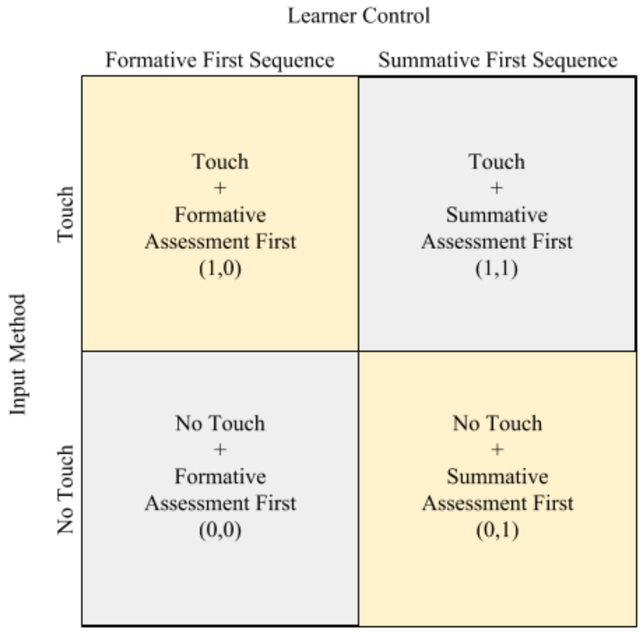

Figure 3.4: Emerging groups from the data disaggregation process

Description of Group 1 (Independent Group—Haptic Input)

Learners were given access to the course in the DDL. The device they used to participate in the course had touch screen access. This group was secondarily dichotomized by their choice in learner-controlled sequencing, whether they took the summative assessment prior to the formative or vice versa.

Description of Group 2 (Comparison Group—Traditional Input)

Learners were instructed on how to access the course. The device they used to participate did not have touch screen access. This group was also secondarily dichotomized by their choice in learner-controlled sequencing, whether they took the summative assessment prior to the formative or vice versa.

Summary

This research was based on a comparison of distinct, self-selected, groups of students (traditional input taking formative assessment first, traditional input taking summative assessment first, touch input taking formative assessment first, and touch input taking summative assessment first) that was suited to the research design. Database mining, regression, and descriptive statistical analyses were conducted to compare the test scores, test attempts, and score range of students who used haptic input devices versus those who did not, as well as students who exercised different levels of learner control. A premise for this research could be that learners using touch screen haptic input in an online distance education course would not display any more or any less learner-controlled sequence interactivity with digital content. Further, that learners would define appropriate sequence choices in an online distance education course based on achieved success with fewer attempts and a lower range of scores. Finally, learners using touch screen haptic input in an online distance education course could achieve the same success as learners using traditional input methods with high scores, fewer attempts, and a lower range of scores. The results of the data analysis are represented in Chapter Four.

CHAPTER 4

RESULTS

The purposes of this study were to determine if there are differences in how a learner interacts with digital content in an online course based on the type of input methods used. Input methods are correlated to the capabilities of the type of device used by the learner. Based on the availability and popularity of modern touch screen technologies, haptic input has become a prevalent option during prescribed digital learning activities. The data being presented in this chapter will be demographics of the participants, descriptive statistics, correlations between variables, and the hypotheses testing. All statistical analyses were conducted using the Statistical Package for the Social Sciences 23 (SPSS).

Research Questions

This study sought to answer the following questions:

1. Is there a difference in learner-controlled sequence interactivity in an online open distance education course based on the input methods being used to access the course?
2. Do learner choice on sequence (a learner control element) and input type have a significant effect on assessment score range, which is used as an indicator of performance?
3. Do learner choice on sequence (a learner control element) and input type have a significant effect on the number of assessment attempts, which is used as an indicator of performance?

The following hypotheses were tested in this study:

Hypothesis 1: There is a no significant difference on learner-controlled sequence in learners interacting with digital content through haptic input when compared to learners who are interacting with digital content through traditional input.

Hypothesis 2: There is no significant difference in the score range on assessments in an online open distance education course when comparing the two different input type groups and learner-controlled sequence.

Hypothesis 3: There is no significant difference in the number of assessment attempts in an online open distance education course when comparing the two different input type groups and learner-controlled sequence.

Demographic Data

All statistical analyses were conducted using the Statistical Package for the Social Sciences 23 (SPSS). Through a data cleansing process, 180 records were eliminated from the data set for either being duplicate records or for having missing variables. The SPSS "identify duplicate cases" process, keying on the Assessment ID variable, found 22 duplicate records in the data set. Additional cleansing eliminated records from the data set that had missing data in any of the following variables: input type, location, school level, account level, and number of attempts. Missing data in the input type and location fields is explained by assessments being taken prior to the platform automatically capturing this metadata along with user interaction. There were 14 records with missing input type data and 15 records with missing location data (see Table 4.1). Missing school level and account level data are explained by user error upon account creation process. For a brief period of time, it was possible for a user to create an account without self-identifying as a student or teacher. That has since been resolved in the account creation workflow.

Table 4.1

Classification of Participant Observations by School Level and Location

Variables	N(4746)	%
School Level		
Middle School	2868	60.4
High School	1878	39.6
Location		
On Campus	2467	52
Off Campus	2279	48

Note: Missing data in four key variables per record were removed for analysis resulting in 54 records being eliminated (N = 4926-180 = 4746).

Further, there were 11 records with missing account level data and were eliminated. School level missing account information remains a possibility, as users do not have to indicate if they are attached to a specific district or school. There were 20 records with missing school level data. Additionally, there were 126 records with zero attempts. This occurred by the learner saving an attempt, but not submitting it. The 126 records with zero attempts were also eliminated. Upon completion of the data cleansing process there were 4,746 eligible assessment records to be studied from the original 4,926.

In the specific module that was studied on digital law, rights, and responsibilities there was one summative assessment and two formative or practice assessments. Due to the presence of multiple assessments in the studied module, there was a total of 2,266 individual learners who took 4,746 different assessments, accumulating a total of 19,365 assessment attempts. This resulted in an average of 4.08 attempts per participant, per assessment.

Table 4.2 highlights the descriptive details of the 4,746 assessment records participating in the study. Of the assessments, 21% were completed using haptic input devices, while the remainder 79% used traditional (non-haptic) input devices. Learners chose to take the formative or practice assessments prior to attempting the summative assessment 71.6% of the time. The learner-controlled sequence of formative (or practice) assessments suggested that, when given a choice, learners worked through the practice and learning content prior to even attempting the summative assessment.

Table 4.2

Number of Assessments and Attempts by Input Type and Learner-Controlled Sequence

Variables	Assessments	%	Attempts	%
Input Type				
Touch Input	1015	21.4	4168	21.5
No Touch Input	3731	78.6	15197	78.5
Sequence				
Formative First	3383	71.3	13585	70.2
Summative First	1363	28.7	5780	29.8

Note: Assessment N (4,746); Attempts N (19,365)

The percentages of attempts on input type were near identical when compared to the data on over all assessments. Specifically, there was no difference between assessments and attempts per assessments when identifying the input type (touch input versus no touch input). However, there was a slight difference (+/- 1%) when comparing the number of assessments and the number of attempts per assessment of the learner-controlled sequence selection group.

Outcome Measures

This subsection presents the score, attempts, attempts mean, score range, summative assessment observations, and includes descriptive statistics of the data gathered, including a summary of each variable. Table 4.3 highlights variables resulting from general interactivity in the module.

Table 4.3

Descriptive Statistics of Interactivity Variables

	N	Mean	Std. Deviation	Variance
Score	4746	61.35	37.379	1397.222
Attempts	4746	4.08	4.882	23.832
Attempts Mean	4746	51.07	32.188	1037.074
Score Range	4746	19.52	23.415	548.254

Note: Attempts Mean is the mean of the list of scores per assessment attempt.

Score

Every assessment attempted by participants in this study resulted in an achievement score, represented in the form of a percentage, and was based on the number of questions in the assessment. The assessment score variable in this study, while not used in the hypothesis testing procedures, was used as a descriptive variable to learn more about the dependent groups being tested. The mean for all observation scores was 61.35 and the standard deviation was 37.379.

Attempts

The attempts variable refers to the number of attempts by a learner per assessment. Each assessment observation has at least one attempt. The attempts mean was 4.08 and the standard deviation was 4.882. The number of attempts was used as a primary dependent variable in the hypothesis testing procedures.

Attempts Mean

The attempts mean variable represented the mean of the individual scores captured per attempt in a single assessment by each unique learner. The mean score of the attempts mean was 51.07 while the standard deviation was 32.188.

Score Range

When analyzing the string of scores per attempt on a single assessment per learner, the score range scale variable represented the difference between the lowest score and the highest or final score. The mean of the score range was 19.52 and the standard deviation was 23.415. The score range was used as a primary dependent variable in the hypothesis testing procedures.

There were 3,731 observations where traditional input methods were used in the online distance education course, as well as the 1,015 touch input observations. As identified in Table 4.4, the touch input group had a mean score of 64.04. Whereas the traditional input group had a mean score of 60.62. The traditional input group recorded 4.07 mean attempts and a score range of 19.45 and the touch input group had 4.11 attempts with a 19.78 score range.

Table 4.4

Input Type and Learner Control Sequence Means for All Assessments by Score, Attempts, Attempts Mean, and Score Range

Sequence		Score	Attempts	Attempts Mean	Score Range
Traditional Input	N	3731	3731	3731	3731
	Mean	60.62	4.07	50.41	19.45
	Std. Deviation	37.665	4.960	32.384	23.630
	Minimum	0	1	0	0
	Maximum	100	54	100	100
Touch Input	N	1015	1015	1015	1015
	Mean	64.05	4.11	53.48	19.78
	Std. Deviation	36.200	4.583	31.357	22.617
	Minimum	0	1	0	0
	Maximum	100	34	100	100
Formative First	N	3383	3383	3383	3383
	Mean	54.36	4.02	43.89	20.02
	Std. Deviation	40.46	4.90	33.20	23.91
	Minimum	0	1	0	0
	Maximum	100	54	100	100
Summative First	N	1363	1363	1363	1363
	Mean	78.71	4.24	68.87	18.30
	Std. Deviation	19.50	4.83	20.68	22.09
	Minimum	0	1	0	0
	Maximum	100	35	100	100

Table 4.4 further highlights the 1,363 observations accounting for the summative first learner control sequence group and the 3,383 observations for the formative first

learner control sequence group. The average of the attempts mean for the summative first group was 68.87 compared to 43.89 of the formative first group. The maximum number of attempts in the formative first sequence group was 54, while the summative first sequence group saw a maximum number of attempts top out at 35. Score range for the summative first group was 18.30, while the formative first group had a mean score range of 20.02.

Summative Assessment Observations

A foundational design element in the online distance learning course was that summative assessments were required to be completed, while formative assessments were optional. An observation selection process was completed to compare mean differences of required assessments only. When comparing summative assessments only, the differences of the groups were more exaggerated. Table 4.5 emphasizes the touch input group having an 82.72 mean score, 5.18 attempts, and a 22.50 score range compared to the traditional input group performing at an 82.46 mean score with 5.46 mean attempts, and a score range of 23.22. Further, when comparing the learner control sequence groups, the summative first group performed at a mean score of 83.04 with 4.44 attempts, and a 19.14 score range. While the formative first group had a mean score of 82.00, 6.36 attempts, and a 27.00 score range.

Table 4.5

Input Type and Learner Control Sequence by Summative Assessments Only

	N	Score	Attempts	Score Range
Traditional Input	1918	82.46	5.46	23.22
Touch Input	574	82.72	5.18	22.50
Formative First	1241	82.00	6.36	27.00
Summative First	1251	83.04	4.44	19.14

Test of Hypotheses

In this section the three primary hypotheses were tested. Hypothesis 1 assessed the independence of the group variables, input type and learner-controlled sequence. While Hypothesis 2 and 3 examined for significant performance indicators within the groups and observed interactions between the groups.

Hypothesis 1

The purpose of testing Hypothesis 1 was to establish the validity of the distribution assumed for a random phenomenon prior to testing Hypothesis 2 and Hypothesis 3. The Hypothesis 1 test evaluated the null hypothesis, that the data are governed by the assumed distribution, against the alternative, that the data are not drawn from the assumed distribution (Yale University, 1987). This study's first hypothesis was as follows: *There is a no significant difference in the learner-controlled sequence selection of learners interacting with digital content through haptic input when compared to learners who are interacting with digital content through traditional input methods.* To test the hypothesis, a 2x2 Chi-square test was performed to test the probability of independence of two dichotomous independent variables (input type and sequence). This is a "goodness of fit" statistic measuring how well the observed distribution of data fits with the expected distribution if the variables are independent or not related. As previously explained, the “input type” is metadata that is automatically tagged to a record every time a learner signs in to the platform. The “input type” is gauged by the device type and browser type and is binary, either traditional input or haptic input. The “sequence” independent variable is identified by the learner-controlled choice a user makes when deciding to attempt a summative assessment before engaging in practice or formative content or vice-versa. The variable is binary, either summative first or formative first. Of the 4,746 records in the distribution, 2,711 attempted formative assessments first through traditional input, while 672 attempted formative assessments first through haptic input (see Table 4.6). Respectively, 1,020 attempted the summative assessment first through traditional input, while 343 attempted the summative assessment first through haptic input. The expected counts were based on the ratio of the overall traditional and haptic rates. For example, for the summative first learner control sequence, there were 1,072 expected ((3731/4746)*1363 = 1,072) summative first traditional input observations. For the formative first learner control sequence, there were 2,660 expected ((3731/4746)*3383 = 2660) formative first traditional input observations.

