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NAVIGATING BY TIME, TOPIC, OR TOOL:

LOST IN THE LEARNING MANAGEMENT SYSTEM?

By

Lisa C. Kidder

A dissertation

submitted in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy in the Department of Instructional Design

Idaho State University

Spring 2017

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September 20, 2016

Lisa Kidder
Educational Tech Services
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RE: regarding study number IRB-FY2017-42: Navigating by Time, Topic, or Tool: Lost in the Learning Managment System?

Ms. Kidder:

Thank you for your responses from a previous review of the study listed above. I agree that this study qualifies as exempt from review under the following guideline: Category 1: Normal educational practices & settings. This letter is your approval, please, keep this document in a safe place.

Notify the HSC of any adverse events. Serious, unexpected adverse events must be reported in writing within 10 business days.

You are granted permission to conduct your study effective immediately. The study is not subject to renewal.

Please note that any changes to the study as approved must be promptly reported and approved. Some changes may be approved by expedited review; others require full board review. Contact Tom Bailey (208-282-2179; fax 208-282-4723; email: humsubj@isu.edu) if you have any questions or require further information.

Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

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Dedication

To my husband, Patrick Kidder, whose efforts are very much a part of this work. As Sun Tzu, wrote, “Great results can be achieved with small forces” (p. 24). It has been through small and simple acts that he has helped, supported, and encouraged me. He has kept me well stocked with caffeine and chocolate, cooked amazing meals, and washed the laundry and the dishes. He patiently listened, asked good questions to make me think, and was the best stats tutor. And when the work was overwhelming, he would work quietly on his computer next to me so I would not feel alone. I could not have done this without him.

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TABLE OF CONTENTS

List of Figures x

List of Tables xi

Abstract xii

CHAPTER I: Introduction 1

Theoretical Frameworks 4

Purpose of the Study 8

Research Question 9

Research Design 10

Definition of Terms 12

Limitations and Delimitations 13

Significance of the Study 16

CHAPTER II: Review of Literature 18

Learning Management Systems 18

Cognitive Load Theory 22

Prior Knowledge and Schema Creation 26

Signal Available Relevant Accessible Theory 29

Comparative Usability Testing 34

Gaps in the Literature 35

CHAPTER III: Methodology 37

Research Design 37

Potential Participants and Sampling Criteria 38

Materials 39

Instrumentation 44

Procedure 48

Data Analysis 49

CHAPTER IV: Results 50

Description of the Sample 50

Questionnaire and Performance Measure Results 53

Assumptions 57

Results for Research Question 57

Summary of Results 60

CHAPTER V: Conclusions 61

Discussion of Results 61

Recommendations for Future Practice 66

Recommendations for Future Research 67

Summary 68

REFERENCES 69

Appendix A: Default Views of the Top Five LMS in Higher Education 81

Appendix B: Development of the Courses 84

Appendix C: Development of the Tasks 87

Appendix D: Counterbalancing of Tasks with the Treatments 91

Appendix E: Development of Articulate Storylines 93

Appendix F: Participant Demographics Questionnaire 95

Appendix G: Computer Self-Efficacy Questionnaire 103

Appendix H: Mental Effort Questionnaire 104

Appendix I: Disorientation Questionnaire 105

Appendix J: System Usability Questionnaire 106

Appendix K: Post Questionnaire 108

Appendix L: Letter of Invitation 109

Appendix M: Consent Form 110

List of Figures

Figure 1. The Morrison et al. (2011) instructional design model. 2

Figure 2. Research model 11

Figure 3. Trends in the LMS market share. 20

Figure 4. Basalt Course showing the organization structure based on time. 40

Figure 5. Jasper Course showing the organization structure based on topic. 41

Figure 6. Quartz Course showing the organization structure based on tools.................... 42

Figure 7. The task screen in the Articulate storyline 43

Figure 8. Sequence of the questionnaires, tasks, and instructions 49

Figure 9. Comparison of medians of ME, DIS, rSU and NE scores................................ 59

Figure 10. Comparison of mean ranks of ME, DIS, rSU and NE.................................... 60