Table 4.6

Distribution of Input Type by Learner Control Sequence

			Input Type		Total
			Traditional	Haptic	
Sequence	Formative First	Count	2711	672	3383
		Expected Count	2660	724	3383
	Summative First	Count	1020	343	1363
		Expected Count	1072	292	1363
Total		Count	3731	1015	4746
		Expected Count	3731	1015	4746

As seen in Table 4.7, there is a significant association between the sequence in which learner takes an assessment and the type of input (haptic or traditional) used to interact with the course. Sequence is not independent from input type. Sequence is statistically dependent on the input type used by the learner, as a significant relationship was found ($x^2 (1) = 20.287$, $p < .001$). Thus, the experiment rejected the null hypothesis because the observed distribution did not fit the expected distribution if the variables had been unrelated. The analysis did not indicate whether the groups are meaningful or provide any detail about the relationship between the variables, simply that the factors are related, dependent upon each other, and form defined groups. The four defined and distinct groups were the formative first touch group (FFT), the formative first no touch group (FFNT), the summative first touch group (SFT), and the summative first no touch group (SFNT).

Table 4.7

Chi-Square Test for Hypothesis 1

	Value	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	16.239[a]	.000	
Continuity Correction[b]	15.925	.000	
Likelihood Ratio	15.870	.000	
Fisher's Exact Test			.000
N of Valid Cases	4746		

Note: (a) 0 cells (.0%) have expected count less than 5. The minimum expected count is 291.50. (b) Computed only for a 2x2 table.

Even though there were fewer overall observations, there was a higher percentage of learners who used a haptic input device in the summative first sequence group (25%) and statistically more than expected, than in the formative first sequence group (20%). Additionally, there were fewer observed cases in the formative first sequence group who used haptic input devices than statistically expected. The results of this study indicate that input type and learner control sequence are related. It can be concluded from the Chi-square results that each of categories formed are distinct. Based on the identification of four distinct categories (FFT, FFNT, SFT, SFNT), Hypotheses 2 and 3 testing could proceed with greater fit confidence.

Hypotheses 2 and 3

Based on the examination of the distribution used in this study, prior to testing the second and third hypotheses, only the observations that represented no prior knowledge, as well as, non-zero scores were selected. Additionally, due to the course design being a mastery model, data set normality was achieved by running a variable transformation process for the attempts dependent variable. Appendix D highlights the complete data set normality results (see Tables D.1 and D.2). Content prior knowledge was represented by observations in the summative first sequence with only one attempt resulting in a passing score. Zero scores that were removed prior to hypotheses testing were represented by zero scores in the overall assessment score and zero scores in the score range variable, indicating only one attempt prior to passing regardless of the learner control sequence group.

Prior Knowledge Assumptions

Based on the examination of the observations an assumption of available or existing prior knowledge of the assessed content by the learner could be formulated. Due to "learning novel content" forming a primary tenant in the cognitive theory for multimedia learning's learner control principle (Mayer, 2005; Paas et al., 2010), it was important to understand the observations in which the learner brought forth a previously acquired understanding of the skills being assessed. A selection process was completed of summative observations where the learner attempted the summative assessment first, had only 1 attempt, and scored an 80% or greater (prior knowledge = (sequence = 1 & assessment type = 1 & Attempts = 1 & Score >= 80)). For testing purposes, identification was placed on records where there was an availability of prior knowledge, prior knowledge was limited, or altogether lacking. Of the 4,746 observations, 486 met the requirements set forth by the prior knowledge assumption (having knowledge of the content prior to engaging in the distance education course). Of the remaining observations, 4,260 records in the data set were identified as lacking prior knowledge and not passing the summative assessments with minimal attempts.

Zero Scores

Further examination of the observations found 1,205 records from 1,106 unique learners in the data set had a zero score for the assessment and the score range. Of which, 1,138 were obtained from formative assessments, while 67 were from the summative assessment. Overall, there were 2,033 attempts that resulted in a zero score. This is explainable by the nature and design of the formative assessment. Nearly all (99.6%) of the zero scores were from a formative assessment where questions of familiarity were asked pertaining to specific scenarios. While not having correct or incorrect answers, and therefore not assigning a score, the feedback responses ultimately resulted in the learner gaining further knowledge and understanding about the presented scenarios. In this assessment, even though no scores were assigned upon interactivity with the content, learners reset and answered the questions, which increased their number of attempts, after receiving feedback. Observations were removed for hypothesis testing where these conditions were met.

Hypotheses 2 and 3 Model

The second and third hypothesis in this study focused on the relationship of the dependent variables and the results of the interaction with the content in the course, as performance indicators. Hypothesis 2 was as follows: *There is no significant difference in the score range on assessments in an online open distance education course when comparing the two different input groups and learner-controlled sequence groups.* Hypothesis 3 was as follows: *There is no significant difference in the number of assessment attempts in an online open distance education course when comparing the two different input groups and learner-controlled sequence groups.*

A general linear model routine with a regression analysis was used. Two separate two-way Analysis of Variance (ANOVA) tests were performed using the multiple linear regression framework. The terms used in the regression were input type, learner control sequence, score range, and number of assessment attempts (see Figure 4.3). Due to having multiple dichotomous factors (independent variables), the two-way ANOVA was deemed appropriate. In this study, the two-way ANOVA compared two or more factor variables (e.g., input type and learner control sequence) by one continuous response variables (e.g., score range and number of attempts) at a time.

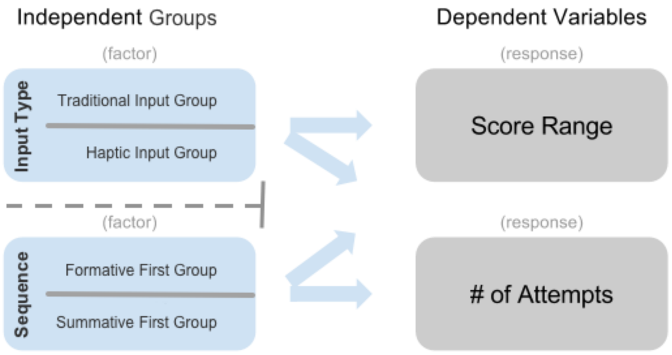

Figure 4.3: Two-way ANOVA by two separate factors and two responses

Following the regular statistical practice (Norton, Wang, & Ai, 2004), an interaction term was created between the two dichotomous independent variables. The interaction term was designed to examine if learner control sequence depended on input type for outcome (dependent) variables of number of attempts and score range. If the interaction term was statistically significant, then the sequence effects depended on input type. If the interaction term was not statistically significant, then the sequence effects did not depend on input type.

Results for Score Range

The score range dependent variable was used in Hypothesis 2 testing. Table 4.8 includes the results of the Hypothesis 2 ANOVA test and highlights that the interaction term between the effects of the two independent variables was not significant ($p \geq .05$) and therefore found no simple main effect between the two independent variables.

Table 4.8

ANOVA Tests of Between-Subject Effects for Score Range (Hypothesis 2)

	Mean Square	F	Sig.	Partial Eta Squared
Input Type	1186.270	3.127	.077	.001
Sequence	16783.020	44.246	.000	.017
Input Type* Sequence	5.232	.014	.907	.000

Based on the results of the ANOVA found in Table 4.8, there was no statistically significant difference between the two different input types (touch input and no touch input) and the overall score range ($p \geq .05$). However, there was a statistically significant difference in the learner-controlled sequence groups based on the performance measures of the score range ($p \leq .05$). Therefore, due to the main effect in learner-controlled sequence, this study rejects null Hypothesis 2 using score range as a performance indicator. There was a main effect established for the learner-controlled sequence groups (formative first, summative first), but no main effect found for input type groups (touch input, no touch input).

Results for Number of Attempts

A secondary performance measure that was established due to learners having the option of attempting the assessments until mastery was the logged number of attempts.

The number of attempts dependent variable was used in Hypothesis 3 testing. Table 4.9 includes the results of the Hypothesis 3 ANOVA test and highlights the two independent variable groups, input type (touch input, no touch input), sequence type (formative first, summative first), and the interaction term between the effects.

Table 4.9

ANOVA Tests of Between-Subject Effects for Number of Attempts (Hypothesis 3)

	Mean Square	F	Sig.	Partial Eta Squared
Input Type	.114	1.150	.284	.000
Sequence	.847	8.558	.003	.003
Input Type* Sequence	.161	1.625	.202	.001

Based on the results of the ANOVA shown in Table 4.9, there was no statistically significant difference between the two different input types (touch input, no touch input) and the number of attempts ($p \geq .05$). However, remaining consistent with Hypothesis 2 testing, there was a significant difference in the learner controlled sequence groups based on the performance measure of number of assessment attempts ($p \leq .05$). Therefore, due to the main effect in learner controlled sequence, this study also rejects null Hypothesis 3 using number of attempts as a performance indicator. There was no main effect found for input type groups (touch input, no touch input), no simple main effect found between both independent groups, however, there was a main effect established for the learner controlled sequence groups (formative first, summative first).

Summary

In this chapter, participant demographics, descriptive statistics, prior knowledge assumptions, rationale for exclusion of zero scores, observation normality statements, hypothesis testing, as well as results, were presented. The analysis of the results showed that the initial hypothesis, that there is a significant difference on learner-controlled sequence in learners interacting with digital content through haptic input when compared to learners who are interacting with digital content through traditional input methods, was supported by the data gathered. There was a statistical relationship between input type used and learner control sequence.

The secondary analyses in this study focused on the relationship of the two dependent variable groups and the results of the interaction with the content in the course (i.e., score range and number of attempts). The hypotheses were separated into two different statements to account for both tested variables. The analysis of the results showed that the hypothesis, that there is a significant difference in the score range on assessments in an online open distance education course when comparing the two different input groups and learner-controlled sequence, was not supported by the data for learner-controlled sequence. However, the results of the analysis did support the difference in the two different input type groups. Further, the analysis of the results for the hypothesis, that there is a significant difference in the number of assessment attempts in an online open distance education course when comparing the two different input groups and learner-controlled sequence, was not supported by the data for the learner-controlled sequence groups. However, was supported by the data for the input type groups. The decisions a learner makes, in terms of content sequence in an online and distance education course are significantly related to the number of attempts it takes to pass assessments and the score range of those attempts. Conversely, the input type provided by the device a learner uses was not significantly related to either the number of attempts it takes to pass assessments, nor the score range of those attempts.

There were 2,266 unique learners in the study who took 4,746 different assessments and accumulating a total of 19,365 assessment attempts. Of the 2,266 learners, 1,142 took the summative assessment first and had statistically fewer attempts on the required summative assessment than learners who attempted the formative assessments first. When comparing all assessments (both formative and summative), the touch input group had higher scores (including almost a three-point higher score per attempts mean) than the no touch or traditional input group. Whereas the traditional input group had slightly fewer attempts and a slightly lower score range. While not statistically significant, when observing summative assessments only, the touch input group had slightly higher scores, with fewer attempts, and a lower score range. The lower score range indicates that the lowest attempt score was not as low as the no touch or traditional input group. However, attempts before passing was lower from the touch input group observations. Furthermore, when comparing the learner control sequence groups, the summative first group performed better with higher scores, almost two fewer attempts (on average), and a lower score range, which was statistically significant.

When analyzing the descriptive statistics for these group observations, the average of the attempts mean was 25 points higher for the summative first sequence group. Of importance, the maximum number of attempts in the formative first sequence group was 54, while the summative first sequence group saw a maximum number of attempts top out at 35.

The results of this study indicate that input type is not a significant factor in assessment performance in an online distance education course. However, the content sequence a learner preferred was a significant performance factor. Lastly, the effect level of identified input type did not depend on the effect level of sequence chosen as there was no interaction between the two binary and independent attributes.

In the following chapter, the implications of the analysis will be discussed, along with fidelity of the experiment, limitations of the study, and recommendations for future research.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to determine whether there is a relationship and significant difference in the performance of distance education students who exercise learner control interactivity effectively through a traditional input device versus students who exercise learner control interactivity through haptic methods. Given the lack of consistency and agreement found in the literature, which has produced ambiguous results (Kalyuga, 2012), as well as the consideration of the advancement of today's new technologies used in the learning, this experiment intended to help address the ever-expanding field of digitally enhanced online distance learning.

This chapter discusses the results of the study, including the hypotheses tests, conclusions considering the literature review, the study's limitations and future corrections, recommendations for future research, and a summary of the comprehensive research project.

Summary of the Study

The research in this study involved four groups: (1) a touch input formative assessment first group; (2) a touch input summative assessment first group; (3) a non-touch input formative assessment first group; and (4) a non-touch input summative assessment first group. All groups were given access to an open online distance education course and self-selected into the groups based on personal preferences of learner-controlled sequencing and the input methods of the device they used to interact with the platform. The two formative assessment groups navigated a traditional sequence based on being exposed to content first, then after learning some base information taking a summative assessment. The summative assessment first groups launched directly into the summative assessment and submitted answers to questions. Based on their results, either attempted it again or navigated back through the learning content prior to submitting additional attempts.

To determine the effects haptic interactions and learner control sequence choices had in the online distance education course the metadata from the course was analyzed. This study included two primary independent variables that were examined relative to impact on score range and number of attempts in assessments throughout one module of the course. Additionally, performance measures were uncovered to gain additional insights on decisions learners made while participating with digital content.

Hypotheses Conclusions

Based on the data gathered and the analysis conducted, the study's hypotheses, while grounded on no significant differences, were mostly rejected. There is a significant interactivity association between haptic input and learner control sequence selection. Further, while there is little significance in input method (touch or no touch input) and performance in an online distance education course, there is a significant difference in learner control sequencing choices and performance. This was measured through a general linear model routine with regression analyses that were found to be significantly different between the two learner control sequence groups using the response performance measure variables. The previous researchers' theories that haptic input interactivity had no significant impact (Wang et al., 2010) has been confirmed in the current study. These findings challenge the results of Krcmar and Cingel (2014), Zack et al. (2013), who found negative results when testing haptic input, and the positive results of Sung and Mayer (2013), who found increases in student motivation with haptic input devices and learning activities. More importantly, preceding researchers' theories on the negligible effects of promoting full learner control (Karich et al., 2014; Scheiter & Mayer, 2014) were not supported by the current study. This current study found that providing full learner control in sequencing, under certain conditions, had a positive benefit for the learner and had significant performance and outcome measure differences between the two groups. The following is a breakdown of hypotheses conclusions considering the literature review.

Hypothesis 1

This study's first hypothesis was as follows: *There is a no significant difference in the learner-controlled sequence selection of learners interacting with digital content through haptic input when compared to learners who are interacting with digital content through traditional input methods.* The results of this analysis rejected the hypothesis and proved that there is a significant relationship between the two independent variables, combining to form four distinctly significant groups of learners. The analysis did not indicate whether the groups were meaningful, nor did it provide any detail about the relationship between the variables; simply that the factors were related, dependent upon each other, and formed distinct and defined groups. The four groups that formed were: (1) learners who use touch input methods and attempt the summative assessments first; (2) learners who use touch input and attempt the formative assessments first; (3) learners who use traditional input methods and attempt the summative assessment first; and (4) learners who use traditional input methods and attempt the formative assessments first.

The literature is limited with experiments testing the association between both input methods and learner control. However, separately, there is an abundance of literature and experimental research on the topics as separated. One experiment (Sung & Mayer, 2013) indirectly tested this, but from the perspective of cognitive load effect of mobile technology versus traditional stationary technology. Sung and Mayer (2013), in testing for a media effect of mobile tablet haptic input learning experiences versus that of traditional input desktop experiences, found that the mobile groups produce stronger ratings than the desktop groups on self-reported willingness to continue learning, yielding a media effect on motivational ratings. Two main differences in the Sung and Mayer (2013) study and the study completed by this researcher are that the aforementioned study was based on media differences in mobility and measuring cognitive load effects through pre-, post-, and delayed post-testing while this researcher focused on haptic input and learning outcome or performance measures.

In the current study, based on the results of the Chi-square analysis, this researcher found that more haptic input learners than statistically expected—17% more—attempted the summative assessment before interacting with the formative assessment learning content. Instructionally, there was an untested expectation that learners would generally navigate and engage with content before testing themselves. This could be due to a similar media effect findings as the Sung and Mayer (2013) study, based on motivation ratings. However, as suggested by other experts (Henderson & Yeow, 2012; Neumann & Neumann, 2014; Rosin, 2013), it could also be related to possible ease and freedom of navigation of content while directly behind a digital screen, which needs further testing.

Hypothesis 2 (Score Range)

This study's second hypothesis was as follows: *There is no significant difference in the score range on assessments in an online open distance education course when comparing the two different input groups and learner-controlled sequence groups.* The analysis for Hypothesis 2 was conducted using the same testing model as Hypothesis 3, but with a different outcome variable. Through testing, Hypothesis 2 proved to have some significance and therefore rejected the null hypothesis. Having full control over sequence decisions, learners in this study produced a main effect by examining the score range as a performance measure. Secondarily, the results of the analysis did not find a main effect with input type (touch and no touch input), nor did the analysis find an interaction effect, as the effect of input type did not significantly impact the effect of the learner-controlled sequence selection. There was no significant interaction between the two independent variables and overall learner outcome. This finding is aligned with the research from Wang et al. (2010), which indicates from a learner-centric perspective, there is no positive or negative effect from using touch input to interact with digital content. These results imply that instructional designers should limit or eliminate concerns on the input methods used to interact with instructional content. However, instructional designers should attend to learner-controlled sequence elements when designing digital content for distance learning. If learner-controlled sequence options are not given to the learner, then designers should adhere to proven models of mastery learning and assessment, where summative assessments are evaluation procedures that are used to appraise the outcomes of instruction and help the learner know their level of understanding (Bloom, 1968). This type of assessment can inform the learner of their mastery of the subject, and under certain conditions, can help build motivation and self-regulation skills.

Hypothesis 3 (The Number of Attempts)

The analysis for Hypothesis 3 was conducted using the same testing model as Hypothesis 2, but with a different outcome variables, the number of assessment attempts. The third hypothesis was as follows: *There is no significant difference in the number of assessment attempts in an online open distance education course when comparing the two different input groups and learner-controlled sequence groups.* The analysis for Hypothesis 3 was conducted using the same testing model as Hypothesis 2, but with a different outcome variable. Conversely, the results of Hypothesis 3 testing also rejected that there was no difference in the outcome effects due to the learner-controlled sequence groups. There were significant effect differences in the learner-controlled sequence selection the performance outcome variable and the number of assessment attempts. Broadly, the literature provides little empirical evidence (Gerjets et al., 2009; Lunts, 2002; Scheiter & Mayer, 2014) that supports or abandons the promises of providing learner control. However, under defined conditions, this study did indeed discover main effect evidence. Equally, Hypothesis 3 testing also found no effect with input type and no interaction effect when using the number of assessments as a performance measure.

Hypotheses Conclusions General Summary

A foundational design element in the online distance education course was that summative assessments were required to be completed, while formative assessments were optional. When comparing summative assessments only, the differences of the groups were more exaggerated. Comparisons in the learner control sequence groups identified that the summative first group performed better. This group performed with a mean score of 83.04 with 4.44 attempts, and a 19.14 score range on the summative assessment. While the formative first group had a mean score of 82.00, 6.36 attempts, and a 27.00 score range on the summative assessment. Score range differences between the two groups identified a 41% increase in the formative first sequence group. Final results indicated higher scores, a lower score range with more than two fewer attempts was unexpected and significant. In general, an instructional designer might assume that forcing a learner through a linear model of content presentation would produce a lower score range and fewer attempts. For example, learners who received instruction and are exposed to content prior to taking an assessment should show lower score ranges, which is the difference between their lowest score attempt and their highest score attempt. However, the observations in this study proved the opposite. Learners who attempted the final assessment first, before engaging in the structured learning content, performed better with higher scores, fewer attempts, and with greater learning efficiency than their counterparts. This can be explained by the fact that learners were given a choice, which then produced benefits in allowing for them to build self-regulation skills. Results suggest that despite the lack of empirical evidence in the literature, allowing for learner control can be beneficial for some learners under specific conditions.

Learner control boundary conditions. This study aligns with others in that prior knowledge is a foundational component and boundary condition in the learner control principle. As Scheiter and Mayer (2014) express, prior knowledge may help the learner to make smart decisions, that is, skipping only the information the learner already knows, selecting only relevant and helpful information, and avoiding distraction. This study found that while 50% of all learners felt that they were ready and attempted to prove prior knowledge, only 21% possessed the skills to successfully complete the performance event. Therefore, 474 of the 2,266 participants met the conditions set for having prior knowledge and passed the summative assessment in one attempt, prior to attempting the formative assessment. Not having the option to choose a sequence that was most appropriate for 21% of the participants could have produced distraction, frustration, and lower efficiency due to the module used in this study, only accounting for one of six. This is opposed to the linear nature of a program- or system-controlled experience, where every learner systematically works through the same content in the exact same sequence. The results of this study's perspective on prior knowledge also suggests alignment with cognitive load theories expertise reversal effect (Kalyuga, 2007; Salden, Aleven, Schwonke, & Renkl, 2010; Si, Kim, & Na, 2014). The expertise reversal effect has been described as the relative variation in effectiveness of instructional methods as levels of learner prior knowledge change. Designs and techniques that are effective with low-knowledge learners can lose their effectiveness and even have negative consequences for more proficient learners (Kalyuga, 2007).

Findings on the four premises of the learner control principle. The literature suggests that the learner control principle comprises of four main premises relating to theorized positive effects. First, learner control is supposed to aid learning because it provides opportunity for an active and constructive processing of information (Scheiter & Gerjets, 2007). This is a foundational statement for the broad notion of interactivity. Regarding the first premise, this study found that by providing opportunity for interactivity there were positive effects. The second premise of the learner control principle is that learner-controlled instruction is assumed to aid learning because it improves and sustains the motivation to learn (Moos & Marroquin, 2010). In alignment with the literature, the findings from this current study, while not explicitly, do indicate that by choosing to attempt the summative assessment first, learners perform better. In fact, the third and fourth premises of the learner control principle are supported, as well. They suggested that learner control aids learning because it helps learners develop and improve their skills regarding self-regulated learning and customize their personalized instruction to meet their goals, needs, and preferences (Scheiter & Mayer, 2014). The results from this study supported these assumptions in that learners who attempted the summative assessments first were more efficient than learners who worked through the formative content first, with a 7.3% decrease in score range). Further, the summative first sequence learners averaged two fewer attempts on the summative assessments (4.4 average attempts) than formative first sequence learners (6.4 average attempts).

In this study, if learning efficiency can be gauged by the number of attempts and score range, then based on the results, attempting the summative assessment first is a more proven path to greater success, even for learners with no or low prior knowledge (see Table 4.5). Secondary results of hypotheses 2 and hypotheses 3 testing found that the number of assessment attempts and the score range are significant performance indicators and, therefore, can assist in determining prior knowledge and learning efficiency.

Ten key conclusions from the hypothesis testing are highlighted in Table 5.1.

Table 5.1

Ten Key Conclusions from Hypotheses Testing

Number	Key Conclusion
1	10% of observations met the conditions for having prior knowledge and passed the summative assessment on one attempt, prior to going through the formative content.
2	Having the opportunity to prove prior knowledge is valid as opposed to a program- or system-controlled instructional design due to 50% of learners taking advantage of the opportunity.
3	There is a relationship between input type and learner-controlled sequence selection, but there is no interaction (between the two dependent variables and their performance results). Performance measures of learner-controlled sequence was not dependent on input type.
4	The number of assessment attempts and the score range are significant performance indicators and can help in determining prior knowledge and learning efficiency.
5	The input type a learner uses has no significant difference on performance.
6	If learning efficiency can be gauged by the number of attempts and score range, then attempting the summative assessment first is a more proven path to greater success (see Table 4.5), regardless of input type (1.6 points higher on final score).
7	Learners who attempted the summative assessments first were more efficient than learners who worked through the formative content first (7.3% decrease in score range).

Table 5.1, continued

Number	Key Conclusion
8	Content sequence interactivity is a more significant indicator of performance than haptic interactivity.
9	Summative first sequence learners averaged two fewer attempts on summative assessments (4.4 average attempts) than formative first sequence learners (6.4 average attempts).
10	More touch input learners than expected (17% more) attempted the summative assessment before navigating through the learning content.

Limitations of the Study

There are several limitations to be acknowledged regarding this study. This research study was conducted with metadata and interactivity data from a moderately homogenous single school district population participating in an online distance education course. Any conclusions made from this study should keep this limited scope in mind. However, the findings and protocol are scalable and could be reproduced for broader applications of this research where comparisons could be made. In addition to the aforementioned limitations, the following should be considered.

When possible, the researcher executed the data gathering processes and procedures as described in the proposal. The results could be due to several factors that should be addressed in the next study interested in a similar experiment. Some of these factors include the timing of the observations, technical issues, the length of the modules instructions given to the participants, as well as additional limitations. Since there continues to be an increased use of educational technology in schools with mixed results, understanding the potential factors and responses impacting this study is valued.

Timing of the Observations

The observations in this study were collected over a two-year time span with the majority occurring in the fall semester (78.23%) and spring semester (16.1%) on a traditional school calendar. During the time of the observation, there were no content updates made in the platform. Therefore, the researcher determined that from a timing control perspective, there was consistency in the experience of the learners throughout the observation data set. The experiment revealed that there were 269 observations accounting for 5.67% from 136 learners participated in a summer term. While the timing of the observations was not controlled, it was captured in the interactivity and could be tested in the future.

Technology Issues

There were no technology issues found in the study. During the time of this study, platform traffic patterns remained steady and consistent, and no significant help requests were submitted to the design team. As a design element in the platform, multiple measures for self-help were included, such as instructional videos on how to navigate the platform as well as self-service password reset options. Additionally, throughout the experience in the DDL platform, learners were notified through automated emails with multimedia informational messages for taking the next step in order to successfully complete.

The Length of Modules

All learners in the observation participated in the same module and in terms of the summative assessment, all learners answered the same 11 questions. Furthermore, all learners were exposed to all of the same learning content. However, due to the nature of interactivity and opportunities provided by learner-controlled choices the selection, sequencing, and pace dictated how long each learner spent in the course. Basic assumptions could be made by gauging the sequence selections and the number of assessment attempts. In other words, a learner with 10 attempts on each of the three assessments most likely spent a longer length of time than a learner who attempted and passed the summative assessment on the first try prior to engaging in any of the learning content. All learners were presented with a consistent length of module however, there were no controls in place to force a specific length of engagement nor does this researcher believe that would be a good idea in general practice. Forced length of time spent could be something to experiment with due to “forced length of class period” providing an interesting parallel. In other words, creating an online or digital requirement to match that of traditional schooling requirement (i.e., seat time).

DDL Participation Instruction

Based on the participation rate in the observations it was obvious that students were instructed on the requirement to successfully complete the online course. It is possible that students in different classes, with different teachers, received different instructions and supports. A controlled standard set of instructions were placed inside the platform. However, there is no guarantee that the instructions inside the course were attended to. There was no check for understanding of the course instructions. It is conceivable that learners could have been forced to review the instructions upon logging in. Since the period between when students received initial instructions and the actual time in which they started their participation was unknown, general teacher instructions could have been forgotten by the time they were ready to start the course. If instructions were embedded within the course, forced to review, and checked for understanding, the reminders could likely encourage deeper understanding of the platform used in this study.

Haptic Attribute versus Mobility

The identification process of metadata tagging logins based on a parsing activity of the user agent string was completed with confidence in this study. Upon logging in to the platform, characteristics such as the device operating system version, the device make and model, the browser version, and the screen size were logged to the user profile. This procedure provided the opportunity to know with confidence the observations that were completed using a touch input enabled device. However, not addressed in this research is the characteristic of mobility. While many mobile devices rely heavily on touch input, and statements can be made from this research on having access to mobile learning experiences, it was not a focus of this study. In fact, of the 1,015 observations tagged with having touch input, 54 (5%) observations would not be classified as *mobile* based on the device size or physical footprint (Norris & Soloway, 2011).

Additionally, tagged in the metadata for the studied observations was a dichotomously coded variable for location. The location was tagged based on on-campus IP addresses as opposed to off-campus IP addresses. The location of the student when completing an assessment, while not an exact indication of mobility, lends further understanding to the physical space of learning. While not a focus in this study, it could support the assertions of Sung and Mayer (2013) that learning with a mobile (touch screen) device in an informal environment leads to a greater willingness to continue studying new lessons, through motivation and preference, than learning with a desktop computer in a formal setting.