Figure 11. Default structure for Blackboard Learn 9.1 81

Figure 12. Default structure for Brightspace 81

Figure 13. Default structure for Canvas 82

Figure 14. Default structure for Moodle. 82

Figure 15. Default structure for Sakai. 83

Figure 16. Original Anthropology course. 84

Figure 17. The navigation menus for each organizational structure 86

Figure 18. A comparison of sections from each course 86

Figure 19. One task from each category was used to explore the course. 88

Figure 20. Distribution of 17 potential tasks across the chapters in the textbook. 89

Figure 21. Distribution of the final nine tasks 90

Figure 22. Flowchart for the creation of the Articulate storyline. 94

List of Tables

Table 1. Research design for the proposed study 11

Table 2. Demographic information for the sample 51

Table 3. CSE and LMS experience for the sample 52

Table 4. Summary of mental effort ratings 54

Table 5. Summary of disorientation ratings 54

Table 6. Summary of system usability ratings (reversed) 55

Table 7. Summary of navigational efficiency scores (in seconds) 56

Table 8. Counterbalancing the tasks 91

Table 9. Counterbalancing of the courses and tasks per participant 92

Abstract

This study was designed to examine how three different organizational structures (time, topic, and tool) of a course in an LMS affected learners. The signal available relevant accessible (SARA) theory provided a framework to clearly describe the signals (headers) used to differentiate the three organizational structures. Cognitive load theory (CLT) provided four measures of potential extraneous load; mental effort (ME) and disorientation (DIS) were selected from the domain of instructional design with system usability (SU) and navigational efficiency (NE) from human computer interaction.

Data analysis using a Friedman test showed a significant difference in DIS between the organizational structures of time and tool (r = .40). No significant differences were found for ME, SU, or NE between the three organizational structures. However, patterns in the numerical data supported previous research which indicated that prior system knowledge and experience would influence performance. For all measures, the organizational structure of time had the best ratings. This reflects the level of prior experience of the participants who had the most experience with the organizational structure of time

In contrast, the response and post comments revealed an overall preference for both organizational structures of time and tool. The qualitative comments support SARA theory, in that both these organizational structures used signals *relevant* to the participants' goals. These results highlight the complex nature of extraneous load and the need for multiple measures, including quantitative and qualitative methods.

CHAPTER I

Introduction

Learning is a complex endeavor that begins with finding and accessing information (Ally, 2008). Upon accessing the online portion of a course, learners must orient themselves to the structure of the course, which may require additional effort if the course structure is unfamiliar. So in addition to learning the actual content of the course, the learner needs to determine where materials and activities are located, how to navigate within the course, how the content is delivered, how to determine the expectations for engaging in the course, and how to engage with any other features unique to the course (Stavredes, 2011).

Many institutions of higher education have invested in a learning management system (LMS) to facilitate the delivery of online and hybrid courses (Jones, 2011). The LMS is a hypermedia environment where course content and activities are organized and sequenced. As faculty or instructional designers designate the titles and heading of sections, course materials, and activities, they take on the role of information architect in organizing and labeling materials so that navigation through the content is clear (Schaik, Muzahir, & Lockyer, 2015). The titles and headings of sections, course materials, and activities communicate the design of the message. The navigational menus and the interface of the LMS often determine the organization and sequencing of content, or in other words, the design of the system strongly influences the course structure. Extraneous load, that is information, processes, or procedures outside the learning goals (Leppink, van Gog, Paas, & Sweller, 2015), can be introduced through both the design of the instruction and the design of the system (Hollender, Hofmann, Deneke, & Schmitz, 2010). This role of an information architect is evident in two steps of the Morrison, Ross, Kalman, and Kemp (2011) instructional design model – content sequencing and designing the message, as highlighted in Figure 1.

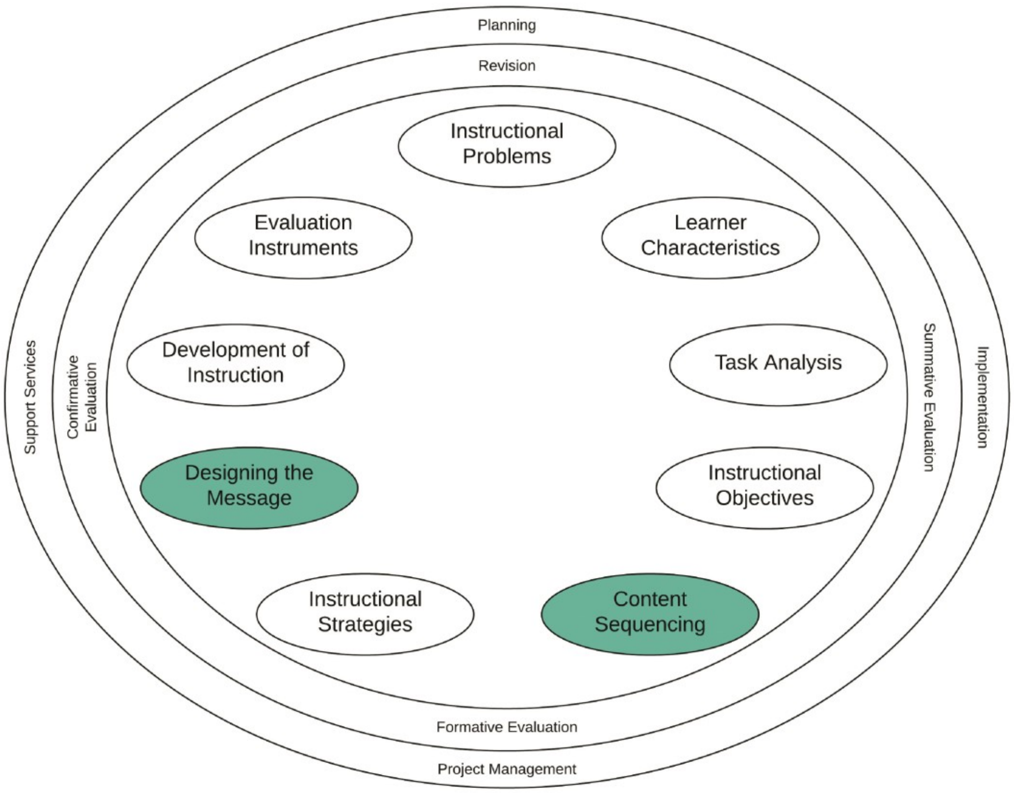

Figure 1. The Morrison et al. (2011) instructional design model showing where content sequencing and designing the message appear in the model.

The LMS is a hypermedia environment in that the learner freely navigates through the course. This ability to navigate freely introduces extraneous load in that learners need to make decisions about which path to take, based on the navigational and organizational signals in the system (Amadieu, van Gog, Paas, Tricot, & Mariné, 2009). The impact of this decision making process or extraneous load can be seen in reports of higher mental effort (Longo & Dondio, 2015), feelings of disorientation (Sandberg, 2013), reports of low system usability (Fang & Holsapple, 2011), and inefficient navigational choices (Brouwers, 2014; Warwick, Rimmer, Blandford, Gow, & Buchanan, 2009).

The LMS is designed to manage course creation, learner enrollment, and course activities, and provide reports for faculty (Mabed & Köhler, 2012). And while many technologies in education follow a cycle of "early inflated rhetoric, varying degrees of diffusion, and disappointing levels of use…before finally being replaced by the 'next new thing'" (Krumm, 2012, p. 2), the LMS has not followed this pattern, becoming a fairly constant technology fixture in the higher education classroom. In addition, course material has been historically organized by *topic* (hierarchy), as in textbook chapters, or by *time* (sequence), as in weekly course schedules. The various LMS introduced another organizational structure – by *tools* (function). The organization by tools groups all the items related to a specific technological function or activity in the same section or navigational menu, e.g., quizzes, assignment uploads, discussions, or files.