Screen Size

Some researchers have found that the physical screen size plays a significant role in success while learning online (Mercer, 2015; Norris & Soloway, 2011). However, screen size, even though it was captured in the metadata, was not a consideration in this study. Future studies could look at screen size as a contributing independent factor.

Devices with Multiple Input Options

In the data set, there were 54 observations that had multiple input options. In other words, the devices that were used to interact with the learning content functioned with both traditional input options (mouse or trackpad) as well as touch screen input options. This was primarily found with learners using Windows 8 or Windows 10 computers with touch screen options. For the purposes of this study, because the touch screen input was an option, these observations remained tagged as such. However, in future studies it would be ideal to either remove the 54 observations or do a closer qualitative study to understand which form of input was used most in the specific observations with multiple input options.

Adult Participation and Adult Learning

Early research on adult learning was framed around a central idea attempting to understand if adults could learn (Merriam, 2001). However, in the mid-20th century, research shifted to the study of adult learning being different than that of children. Knowles (1970) established a new wave of redefining adult learning theoretically as *andragogy*, having different characteristics than *pedagogy*.

Today, there is not consistent agreement to the degree that adult learning is different than student or child learning. However, as a researched theory, instructional design, especially with online and distance education platforms could account for the differences in adult learning theory. As a limitation of this study, the differentiation of adult learning theory and child learning theory was not addressed. Upon account creation, the platform did capture adult learners from student learners within the account metadata (i.e., the account level variable). Using similar models as used in this study, future research could uncover relationships and interactions between a dichotomous independent variable of account level. Sixty-three observations were recorded from adults in the original dataset. While the school district participating in the study did not require adult participation, it is worth noting that in the platform other schools and districts do require it. Adult participation in the platform continues to expand and is worth studying in the future.

Additionally, there was no qualitative control for the role adults played in this study. A previous pilot analysis in the platform indicated that there was a difference in interactivity in schools where adults (i.e., teachers) participated alongside child learners (i.e., students) versus a school where adults did not participate. There is an assumption that with adult participation there is an increase in conversation, motivation, and engagement. However, without adult participation learners are left to their own accord. An additional limitation of this study was that adults mainly played the role of tracking completion as opposed to participating in the learning content. Future research could be designed to gain further qualitative measures on adult participation alongside that of students.

Degrees of Prior Knowledge

Prior knowledge was accounted for in this study by identifying the observations that attempted the summative assessment first and performed successfully on the first attempt. The prior knowledge assumption used in this study identified these observations and excluded them from hypotheses testing. This was an element in the model design due to the importance that is placed on learning novel content in the cognitive theory for multimedia learning. Learning novel content forms a primary tenant in the cognitive theory for multimedia learning's learner control principle (Mayer, 2005; Paas et al., 2010). Therefore, it was important to understand the observations in which the learner brought forth a previously acquired understanding of the skills being assessed.

However, a limitation in this assumption is the extended degrees of prior knowledge, as prior knowledge is likely not a binary-coded assumption. Varying degrees of prior knowledge was not accounted for in this study. It was possible for a learner to successfully have passed the summative assessment on the second, third, or fourth attempt due to having some degree of prior knowledge of the content and therefore not be identified as *learning novel content*. Beyond a single successful attempt, accounting for varying degrees of prior knowledge could have been a limitation in the design of this study. A new prior knowledge assumption could be positioned in future studies using the number of attempts and the score range as factors. For example, beyond the initial attempt, if the successfully passing the summative assessment upon the second, third, or fourth submission of attempts and the score range was low (meaning the initial score and the final score were not that far apart), then a varying degree of a prior knowledge assumption could be proven with a low number of attempts and a low score range.

Incentivized Use of the Mastery Learning Platform

It is unclear if there was a connection in the mastery learning design with required successful completion and incentives being offered. Students in the observation set were incentivized with a school purchased computer to successfully complete the online distance education course by a specific date. It is unclear if being incentivized to complete the course played a role in the outcomes of participation. Further, while the mastery model itself can be seen as a limitation, both are worth noting as limitations for future research to consider.

Deeper Sequences and Subsequent Attempts

Important elements of the metadata captured for each learner were accomplished as the learner logged in to the platform. In short, every login was assigned a unique number and that number was attached to every assessment attempt. The central focus of this research study was on the initial sequencing decisions of the learner. More specifically, attention was placed on whether the learner's first choice was to attempt the summative assessment prior to attempting one of the formative assessments. The sequencing procedure only accounted for the initial sequence and the learner-controlled sequence was dichotomously coded. A limitation in this study was identified through all of the possible sequences and how they played a role in the success of the learner. Figure 5.1 illustrates all of the possible learner profiles that were observed in the data set used in this study, where "F" represents formative assessments and "S" represents the summative assessment.

Figure 5.1: Learner-controlled initial sequence combinations and permutations

The illustrated learner profiles are based on initial combinations and permutations of the three assessments designed in the specific module used in this study. Future research, modeled after this study, could further understand the impact of the deeper learner-controlled sequences within and between the assessments and the related content. For example, a permutation with the three assessments (one summative and two formative) could observe the learner navigating back and forth between subsequent attempts not just the combination and order of the initial attempt.

Randomization

This study was completed as an *ex post facto* research design and was used to explore the input type, the learner-controlled sequence, and their relationship to several dependent outcome variables within a pre-existing data set. A randomization limitation could have been identified for not randomly assigning input type and sequencing types to random participants. Random assignments were not considered in this study. Future research could randomly assign degrees of learner control to users as they log in. It is conceivable to tag a learner as having full control, partial control, or no control and present an experience based on that random assignment. To randomly assign input type (i.e., touch input or traditional input) additional resources would be required. In other words, different devices would need to be supplied in the study design as opposed to a design where the learner participates based on what they have access to. Further, randomization of study participants could be accomplished by randomly selecting users from any school or district across the platform as opposed to only selecting users from one identified and controlled school district.

Age or Grade Levels

The age or grade level of participating students was not a core part of the research design. A limitation could have existed in middle school students versus high school students in terms of interactivity and learner control sequence. Of interest, while the number of middle school students (1,148) was only thirty-two greater than the number of high school students (1,118), more middle school students attempted formative assessments. The metadata helped identify that 322 middle school students interacted with the content using touch input while only 282 high school students used haptic input devices. An excessive targeting of younger and inexperienced learners is one of the drawbacks of empirical studies on learner control. Research suggests (Lunts, 2002) that the age of participants may relate to how learner control affects instructional outcomes. It is possible that younger learners cannot sufficiently respond to greater degrees of learner control because their developmental level is not yet prepared to realize learner control elements.

In terms of learner control sequence, 384 middle school students (34%) attempted the summative assessment first (742 or 66% attempted the formative assessment first), where high school students proved almost the opposite in sequence. High school students accounted for 738 summative first sequence learners (66%) and 385 formative first learners (34%). Analyzing performance and efficiency, middle school students averaged an 82% score on summative assessments with an average 6.18 attempts to successfully complete. However, high school students averaged a score of 83% with 4.66 attempts, appearing to be more efficient in the platform. A limitation in the current study was the refrainment in age differentiation of those participating in the research design and statistical models. However, age and grade level could be addressed in future studies using similar designs and taking advantage of the metadata in this or similar platforms.

Module and Element Order

The design of the platform used in this research was to take advantage of full learner control. That is, learners had the opportunity to interact with any element inside of any module in whatever order or sequence they desired. In this study, only one out of six modules was dissected. An additional limitation of this study could have been the order that the learner interacted with the specific module in this research could possibly affect the overall prior knowledge of the content, which was not accounted for in the study design. Future research could account for this. In a larger study of all modules, the sequence could be codified and this possible limitation could be eliminated.

Additionally, it was possible for a learner to review the content without participating in the feedback measures or interacting with the formative questions. In other words, while the platform does track navigational or click analytics at an aggregate level on course elements, it does not track individual user sequence clicks on the learning content unless the learner interacts with the assessment measures. In future studies, this limitation would continue to exist unless additional interactivity is designed and logged into the platform database.

Ability Levels

This research did not focus on the identification of ability level of the learner (i.e., reading level, comprehension level, etc.). All learners interacting in the platform were treated the same way. While accommodations and modifications were endorsed and encouraged through tools such as screen readers, they were not accounted for in the research design. A possible limitation in this study was not designing a model that accounted for a differentiation of learner ability levels.

Learner Control is Not a Unitary Construct

While this study only accounted for one element of learner control, sequencing, literature suggests that it is not a unitary construct (Hannafin, 1984). This study did not measure additional learner control elements such as pacing control, selection control, and content control. Assertions are that learners with a lower level of prior knowledge would attain a better score with fewer learner-controlled elements. For example, pacing might be the only learner-controlled element given to a learner with a lower level of prior knowledge, as additional elements would likely be distracting. Additional elements of learner control were available to the learner within the platform used in this study. However, they were not considered as attributes in the study.

Future Research

While this research has shown that learner-controlled sequencing can significantly impact performance in an online distance education course, it has also revealed that input type does not have a significant impact. To expand this research into an even greater comprehensive design, the following modifications in future studies are recommended:

1. Eliminate mobility altogether through sample control or add mobility as a possible independent explanatory factor.
2. Eliminate screen size as a possible independent explanatory factor.
3. Remove observations containing devices with multiple input options.
4. Design for greater differentiation between adult learners and child learners, as well as controlling for the role adults play in the participation design.
5. Create a research protocol for detailing the possible degrees of prior knowledge and build the protocol into the research model.
6. Through qualitative measures, compare incentivized participation versus un-incentivized participation.
7. Build the ability to sequence individual attempts of assessments into the metadata and interactivity measures, beyond the initial attempt on the assessment. Track user interactivity of module and element order, as well. This could provide corrections for deeper learning about the effects of learner-controlled sequencing and content selection.
8. Establish research protocol to control for randomization of learner control. Through a research protocol upon logging into the platform, learners could be randomly assigned different levels of learner control along a control spectrum from full control to no control.
9. Design for a research model to compare age levels of learners.
10. Design for a research model to compare ability levels of learners.

Recommendations for Future Research

Given the results of this study and cited limitations, the following are recommendations for future research in this field. Future research should consider the following as a foundation for new questions and adaptations of this study.

Research Additional Interactive and Learner Control Elements

While this research primarily focused on a single element of learner control, sequence selection, there are additional cited learner control elements that should be further explored. Pacing, content control, and presentation or representation control should also be researched. Using a consistent design as found in this study, future research could seek to find if additional elements of learner control have effects on outcomes of performance. Pacing, the opportunity to choose how long to focus on a learning objective (Karich et al., 2014), could be captured and codified with additional timestamp metadata in a platform where deeper interactivity is logged. Content control could be codified with user preference settings as a learner advances engagement throughout the learning materials, activities, and assessments.

As cited in Figure 1.1 of this study, Moreno and Mayer (2007) outline five types of interactivity found in online digital learning environments. While this researcher only focused on two of the interactivity types, controlling and navigating, it stands to reason that dialoguing, manipulating, searching could also be researched using the model presented in this study.

Additionally, Hirumi (2002, 2013) expressed a framework for intentional planning for “learner-nonhuman” digital interactions. The author’s Level II of the framework includes interactions where the learning interacts with content, tools, the environment, and an interface. It seems appropriate to add Hirumi's (2013) Level II to the model possibilities found in this study.

Performance Measures in Mastery Learning Designs

As opportunities and access to online and distance education continue to grow and develop, additional research could be performed with learners taking all varieties of online distance education courses using the number of attempts and the score range as valid performance measures in mastery learning designs (Kulik, Kulik, & Bangert-Drowns, 1990). Not all distance education courses are designed as a mastery learning model, where multiple attempts on formative or summative assessments are permitted. However, whether with practice or end-of-course high-stakes assessments, a challenge still exists on finding performance measures that aid a learner in successful pathways while engaged in distance education experiences. The experiences in online learning are still hit or miss for some learners. Therefore, it is a recommendation for future research to expand learning experience designs based on the results of proven performance measures such as the number of attempts and the score range of assessments. As suggested previously, the mastery model used within the platform could be limiting. However, different models lend themselves to addressing different questions. Instructional designs using constructivist strategies and approaches could help answer further questions and could be tested in future studies by using additional models, beyond the mastery learning design.

Sequencing, Prior Knowledge, and Learner Profiles

Understanding more about deeper sequence choices and performance could aid future research in identifying learner profiles during learning as opposed to after learning has already occurred. If future research took into the account the sequence that a learner interacts with content and the performance on assessments through the number of attempts, the score, and the score range than learner profiles could help better determine learning efficiencies. For example, if Learner A is unsuccessful on the first attempt, but scores relatively high, then successfully completes the assessment on the second attempt, the learner profile in that scenario might indicate a varying degree of prior knowledge due to a low number of attempts and a low score range. However, if Learner B exposes a different learner control sequence where after a low score on the first attempt, the learner then navigates back to the learning content and attempts formative activities and the second attempt is successful, posting a high score range, then the degree of prior knowledge would be recorded as *low*, but the learning efficiency as *high*. A recommendation for future research would seek to prove that identifying learning profiles might help shape content and help in adaptive learning designs (Kelly, 2008; Sonwalkar, 2008).

Program Control versus Learner Control

Instructional design is vital in the overall learning experience (Chandler & Sweller, 1991, 1996; Hannafin, 1984; Reeves, 1993). Especially in a learner-(non)human planned digital interactions (Hirumi, 2013; Moore, 1989). The results of this study suggested the value of giving a learner control of their own pace, sequencing of content discovery. Future research should continue the quest of discovery on the spectrum of program- or system-controlled experiences versus learner-controlled experiences, as well as how adaptive (Kelly, 2008; Pythagoras et al., 2006; Si et al., 2014; Sonwalkar, 2008) approaches can fill in the gaps.