The top LMSes used in higher education have the same basic tools within their hypermedia environments; however, the default navigational and organizational structures differ (Fuentes Pardo, Ramírez-Gómez, García, & Ayuga, 2012). Each LMS is designed with flexibility to adjust the organizational structure to match course content or personal preferences; however, faculty tend to rely on the default settings (Goh, Hong, & Gunawan, 2014). Thus, programmers and LMS administrators who designate the default settings determine the organizational structure of many courses. As a consequence, "faculty are led by the interface of a [LMS] not only because they do not immediately see an alternative, but because the familiar signposts (the syllabus button) imply a single way of completing the task (upload a document)" (Lane, 2009, p. 5). This perpetuates the idea that the LMS forces "both the faculty and the students to adapt themselves to the organization and to the platform requirements" (Fidalgo-Blanco, García-Peñalvo, Sein-Echaluce, & Conde González, 2014, p. 110) and unfortunately, results in organizational structures that may not be based on current research about how people learn.

Theoretical Frameworks

This study relied upon cognitive load theory (CLT) along with the signal available relevant accessible theory (SARA), to frame the constructs of the study. This section describes CLT and SARA, explains their relationship, and describes how they provide a framework for this study.

Cognitive load theory. CLT uses five principles to describe how human cognition functions: 1) the information store principle; 2) the borrowing and reorganizing principle; 3) the randomness as genesis principle; 4) the narrow limits of change principle; and 5) the environmental organizing and linking principle (Leppink et al., 2015, pp. 207–208). This means, according to CLT, individuals can store and process vast amounts of information. This is done as information is borrowed and reorganized based on various interactions (e.g., writing, video, or in person). As working memory capacity is limited, changes to knowledge occur incrementally. Additionally, based on internal schema or organized patterns of information in long-term memory, signals from the environment can efficiently draw upon information stored in long-term memory to reduce the overall impact on the working memory or cognitive load. Thus, prior knowledge allows experts to draw upon their previous experiences in an efficient and effective manner when compared to novices.

CLT is especially applicable within contexts where processing a large amount of information is necessary, such as training and practice (Leppink et al., 2015). In the context of instruction, there are three types of cognitive load: *intrinsic*, information inherent in the content; *germane*, information required to learn the content; and *extraneous*, superfluous information that adds to the cognitive load but does not support learning (Sweller, 2010a). At the heart of changes in learning are the processes that take place in working memory, which is limited (Kalyuga & Singh, 2015). Thus, the focus of CLT research has been centered on optimizing working memory (Kuldas, Hashim, Ismail, & Bakar, 2015); specifically, how to optimize intrinsic and germane loads while reducing extraneous load (de Jong, 2010).

Extraneous load can be introduced through either instructional design (Brünken, Seufert, & Paas, 2010) or system design factors (Hollender et al., 2010). For example, within instructional design, extraneous load can be introduced with a large amount of information presented at one time, the placement of visual information, or creating redundancy by using both text and audio to communicate the same information. In the design of the system interface, similar types of extraneous load can be introduced in the amount of information presented at one time, the placement and organization of visual information, and the inability of the user to recover from errors in using the system.

Drawing from the domains of instructional design, information architecture, and human computer interaction, there are several concepts and measures related to potential extraneous load. In the domain of instructional design, measures of mental effort have been relied upon for insights in overall cognitive load (Paas & van Merriënboer, 1993). Information architecture approaches cognitive load from the perspective of findability

(Morville, 2005), which influences feelings of disorientation (Ruttun & Macredie, 2012). Next, from the domain of human computer action, the goal of usability is to reduce extraneous load (Cheon & Grant, 2012). Lastly, all of these concepts influence the common educational measure of time on task (Amadieu, Salmerón, et al., 2015; Goldhammer, et al., 2014). (All four of these concepts are discussed in detail in the following chapter.) Whereas extraneous load can cause high mental effort, feelings of disorientation, low usability, and inefficient navigation, research has demonstrated that structure and signals can reduce the impact on extraneous load.

As noted by the organizing and linking principle from CLT, signals from the environment can aid in accessing schema stored in long term memory, thereby reducing the overall load on working memory and linking new information more efficiently to the long-term information store (Leppink et al., 2015; Sweller, 2010a). Alternatively, signals could add unnecessary information, impose increased extraneous load, and reduce the amount of working memory available for intrinsic and germane load processing (Cheon & Grant, 2012). Unfortunately, signals in the research are a "hodgepodge of devices that [include] headings, typographical variations, topical overviews and summaries, outlines, bulleting and numbering, preview sentences and other devices" (Lorch Jr, Lemarié, & Grant, 2011b, p. 139).