One of the dominant discoveries in this study was the added value of giving a learner control and choice of their experience. At one end of the computer-assisted digital experience is program control, where the learner is forced down a very specific and standard path. At the other end is full learner control, where the learner freely interacts and directs their learning. Within the DDL platform that was used in this study, there was an adaptive release feature that forced completion of linear actions prior to advancing to the next step. During the time of this study, that feature was not leveraged in the design of the modules. Had it been in use, it is this researcher's opinion that it would have been detrimental to the success of some students, as 50% of the observations naturally selected a sequence that would have not been permitted. Furthermore, the content developers would have chosen the incorrect sequence, based on the expected results and what was observed. In fact, pilot anecdotal observations prior to the general release of the distance learning course through the DDL platform, where the adaptive release feature was implemented, exposed extreme user frustration and general dislike of the experience. The ultimate decision to implement full learner control in the general release of the course was not in full alignment with Sung and Mayer (2012), in that a learner enjoying an experience does not always translate to enhanced knowledge construction.

In this study, learners performed better in the course and were more efficient after taking the summative assessment first. Therefore, the argument could be made for a greater degree of adaptive release. From a program-controlled approach, forcing students to take the summative assessment first, regardless if they felt ready to take it, may result in better performance effects with lower number of attempts. Future research may show that by taking this design approach a result may be an overall lower number of attempts with a higher score range, proving an elevated learning efficiency rate.

This could lead to future research based on new designs of automated responsive designs based on immediate or adaptive interactivity choices of the learner or even based on the type of device they are using. The latter would not be much of a stretch since responsive visual and content designs are a cornerstone of web design today. It is probable that future research could dynamically discover significant differences in the way haptic input, mobile, or physical size-based interactivity decisions are being made by a learner, then through responsive and user agent parsing, a tailored learning experience could present a more program-controlled approach. This would blur the lines of learner control and adaptive designs even further. Future research should seek to provide modern insights on when to give more gradual release of controls (Fisher, 2008; Kalyuga, 2007) to the learner based on choices of interactivity and performance throughout the learning experience.

New Interactivity Types

As an expansion of the research found in this study, future researchers should continue to explore how new user interfaces effect learning performance in online and digital experiences. Haptic input should be considered in its infancy as a user interface. High-quality touch and multi-touch input has only been mainstream and widely available since 2010. Therefore, there continues to be much to learn in how the use of new interactions can be used in positive ways while engaged in learning. This study found touch input to have no significant difference in performance in a distance education course. Some could consider this a positive result, while others may see the insignificant difference as disappointing due to touch input continuing to increase as the default input method for some learners. It stands to reason that as new technologies hit the market and innovations push new types of interactions, such as virtual reality, augmented reality, immersive reality, wearables, force-touch (Gibbs, 2015), and taptic-engines (Carlson, 2015), continued research should eliminate the new input methods as having negative effects, at a minimum. Expressly, new input methods should prove, through future research, to either improve performance or have no significant difference in performance. Designing for new digital learning experiences, as researchers, there must be a strong commitment not to design based on the technology for technology's sake, pleasure, or entertainment, but instead for true learning and effective instructional design. This is the basis for learner-centric research design versus techno-centric research design.

Testing for Cognitive Load Implications

Beyond testing for learner outcomes and performance objectives, future research should also test for cognitive load measures. As mentioned in Chapter 1, in this study the bodies of research on cognitive load theory and the cognitive theory for multimedia learning while interchangeable, were not an integral part of the research design. Given not everything can be researched in one study, cognitive load was only used as foundational theory but not measured in the research model. In recent literature, researchers are starting to use cognitive load measures to test interactivity and learner control implications in digital or hypermedia environments (Kalyuga, 2012; Paas et al., 2003; Vandewaetere & Clarebout, 2013). Computer-assisted digital learning strategies can aid in adaptive instruction and can also provide control to the learner along a spectrum filled with cognitive load issues. At one end of the spectrum is *program* *control*, where learners follow a specified path, and at the other end of the spectrum is *learner control*, where the learner freely interacts with and directs their learning (Karich et al., 2014). Different degrees of cognitive load issues may be present for individual learners at any point along that spectrum and should be considered in future research. Based on the results of this study, the trend to use cognitive load measures could continue to build consistency in defining effects of learner control. Future research should focus on overall performance of the student as well as corresponding results from pre-test, post-test (Evaluation Toolkit, n.d.), transfer test, and delayed-post cognitive load effects.

General Summary and Conclusion

In this chapter, hypothesis conclusions, fidelity of the experiment, limitations of the study, and future research recommendations were discussed. The purpose of this study was to determine if there was any significance in the interactivity and overall performance effects of learners participating in an online distance education course based on the input methods used and personal sequence choices. This study postulated that interactivity plays an important role in instructional design and that the ease of creating digital content designed for knowledge construction should be met with increased scrutiny for learner success. From a pure techno-centric posture, general assumptions are that touch-based interactivity is positive, as more and more computer devices are designed to have touch as the native input method. Additionally, since the early 1980s, researchers have theorized on the positive benefits of giving a learner control over their own sequencing, pace, content, and representation in a computer-based instructional platform or application, but have failed to agree on methodology and outcomes (Karich et al., 2014; Scheiter & Gerjets, 2007).

Specifically, this study focused on whether there is a significant difference in the performance of distance education students who exercise learner control interactivity effectively through a traditional input device versus students who exercise learner control interactivity through haptic methods. The study asked three main questions about the relationship and potential impact touch input had on the interactivity sequence a learner chooses while participating in an online distance education course. Effects were measured by using criterion from logged assessments within one module in the course.

In this study, the researcher observed two different dependent variables for interactivity, found no difference for input types (touch input and no touch input), but for learner control sequence (summative first and formative first) there was a main effect difference. There was an association discovered between touch-based interactivity and the sequence decisions that a learner made in the online learning modules. There was a significant difference in the expected sequence choice for touch input learners, as touch input learners chose to try the summative assessments first more than expected. Touch input learners performed as well as traditional input learners, and summative first sequence learners outperformed all other learners. These findings support the beliefs that new input methods are not detrimental and that learner-controlled options while participating in digital online courses are valuable for certain types of learners. Even though there was a statistically significant relationship between input method and learner control sequence selection, results did not support that input method, touch or non-touch input, had any effect on the outcome or performance of the observed learners. Finally, performance measures of learner-controlled sequence was not dependent on input methods.

Additionally, hypotheses testing also addressed curiosities over general interactivity. Broadly speaking, this study of a digital interactive learning environment positioned the learner in the driver's seat to manipulate the presentation, the pace, and the sequence of digital information through the screen. *Interactivity*, in general, means different things to different people in different contexts (McMillan, 2002, 2006; Moreno & Mayer, 2007). In the context of this research and the findings, there is alignment with the literature; interactivity is a characteristic of the learning experience that enables multidirectional (two-way) communication *between* a learner and an instructor, or a learner and an instructional platform, with the goal of knowledge construction consistent with the instructional goal (Kalyuga, 2012; Markus, 1987; Moreno & Mayer, 2007; Puntambekar et al., 2003; Wagner, 1994). This is contrary to one-way communication from an instructor to a learner.

In conclusion, learner control sequence choices did prove to have significant effects on learner outcomes. However, input method did not. The sequence that learners choose had positive effects on scores, the number of attempts it took to pass assessments, and the overall range of scores per assessment attempts. While constructing experiences for learners, instructional designers should attend to learner control concepts and understand the scenarios in which they can be employed. One may expect a learner who worked through the formative content first would do better on assessments, although that was not a generalization concluded in this study. Additionally, this study did not conclude that instructional designers should attend to haptic input as an emphasis in the design process as the two input types studied did not show any significant effect differences. However, instructional designers should continue to work with a greater sense of comfort in the understanding that touch input interactivity did not prove to have negative effects.

Beyond the findings, the following areas for future research were also identified. Researchers should study the effects on additional learner control elements, as learner control is not a unitary construct. Researchers should also study additional performance measures in distance education courses. Future research should additionally identify where adaptive learning strategies could bridge the gap found in online distance education courses between program-controlled instructional design and full learner-controlled design. In researching the effectiveness of haptic interactivity and learner control elements, while producing findings that support providing learner control as opposed to linear program or system control, the results have also produced arguments and implications for adaptive solutions. Adaptive experiences may prove to bridge the gap between the often-studied system-controlled experience and full learner control experiences.

This study also generated several questions that should continue to be researched further, including future questions concerning age and ability levels in a learner-controlled environment, questions around consistently measured cognitive load implications, and questions centered on isolating mobility and screen size as additional constructs in the research design.

The quality of an online distance education experience depends significantly on the quality of the digital content, the quality of the instructional design, and the dispositions of the participating learner. It is increasingly important for online platforms to have rich diagnostically informative learning models (Kalyuga, 2007). These models should not only represent true levels of learner knowledge construction in a specific domain but also modern.

Therefore, an important advantage of the potential of immediate diagnosis and near instant prescription of instructional design to a learner-adapted and learner-controlled environment is combining precision in constructing learner models with the simplicity of implementation. While there is much debate (Watters, 2016) on the practices of using digital platforms to implement aspects of personalized or customized learning design, in making a case for learner-controlled solutions, this study may have also made a case for an adaptive, dynamic tailored solution.

APPENDIX A

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Appendix A Tables

Appendix A consists of a breakdown of the journal analysis used for background literature review research in this study.

Table A.1

Constructs & Sub-Constructs

100 Type	The different categories of articles identified
110 Talk-Talk	Book Reviews, Editorials, Reflections
120 Experimental	Experimental research articles
130 Theoretical	Articles discussing theoretical approach to distance education research.
140 Conceptual	Articles describing new tools and instructional design models

Table A.2

Coding for Identified Interactivity Applied in Research

200 Interactivity	
210 Dialogue	Student/student
220 Dialogue	Student/teacher
230 Dialogue	Both
240 Monologue	One to many (i.e., blog)
250 Control	Learner determines pace and/or order of presentation
260 Navigation	Learner moves to different content areas by selecting from various available information sources
270 Manipulation	Learner sets parameters for a simulation, or zooms in or out, or moves objects around the screen
280 Searching	Learner finds new content material by entering a query, receiving options, and selecting an option

Table A.3

Coding for the Different Types of Learner Participants in Research

300 Learner Characteristics
310 Home school & home tutor
320 Primary
330 Secondary
340 Undergraduate
350 Graduate
360 Business & private sector

Table A.4

Coding for the Variation of Time and Space Used in Articles

400 Time and Space	
410 Asynchronous	
420 Synchronous	
430 Both	
440 F2F	Face to face
450 Hybrid1	F2F combined with asynchronous
460 Hybrid2	F2F combined with synchronous
470 Paper based	Paper/pencil correspondence

Table A.5

Coding for the Delivery Method or Online/Multimedia Tools Used in the Article

500 Delivery method	
510 Radio/Video	
520 Virtual	Second life, etc.
530 Web based	Educational interfaces, Computer Mediated Communication, WebCT, Discussion boards, Moodle, wiki, blog, podcast, social networking
540 Email	
550 Text based	Print materials (with or without web based support)
560 IM	Instant Message (Synchronous)

Table A.6

Coding for the Geographical Location of the Study and/or Authors

600	Geographical Location
610	USA
615	Cyprus
620	Australia
630	Canada
635	Sweden
640	Netherlands
645	India
650	Taiwan
655	Spain
660	South Africa
665	France
670	UK

Table A.6, continued

600	Geographical Location
675	Turkey
680	Italy
685	SMHN: Singapore, Mexico, Hong Kong, New Zealand
690	CLV: Cambodia, Laos, Vietnam
695	MPIP: Mongolia, Philippines, Indonesia, Pakistan

Table A.7

Distance Education 2004

Author/ Date	100	200	300	400	500	600
Inglis, A. May 2004	110					620
Kuboni, O., Martin, A. May 2004	120	230	350	450	530	620
Bernard, R., Brauer, A., Abrami, P., Surkes, M., May 2004	120		340	410	530	630
Lou, Y. May 2004	120	210	350	450	530	610
De Bruyn, L. May 2004	120	210	340 350	410	530	620
LaPointe, D., Gunawardena, C. May 2004	120	210	340	410	530	610
Stacey, E., Smith, P., Barty, K. May 2004	120	230	350	450	530	620
Wikeley, F., Muschamp, Y. May 2004	130					670
Ryan, Y., Lockyer, L., Sims, R. May 2004	110					620
Inglis, A. October 2004	110					620
Lockwood, F., Latchem, C. October 2004	120		360	450	530 550	620 670
Bernard, R., Abrami, P., Lou, Y. October 2004	140					630 610
Hedberg, J., Lim Cher, P. October 2004	110					685
Ruso, T., Campbell, S. October 2004	120	230	340 350	410	530	610

Table A.7, continued

Author/ Date	100	200	300	400	500	600
Oslington, P. October 2004	140					620
Koszalka, T., Ganesan, R. October 2004	120	230 250 260 270	350	450	530	610
Calvert, J., Ling, P. October 2004	110					620

Table A.8

Distance Education 2005

Author/ Date	100	200	300	400	500	600
Naidu, S. May 2005	110					620
Spector, M. May 2005	120	230	340	430 440	520 530 540	610
Muilenburg, L., Berge, Z. May 2005	120		340 350 360			610
Samarawickrema, G. May 2005	120	230	340	430	530	620
Beuchot, A., Bullen, M. May 2005	120	210	350	410	530	630 685
Ng, K., Murphy, D. May 2005	120	210	350	410	530	685
Paulus, T. May 2005	120	210	350	430	530 540 560	610
Dennen, V. May 2005	120	230	340 350	410	530	610
Ingles, A. May 2005	110					620
Simpson, O. May 2005	110					670
Smith, P. October 2005	110					620
White, C. October 2005	130					685
Badat, S. October 2005	110					660

Table A.8, continued

Author/ Date	100	200	300	400	500	600
Panda, S. October 2005	110					645
Calvert, J. October 2005	130					620
Muirhead, B. October 2005	110					630
Saba, F. October 2005	110					610
Inglis, A. October 2005	110					620
Naidu, S. December 2005	110					620
Motteram, G., Forrester, G. December 2005	120		350			670
Ros i Sole, C., Truman, M. December 2005	120	220	340	410	510 530 550	670
Macdonald, J., Hills, L. December 2005	120	250 260 CnT	360	410	530 540	670
Murphy, K., Mahoney, S., Chun-Ying, C., Mendoza-Diaz, N., Xiaobing, Y. December 2005	120	210	350	410	530	610
Jeong, A., December 2005	130	210		410		610
Wisenberg, F., Stacey, E. December 2005	110					620 630
Xuemei, W., Dannenhoffer, J., Davidson, B., Spector, M. December 2005	120	230 250 260	340	430	510 530	610
Ryan, Y. December 2005	110					620
Willems, J. December 2005	110					620

Table A.9

Distance Education 2006

Author/Date	100	200	300	400	500	600
Naidu, Som May 2006	110					
Abrami, Philip C. & Bernard, Robert M. May 2006	130					
Green, Nicole C. May 2006	120	220 250 260	210	410	510	620

Table A.10

Distance Education 2007

Author (Date)	100	200	300	400	500	600
Naidu, S. (May 2007)	110	Editorial				
Zembylas, M. & Vrasidas, C. (May 2007)	120	230	320 350	430	530	610
Manca, S. & Delfino, M. (May 2007)	120	230	350	450	530	680
Fahy, P. J. (May 2007)	120	230	350	410	530	630
Dennen, V. P., Darabi, A., & Smith, L. J. (May 2007)	120	230	340	430 440	530	610
Martens, R, Bastiaens, T, & Kirschner, P. A. (May 2007)	120	230 250-280	360	430	530	640
Tynan, B. & O'Neill, M. (May 2007)	120	220 250 270	310	410	530 550	620 630
Conrad, D. (May 2007)	110	Reflect on current state of research in DE				
Koumi, J. (May 2007)	110	For media and video producers of DE-Open Univ				
Baggaley, J. (August 2007)	110	Editorial				
Latchem, C. (August 2007)	130	Address shortcomings of theoretical research				620
Jamtsho, S., & Bullen, M. (August 2007)	120	230	350	430	530	630
Vuth, D., Than, C. C., Phanousith, S., Phissamay, P., & Tai, T. T. (August 2007)	120	230	340 360	410	530	690
Loh-Ludher, L. (August 2007)	120	230	360	410	530	690
Amarsaikhan, D., Lkhagvasuren, T., Oyun, S., and Batchuluun, B. (August 2007)	120	250-280	360	410	530	695

Table A.10, continued

Author (Date)	100	200	300	400	500	600
Ramos, A. J., Nangit, G., Ranga, A. I., & Trinona, J. (August 2007)	120	250-280	360	410	510 530 540	695
Baggaley, J. (August 2007)	110	PANdora model of collaborative research				620 695
Baggaley, J. (August 2007)	110	Digital Review of Asia Pacific				
Naidu, S. (November 2007)	110	Educational principles and online learning-Turkey Univ.				
Philip, R. & Nicholls, J. (November 2007)	120	230 260-280	340	430	510 530	620
Dennen, V. P. & Wieland, K. (November 2007)	120	230	340	410	530	610
Thompson, E. W. & Savenye, W. C. (November 2007)	120	230	360	410	530	610
Samarawickrema, G. & Stacey, E. (November 2007)	120	210	350*	410	540	620
Akbulut, Y., Kuzu, A., Latchem, C., & Odabasi, F. (November 2007)	130	Examines organizational and educational change			540	620 675
Ros I. S. C. & Hopkins, J. (November 2007)	140	Contrasts pedagogical models used in UK and Spain				670 685
Nichols, M. (November 2007)	110	Student perception of study mode				
Smith, P. J. (November 2007)	110	Stories shared by experienced online instructors				

Table A.11

Distance Education 2008

Author/Date	100	200	300	400	500	600
Naidu, S. (November 2008)	110					
Hannum, W., Irvin, M., Fei, P., & Farmer, T. (November 2008)	120	230 240	320 330	450	530	610
Menchaca, M. P., Bekele, T. A. (November 2008)	120 140	230 250 260	350	430 440	530 540	610
Miller, C., Veletsianous, G., & Doering, A. (November 2008)	130	230 260	340	430	530	610
Bollettino, V., & Bruderlein, C. (November 2008)	130 140	230 260	360	430 440	530	610
Correia, A., & Davis, N. (November 2008)	120	230 240	350	450	530 540	610
Tsai-Hung Chen, R., Bennett, S., & Maton, K. (November 2008)	120	230 240	330	460	530	620
Smith, R. (November 2008)	120	210	350	410	530	610
Dillenbourg, P. (August 2008)	140	230 260	340	430 440	530	635
Goodyear, P. (August 2008)	140	230 240 260	340	450	520 530 540 550	620
Sims, R. (August 2008)	140	230 270	330 340 350	430	520 530	610
Luschei, T., Dimayati, S., & Padmo, D. (August 2008)	130	230 240 270	340 350	450	510 520 530	695
Keller, J. (August 2008)	130	230 240	340	430	530 550	610
ChanMin, K. (August 2008)	130	230 250	340 350	450	540	610
Merrill, M. D. (August 2008)	130	210	320 330 340	430	530 540	610
Naidu, S. (May 2008)	110					

Table A.11, continued

Author/Date	100	200	300	400	500	600
Burge, L. (May 2008)	120	220	360	450	530	630
Bewley, D. (May 2008)	130	230 260 270	330 340 350	450 460	510 520 530 540 550	685
Baggley, J. (May 2008)	130	230 250 260 270	350	430	510 530 540	630
Whelan, R. (May 2008)	120	230 240	360	430	510 520 530 540 560	625
Zembylas, M. (May 2008)	120 130	230 250 270	350	430	530 540	615
Kehrwald, B. (May 2008)	130	260 270 280	360	430 440	520 530	685
Gillies, G. (May 2008)	120	230	350	430	510	670
Smith, P. (May 2008)	110					

Table A.12

Distance Education 2009

Author/Date	100	200	300	400	500	600
Naidu, S. (November 2009)	110					
Slagter van T., P. J., & Bishop, M. J. (November 2009)	130	230 280	340	440	530	610
Wise, A., Padmanabhan, P., & Duffy, T. (November 2009)	120	220	340	450	530	610
Baran, E., & Correia, A. (November 2009)	120	230 240	350	450	530 550	610
Kuboni, O. (November 2009)	120	230 250	340	450	530	645
Bawane, J., & Specto, J. (November 2009)	140	260	360	410	450	610
Funrborough, C., & Turman, M. (November 2009)	120	250	340	450	530	670
Jelf, A., Richardson, J., & Price, L. (November 2009)	120	200 250	340 350	450	530	670
Luck, M. (November 2009)	110					620
Wei, R., & Nanjing, C. (November 2009)	110					645
Salmon, G., & Edirisingha, P. (November 2009)	110					670
Bennett, S., Agostinhno, S., Lockyer, L., & Harper, B. (August 2009)	110					620
Donald, C., Blake, A., Girault, I., Datt, A., & Ramsay, E. (August 2009)	130	220 260	360	450	530 550	685
Griffiths, D., Beauvior, P., Liber, O., & Barrett-Baxendale, M. (August 2009)	140	260 270 280	360	450	530	670
Masterman, E., Jameson, J., & Walker, S. (August 2009)	120 140	220 250	330 340	450 470	530 550	670
Alvino, S., Asensio-Perez, J., Dimitriadis, Y., & Hernaandex-Leo, D. (August 2009)	120	250 260 270 280	360	410 420	530	655

Table A.12, continued

Author/Date	100	200	300	400	500	600
Yongwu, M., Van Der Klink, M., Jo, B., Sloep, P., & Koper, R. (August 2009)	140	230 260	360	450	530	640
Derntl, M. (August 2009)	110					675
Bottuir, L. (August 2009)	110					680
Naidu, S. (May 2009)	110					
Benson, R., & Samarawickrema, G. (May 2009)	140	230 260	340	410	510 530	675
Oliver, K., Osborne, J., & Brady, K. (May 2009)	120 130	220 250 260	320 330	450	520 530	610
Andrade, M., & Bunker, E. (May 2009)	140	270 280	340	410	520 530	610
Hall, D., & Knox, J. (May 2009)	130	220 260 280	360	430	530 550	620
Richardson, J. (May 2009)	120		340		530	670
Bolliger, D., & Wasilik, O. (May 2009)	120	250 260	340 350	410	530	610
Potter, C., & Naidoo, G. (May 2009)	140	220	360	450 460	510	660
Mitchell, I. (May 2009)	110					620
Spector, J. M. (May 2009)	110					610
Baggaley, J. (May 2009)	110					630
Latchem, C. (May 2009)	110					620
Hannum, W. (May 2009)	110					610

APPENDIX B

LITERATURE REVIEW REFERENCES

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Appendix B Tables

Appendix B consists of a breakdown of the journal analysis used for background literature review research on haptic interactivity in this study.

Table B.1

Haptic Interactivity – Experimental Learning/Subject Performance – Summary Matrix

Author(s) (Year)	Type of Study	Field of Study	Haptic Tool	Haptic Category
Bailenson, J. N. & Yee, N. (2008)	Testing Learning/Subject Performance	Education/ Psychology	PHANToM	Haptic Input Only (to device)
Brewster, S. & Cockburn, S. (2005)	Testing Learning/ Subject Performance	Education/ Psychology	Feedback Mouse	Multimodal Output (from device)
Burdea, G., Richard, P., & Coiffet, P. (1996)	Testing Learning/ Subject Performance	Education/ Psychology	Multiple	Both Haptic Input and Output
Cao, C., Zhou, M., Jones, D., & Schwaitzberg, S. (2007)	Testing Learning/ Subject Performance	Medical	ProMIS & MIST-VR	Multimodal Output (from device)
Chan, A., MacLean, K., & McGrenere, J. (2008)	Testing Learning/ Subject Performance	Education/ Psychology	Feedback Mouse	Multimodal Output (from device)
Clark, D., & Jorde, D. (2004).	Testing Learning/ Subject Performance	Education/ Psychology	Thermal Sensation Simulation	Output (Thermal Sensation)
De Poli, G., Mion, L., & Roda, A. (2009)	Testing Learning/ Subject Performance	Fine Arts (Graphics/ Design/ Music)	PHANToM	Both Input and Output
Enriquez, M., MacLean, K., & Neilsen, H. (2007)	Testing Learning/ Subject Performance	Education/ Psychology	Multiple Haptic Tools	Multimodal Output (From device)
Hatwell, Y. (1995)	Testing Learning/ Subject Performance	Education/ Psychology	Human Touch	Output (from device)
Jones, M. et al.(2004)	Testing Learning/ Subject Performance	Education/ Psychology	PHANToM	Both Input and Output
Jones, M., Minogue, J., Tretter, T., Negishi, A., & Taylor, R. (2006).	Testing Learning/ Subject Performance	Education/ Psychology	PHANToM & MS Sidewinder	Both Input and Output

Table B.1, continued

Author(s) (Year)	Type of Study	Field of Study	Haptic Tool	Haptic Category
Michaels, C., Arzamarski, R., Isenhower, R., & Jacobs, D. (2008).	Testing Learning/ Subject Performance	Education/ Psychology	Human Touch	Multimodal Output (From device)
Rovers, A., & Van Essen, H. (2006)	Testing Learning/ Subject Performance	Education/ Psychology	Multiple	Both Input and Output
Newell, F., Bulthoff, H., & Ernst, M. (2003)	Testing Learning/ Subject Performance	Education/ Psychology	Human Touch	Multimodal Input (To device)

Table B.2

Haptic Interactivity – Both Technology and Learning/Psychology

Author(s)/ Year	Type of Study	Field of Study	Haptic Tool	Haptic Category	Dependent Variable
Chan, A., MacLean, K., & McGrenere, J. (2005)	Testing Technology and Learning/ Subject Performance	General	Feedback Mouse	Multimodal Haptic Output (from device)	Vibrotactile display tells users whether they are in control. Cognitive Load
Kyung, K., Kwon, D., & Yang, G. (2006)	Testing Technology and Learning/ Subject Performance	Education/ Psychology	Feedback Mouse	Multimodal Haptic Output (from device)	The capability of users to discern surface texture through kinesthetic force feedback and tactile display simulation.

Table B.3

Haptic Interactivity – Experimental Technologies

Author(s)	Year	Type of Study	Field of Study	Haptic Tool	Haptic Category
Buck, U., Naether, S., Braun, M., & Thali, M.	2008	Testing Technologies	Forensic Science	PHANToM	Both Haptic Input and Output
Chen, H., Sun, H., & Jin, X.	2007	Testing Technologies	Gaming	PHANToM	Both Haptic Input and Output
Choi, K., Sun, H., & Heng, P.	2003	Testing Technologies	Medical	PHANToM	Both Haptic Input and Output
Dachille, F., Qin, H., & Kaufman, A.	2001	Testing Technologies	Fine Arts (Graphics/Design/Music)	PHANToM	Both Haptic Input and Output
Duriez, C., Dubois, F., Kheddar, A., & Andriot, C.	2006	Testing Technologies	General	PHANToM	Both Haptic Input and Output
Ellis, R., Ismaeil, O., & Lipsett, M.	1996	Testing Technologies	Robotics	Planar Haptic Interface	Both Haptic Input and Output
Hamza-Lup, F., & Rolland, J.	2004	Testing Technologies	Medical	Haptic Sensing Glove	Haptic Input Only
Formaglio, A., Prattichizzo, D., & Barbagli, F.	2008	Testing Technologies	Robotics	PHANToM	Both Haptic Input and Output
Harding, C., & Souleyrette, R.	2010	Testing Technologies	Engineering/ Mechanical Design	PHANToM	Both Haptic Input and Output
Heng, P., & Wong, T.	2006	Testing Technologies	Medical	PHANToM	Both Haptic Input and Output
Hinterseer, P., Hirche, S., Chaudhuri, S., Steinbach, E., & Buss, M.	2008	Testing Technologies	Robotics	Multiple	Both Haptic Input and Output
Hsu, C., Huang, T., & Young, K.	2005	Testing Technologies	Flight Simulation	Haptic Joystick	Both Haptic Input and Output
Liu, P., Georganis, N., & Roth, G.	2005	Testing Technologies	General	General	Both Haptic Input and Output

Table B.3, continued

Author(s)	Year	Type of Study	Field of Study	Haptic Tool	Haptic Category
Liu, X., Dodds, G., McCartney, J., & Hinds, B.	2004	Testing Technologies	Engineering/ Mechanical Design	PHANToM	Both Haptic Input and Output
Michel, M., Knoll, T., Koehrmann, K., & Alken, P.	2002	Testing Technologies	Medical	Multiple	Haptic Input Only
Nelson, D., & Cohen, E. (1999)	1999	Testing Technologies	Engineering/ Mechanical Design	PHANToM	Both Haptic Input and Output
Rosch, O., Schilling, K., & Roth, H.	2002	Testing Technologies	Robotics	Haptic Joystick	Both Haptic Input and Output
Rosen, J., Hannaford, B., MacFarlane, M., & Sinanan, M.	1999	Testing Technologies	Medical	FREG (Force Feedback Endoscopic Surgical Grasper)	Both Haptic Input and Output
Rosenberg, I., & Perlin, K.	2009	Testing Technologies	General	Human Touch Sensing Pad	Haptic Input Only

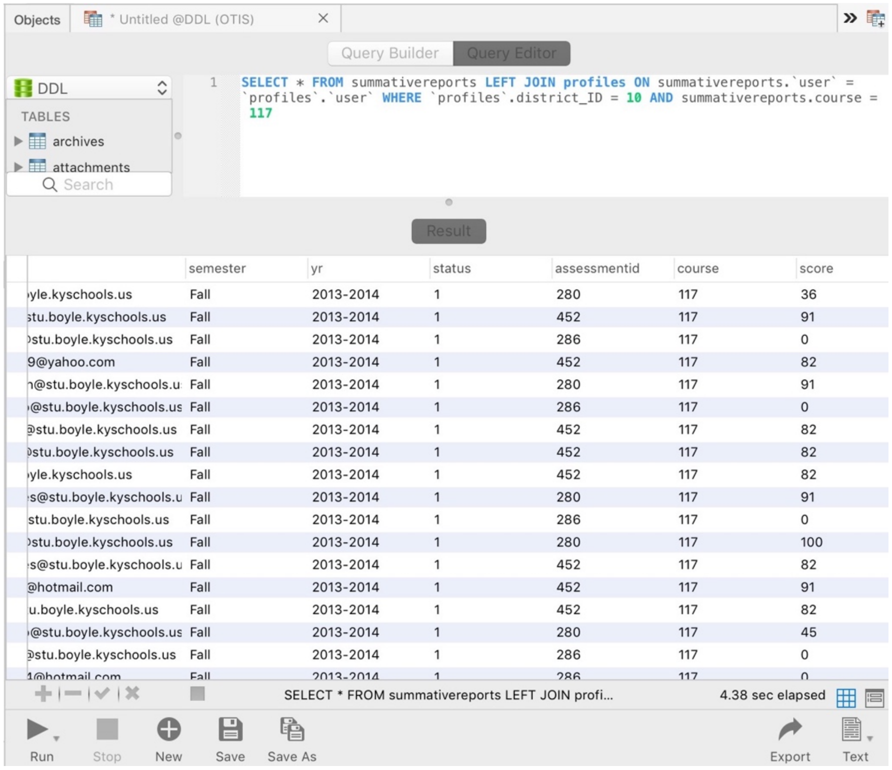
APPENDIX C

DATA RETRIEVAL FROM THE DATABASE AND FORMING THE DATA SET

Users enter all of the data needed to research the question into the database via a web browser-based graphical interface or application. In order to extract the data needed to run statistical regressions, a database query string was designed. The query string used was as follows:

*select * from summativereports LEFT JOIN profiles ON summativereports.user = profiles.user where profiles.district_ID = 10 AND summativereports.course = 117*

Breaking the query down (see Figure C.1), the “select” tells the query what data fields to present in the resulting output. The database query symbol * tells the output to present all fields in the table. In this particular query, data from two different tables are needed and a process to gather the data and combine was required. Specifically, assessment attempts and scores are needed from the summativereports database table and user information, such as district, is needed from the profile database table. As presented previously, the summativereports table of the database contains only one record per user, upon submission of an assessment. This unique field is updated every time a learner resets and submits an assessment (in order to get a higher score). The LEFT JOIN statement tells the query to check the secondary table and only present results that have the same username in both fields of each table and have the district identification number of 10 in the profile table of the database. The district identification number 10, is coded for a specific school district in the “districts” table of the database and is used by users when they created their account. The district_ID number correlates to a district_name which is what users see when creating their accounts and on their account information page. The last statement in the query tells the output to only present results from course number 117. As presented earlier, course 117 is the module capturing skill sets from all other cases. Figure C.1 illustrates the query string used in the Navicat software in order to export the required data for the study.



```sql
SELECT * FROM summativereports LEFT JOIN profiles ON summativereports.`user` =
`profiles`.`user` WHERE `profiles`.district_ID = 10 AND summativereports.course =
117
```

	semester	yr	status	assessmentid	course	score
yle.kyschools.us	Fall	2013-2014	1	280	117	36
stu.boyle.kyschools.us	Fall	2013-2014	1	452	117	91
stu.boyle.kyschools.us	Fall	2013-2014	1	286	117	0
9@yahoo.com	Fall	2013-2014	1	452	117	82
@stu.boyle.kyschools.u	Fall	2013-2014	1	280	117	91
@stu.boyle.kyschools.us	Fall	2013-2014	1	286	117	0
stu.boyle.kyschools.us	Fall	2013-2014	1	452	117	82
stu.boyle.kyschools.us	Fall	2013-2014	1	452	117	82
yle.kyschools.us	Fall	2013-2014	1	452	117	82
s@stu.boyle.kyschools.u	Fall	2013-2014	1	280	117	91
stu.boyle.kyschools.us	Fall	2013-2014	1	286	117	0
stu.boyle.kyschools.us	Fall	2013-2014	1	280	117	100
s@stu.boyle.kyschools.u	Fall	2013-2014	1	452	117	82
@hotmail.com	Fall	2013-2014	1	452	117	91
u.boyle.kyschools.us	Fall	2013-2014	1	452	117	82
@stu.boyle.kyschools.us	Fall	2013-2014	1	280	117	45
stu.boyle.kyschools.us	Fall	2013-2014	1	286	117	0
1@hotmail.com	Fall	2013-2014	1	286	117	0

```
SELECT * FROM summativereports LEFT JOIN profi...
```

Figure C.1: Single case database query for identified school district

Within the identified module, there were three different assessment IDs presented in the output. Table C.1 identifies the assessments found in course number 117: 280, 286, and 452. Each assessment identification number correlated to a section of the case and an individual case topic. It is important to break this down, as some of the statistical analysis being ran will require a review one case at a time or possibly one assessment at a time.

Table C.1

Assessment Identification

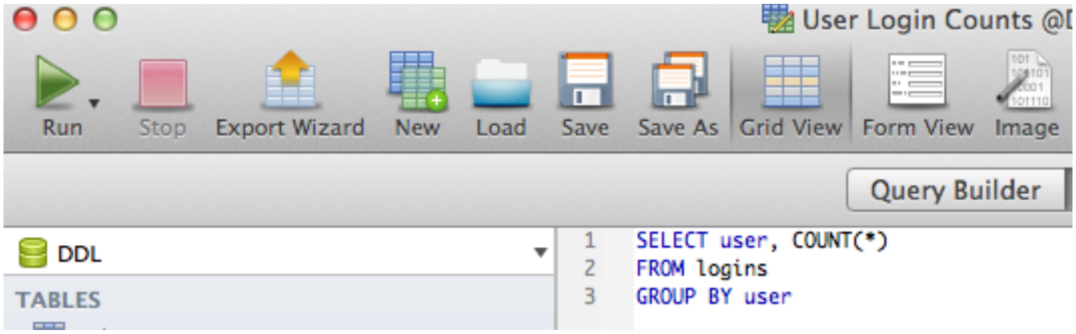
Case/ Course	Assessment ID	Assessment Type
117	280	Formative Assessment
117	286	Formative Assessment
117	452	Summative Assessment

To complete the initial data set, and in order to meet the additional requirements of the study, a secondary query was designed and implemented to also capture the login metadata for each individual participant. Login metadata in this process not only included the number of logins, the time and date of logins, but most importantly the user agent information for the login. The user agent information was vital in this research because it defines not only the type of device used, but also the type of input (touch input or traditional or non-touch input). For this element, a multiple step process was constructed. In doing so, this researcher also discovered some important validation concerns.

To get the login metadata per user, an additional query was executed from the database on the logins table. The following query (see Figure C.2) was designed and implemented using Navicat:

SELECT user, COUNT(*) FROM logins GROUP BY user

Figure C.2 illustrates the query string used in the Navicat software in order to export the total login count per user in the sample.



```
SELECT user, COUNT(*)
FROM logins
GROUP BY user
```

Figure C.2: User count database query

The output of the query resulted in a login metadata for every participant in the DDL. The next step, which was using SPSS to run a data variable merge, was not only to match logins with the correct users, but also to exclude records from participants from other schools not in this sample. Using an SPSS process, variables were excluded and matched from the new data source to the existing data source. Data were matched based on the username variable used as the keyed table. If the username existed, the login count (raw number) was added to the new variable in the data set. Coleman (2008) outlines this merge procedure in his article on merging data sets in SPSS.

Sample data were extracted on January 1, 2016. It is important to make that distinction since the data source is live and participants continuously add data. After data extract, the next step was to identify the variables in questions, then import them into the SPSS software for regression analysis. The known variables were transformed and recoded into categorical and ordinal variable types in order to run additional regressions.

APPENDIX D

DATA SET NORMALITY

The data set failed statistical normality tests. The normality of the test groups were conducted using a Shapiro-Wilk test of Normality. The results of the Shapiro-Wilk test for both dependent variables indicate a significant difference between the independent groups (score range, $p \leq .000$ and assessment attempts, $p \leq .000$) at the 95% confidence level. Therefore, the distribution of the score range and assessment attempts are considered to not be a statistically normal distribution. However, due to the magnitude of the observation sample (n=4746) and a mastery learning design model the normality results can be explained. First, in the mastery learning model all assessments can be taken as many times as needed with the ultimate requirement that they are passed with an 80% score or higher. Therefore, the ultimate result should be passing. Capitani (1997) submits that the two basic distinct concepts of mastery and normality are not always clearly distinguished either in clinical or experimental work. The author submits that mastery is an absolute concept, while normality judgments on subjects are relative. In other words, performance of a subject is rated as normal with reference to other subjects who should be as similar as possible with the subject being examined (Capitani, 1997). Furthermore, an investigation by Micceri (1989) of the distributional characteristics of 440 large-sample achievement and psychometric measures found all to be significantly non-normal. In general, mastery measures exhibit moderate to extreme asymmetry and at least one exponential or extreme tail weight (Micceri, 1989).

An additional influence on the normality assumption is the volume of observations. With large enough sample sizes, Ghasemi and Zahediasl (2012) assert that the violation of the normality assumption should not cause major problems and that it can imply parametric procedures can be used even when the data are not statistically normally distributed. With thousands of observations and tens of thousands assessment attempts, the distribution of the data, while important, can be disregarded. The procedures used in this study work well even when the normality assumption has been violated (What is ANOVA?, 2016). Moreover, transformations of the original data set with one independent variable (number of attempts) corrected minor skew violations.

The mastery learning and assessment model, as well as the volume of the observations, are contributing factors to not having statistical normal distributions in the dependent variables, while visually passing distribution normality assumptions through histograms (see Figures D.1 and D.2).

The distribution of both dichotomous independent variables with the dependent score range variable is represented in Figure D.1. The result is a visual normal distribution. Score range disaggregated by input type produced 1,930 “no touch input” observations with M = 37.61 (SD = 19.915) and 566 “touch input” observations with a slightly lower M = 35.48 (SD = 18.979). Score range disaggregated by learner control sequence produced 1,728 “formative assessment first” observation with M = 39.19 (SD = 19.187) and 768 “summative first” observations with M = 32.49 (SD = 20.131).

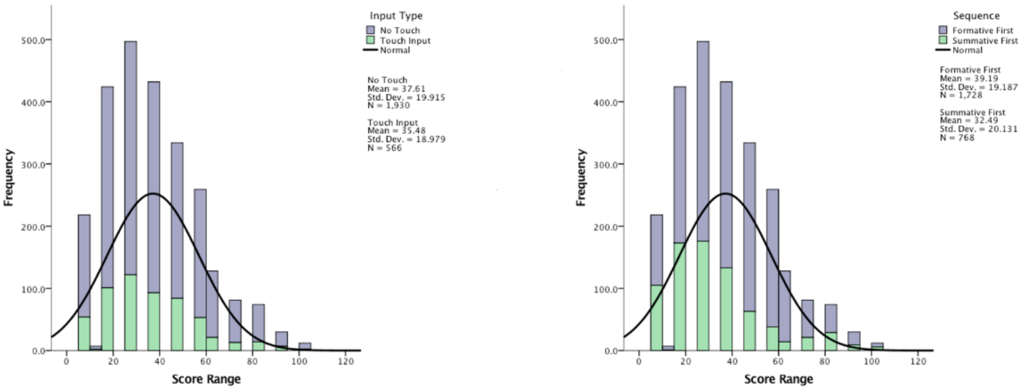


Figure D.1: Distribution of score range

After the comparison of both dichotomous independent variables with the number of attempts, as found in Figure D.2, the result was a positive or right skew. Assessment attempts separated by input type produced 1,930 no touch input observations with a log M = .6968 (SD = .31699) and 566 “touch input” observations with a log M = .6749 (SD = .30788). Respectively, when separated by the learner control sequence independent variable, 1,728 observations were represented by “formative assessment first” with a log M = .681 (SD = .3178) and 768 “summative assessment first” observations with a log M = .7161 (SD = .30749).

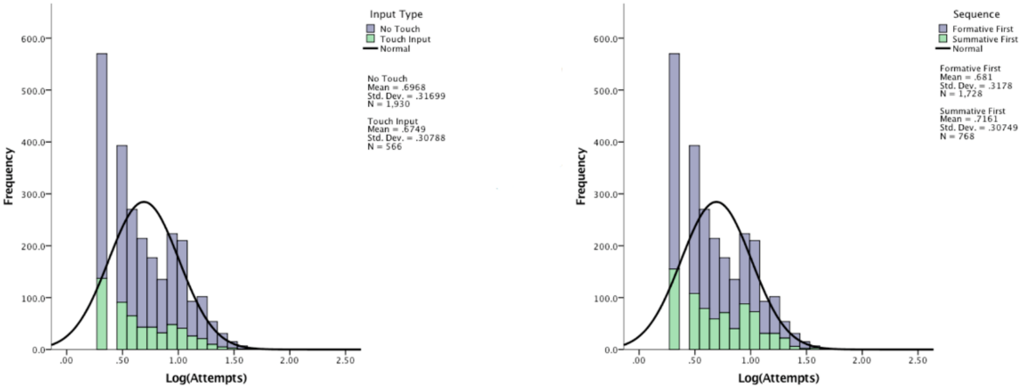


Figure D.2: Distribution of assessment attempts

APPENDIX E

LEARNER DECISION MOMENT

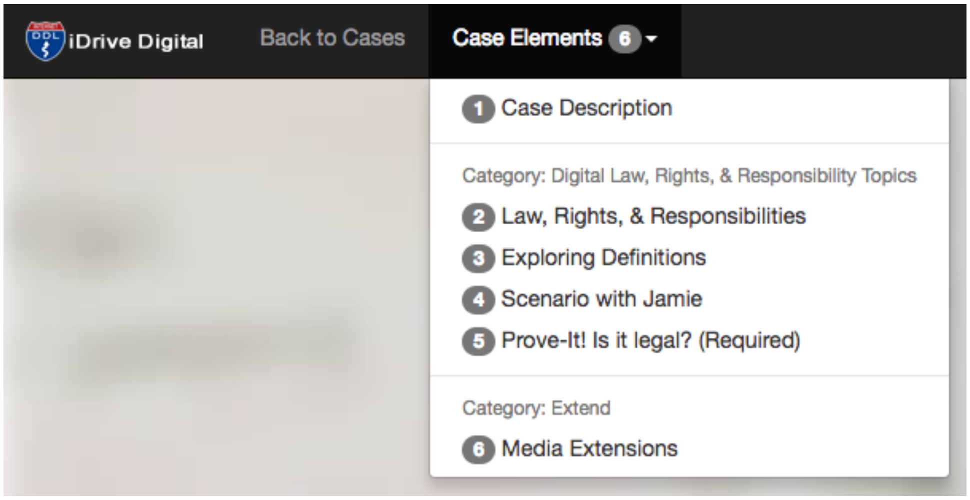
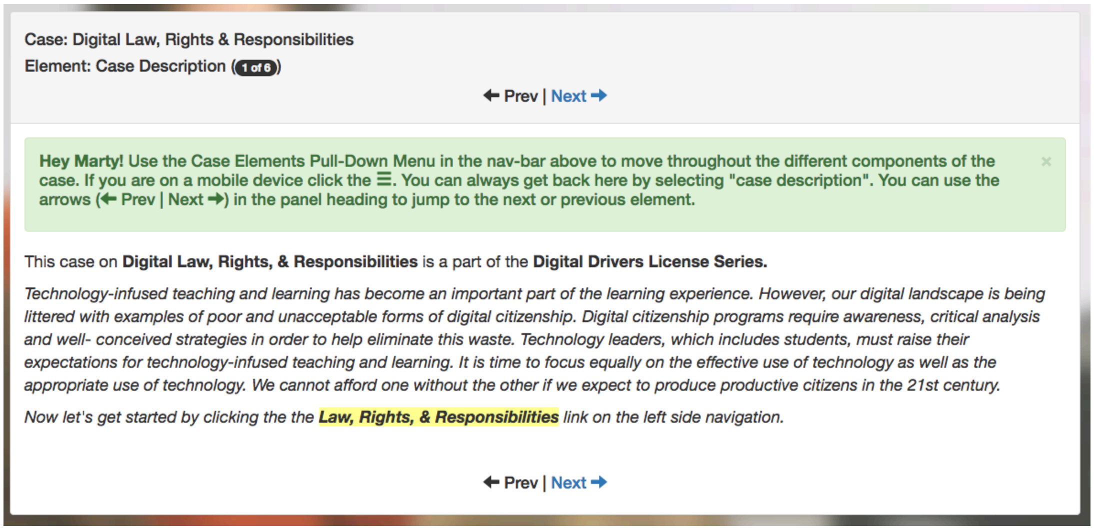


Figure E.1: Learner decision moment 1, exercising the option to jump straight to the only required element, the summative assessment ("Prove-It!").



Case: Digital Law, Rights & Responsibilities
Element: Case Description (1 of 6)

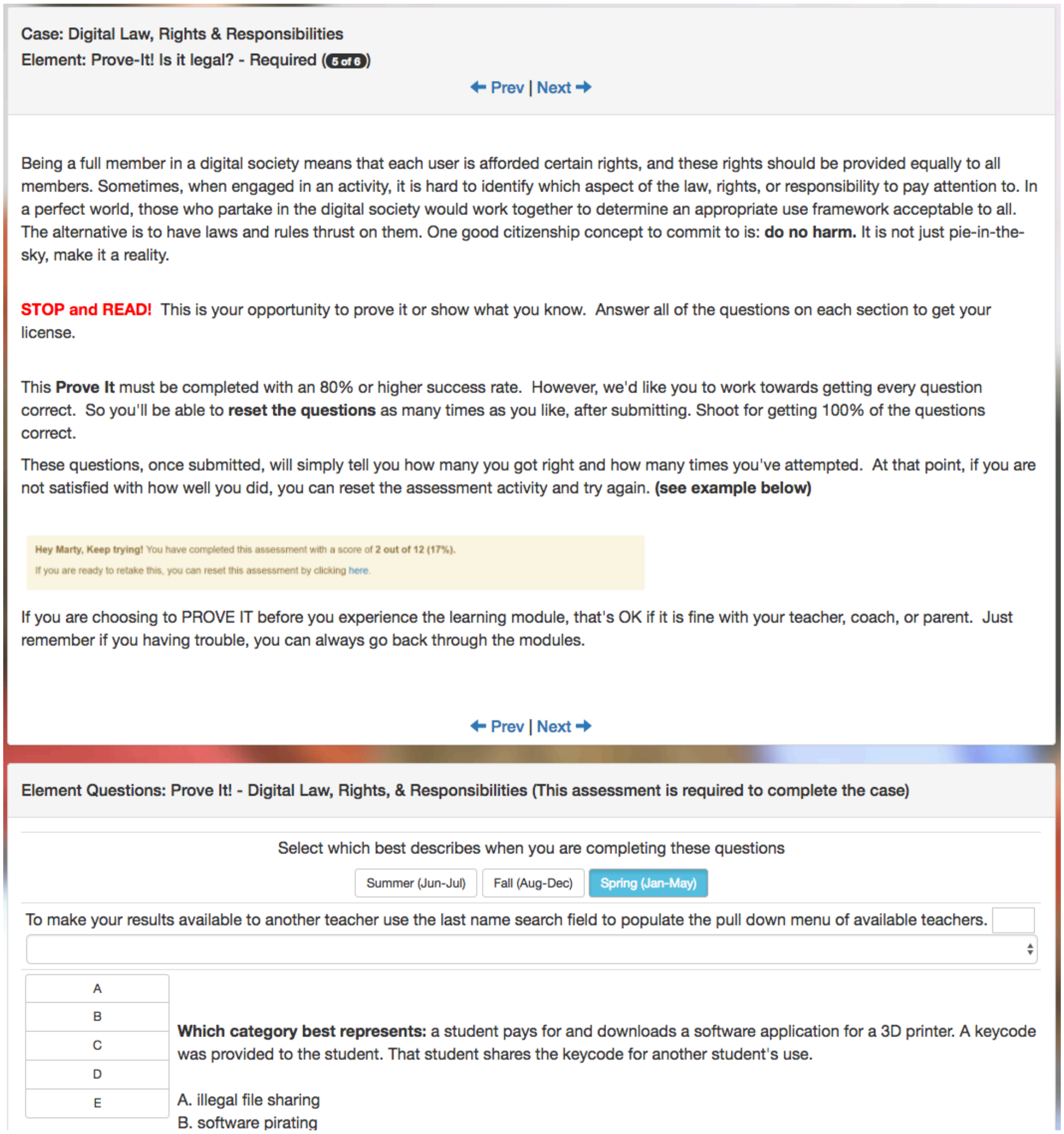
Hey Marty! Use the Case Elements Pull-Down Menu in the nav-bar above to move throughout the different components of the case. If you are on a mobile device click the ☰. You can always get back here by selecting "case description". You can use the arrows (← Prev | Next →) in the panel heading to jump to the next or previous element.

This case on **Digital Law, Rights, & Responsibilities** is a part of the **Digital Drivers License Series.**

Technology-infused teaching and learning has become an important part of the learning experience. However, our digital landscape is being littered with examples of poor and unacceptable forms of digital citizenship. Digital citizenship programs require awareness, critical analysis and well- conceived strategies in order to help eliminate this waste. Technology leaders, which includes students, must raise their expectations for technology-infused teaching and learning. It is time to focus equally on the effective use of technology as well as the appropriate use of technology. We cannot afford one without the other if we expect to produce productive citizens in the 21st century.

Now let's get started by clicking the the ***Law, Rights, & Responsibilities*** *link on the left side navigation.*

Figure E.2: Learner decision moment 2. Linear navigation through the learning content and formative assessments prior to attempting the summative assessment.



Case: Digital Law, Rights & Responsibilities
Element: Prove-It! Is it legal? - Required (5 of 6)

Being a full member in a digital society means that each user is afforded certain rights, and these rights should be provided equally to all members. Sometimes, when engaged in an activity, it is hard to identify which aspect of the law, rights, or responsibility to pay attention to. In a perfect world, those who partake in the digital society would work together to determine an appropriate use framework acceptable to all. The alternative is to have laws and rules thrust on them. One good citizenship concept to commit to is: **do no harm.** It is not just pie-in-the-sky, make it a reality.

STOP and READ! This is your opportunity to prove it or show what you know. Answer all of the questions on each section to get your license.

This **Prove It** must be completed with an 80% or higher success rate. However, we'd like you to work towards getting every question correct. So you'll be able to **reset the questions** as many times as you like, after submitting. Shoot for getting 100% of the questions correct.

These questions, once submitted, will simply tell you how many you got right and how many times you've attempted. At that point, if you are not satisfied with how well you did, you can reset the assessment activity and try again. **(see example below)**

Hey Marty, Keep trying! You have completed this assessment with a score of **2 out of 12 (17%).**
If you are ready to retake this, you can reset this assessment by clicking here.

If you are choosing to PROVE IT before you experience the learning module, that's OK if it is fine with your teacher, coach, or parent. Just remember if you having trouble, you can always go back through the modules.

Element Questions: Prove It! - Digital Law, Rights, & Responsibilities (This assessment is required to complete the case)

Select which best describes when you are completing these questions

To make your results available to another teacher use the last name search field to populate the pull down menu of available teachers.

Which category best represents: a student pays for and downloads a software application for a 3D printer. A keycode was provided to the student. That student shares the keycode for another student's use.

A. illegal file sharing
B. software pirating

Figure E.3: Learner decision moment 3. The summative assessment highlighting the only requirement in the module or case.

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VITA

Marty John Park

Birthplace: Chillicothe, Ohio

Education

2004	Master of Arts, Education Technology, Georgetown College
1999	Bachelor of Science, Education, Georgetown College

Professional Experience

2013-Present	Chief Digital Officer, Kentucky Department of Education, Frankfort, Kentucky
2003-Present	Adjunct Professor, Graduate Education Department, Georgetown College, Georgetown, Kentucky
2000-Present	Assistant Football Coach, Athletics Department, Georgetown College, Georgetown, Kentucky
2007-2013	Kentucky Education Technology System (KETS) Regional Engineer, Kentucky Department of Education, Frankfort, Kentucky
2002-2007	Chief Information Officer and District Technology Coordinator, Clark County Schools, Winchester, Kentucky
2000-2002	Classroom Teacher, Garth Elementary School, Georgetown, Kentucky

Honors

2016	Making IT Happen Award (for visionary educators and leaders who cultivate connected, empowered learners), International Society for Technology in Education (ISTE), Kentucky Society for Technology in Education
2007	Apple Distinguished Educator
2006	NSBA 20 To Watch, 20 Technology Leaders to Watch in the Nation, National School Boards Association

Publications

2015	Creating a Digital Citizenship Program with Foundational Lessons and Performance from the Digital Driver’s License, Digital Citizenship in Schools – Third Edition [Book]
2015	Get Your Students on the Road To Digital Citizenship with a Digital Driver’s License, ISTE.org
2012	Learning Connections - Digital Citizenship, Students Need a Digital Driver's License before They Start Their Engines, Learning and Leading with Technology

Presentations

2016	“Social Media, Schools, and the Law,” Kentucky Association of School Administrators, Lexington, Kentucky
2016	“Student Data Privacy, Vendor Partners, and the Law,” Kentucky Society for Technology in Education, Louisville, Kentucky
2016	“Pushing the Limits on the DDL,” Kentucky Society for Technology in Education, Louisville, Kentucky
2015	“Screen Time: The Top 10 Strategies for Getting “Flipped” learning Right (based on Mayer’s research on Multimedia Learning),” Kentucky Society for Technology in Education, Louisville, Kentucky
2013	“Blended Learning,” College and Career Readiness Summit, Murray, Kentucky
2013	“Exploring the World of Digital Text & Media Fluency,” Digital Text Symposium, Bowling Green, Ohio
2013	“Re-imagining the Student Experience,” Western Kentucky Education Cooperative, Murray, Kentucky

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