Signal available relevant accessible theory. Signals have been shown to facilitate the negative impacts of hypermedia environments (Sung & Mayer, 2012); however, signals have been not been defined consistently in the literature (Lorch Jr et al., 2011b). The SARA theory proposed by Lemarié, Lorch Jr, Eyrolle, and Virbel (2008) provides a mechanism to describe explicitly the signals.

SARA theory states that “the information made available to the reader, and the accessibility of that information is influenced by the realization properties, scope, and location of the signaling device relative to the cued content” (Lemarié, Lorch Jr, et al., 2008, p. 27). In other words, in order to compare the various devices designated as signals within the research, we need to look at how information is made available, relevant, and accessible through the characteristics of the signal. This begins with an analysis in relation to (a) the characteristics of the signals; (b) the relevance to the individual’s goals; and (c) potential cognitive obstacles.

The SARA theory “proposes that the effects of headings and other signals are mediated by the types of information they communicate” (Lorch Jr et al., 2011b, p. 142). The types of information fall into the following seven areas: 1) a demarcation in the structural boundaries; 2) the hierarchical organization; 3) the sequential organization; 4) a label; 5) the identification of the topic; 6) the function; and/or 7) an emphasis on a specific portion (p.140-141). The system design features of navigational menu titles and instructional design features of headers used to communicate the organizational structures fall into the category of signals (Lemarié, Lorch Jr, et al., 2008).

The organizing and linking principle from CLT states that signals should help to reduce cognitive load. SARA theory states that the reduction in cognitive load will depend upon the information and function of the signals in relationship to the learner’s goals. The characteristics and functions described by SARA theory were used to thoroughly describe the signals (headers) used in this study. Thus, both CLT and SARA provide frameworks to explore how three different organizational structures of a course within an LMS affect extraneous load.

In relation to SARA theory, the first step is to provide a specific and explicit description of the signal (Lemarié, Lorch Jr, et al., 2008). Two of the main signals in an LMS exhibit many of the same characteristics, according to SARA theory. Both the navigational menus and the section headers indicate demarcations in the structural boundaries, labels, identification, and emphasis. This leaves the characteristics of hierarchical organization, sequential organization and function defined by the words used in the menus and headings. In the analysis of the signals in the LMS, as long as all the typographical variations remain the same (i.e., bold, font type, color, etc.), the three common types of organization within the LMS are illustrated by the three characteristics of sequence (time), hierarchy (topic), and function (tool).

Purpose of the Study

The purpose of this study was to investigate the effects of different organizational structures on extraneous cognitive load. This was a comparative usability study in a lab setting to avoid any potential negative effects on a real course (Bindal, Gupta, & Khurana, 2014). The investigation of organizational structure within a lab setting using multiple dependent variables provided information on potential negative impacts upon learner performance without affecting learner's final grades.

One way to improve learning outcomes is to reduce the impact of extraneous load (de Jong, 2010). Extraneous load can be introduced through both system and instructional design factors (Hollender et al., 2010). Signals have been shown to help decrease the impact of extraneous load (Sung & Mayer, 2012); however, they have been ill-defined in the literature (Lorch Jr, Lemarié, & Grant, 2011a). Based on studies in other hypermedia environments, it was expected that extraneous load due to instructional design features would be evident in high feelings of disorientation and high mental effort. Extraneous load due to system design features would be evident in low system usability and inefficient navigation.

As the complexity of learning (Ally, 2008) and the complexity LMS make it difficult to examine one feature to the exclusion of others (Morozov, 2009), this study was designed to narrowly focus on one system design aspect. Through the application of SARA (Lemarié, Lorch Jr, et al., 2008), the signals of headers and navigational menus exemplify three common organizational structures used in courses provided through an LMS – *time* (sequential), *topic* (hierarchal), and *tool* (function).

As little research has been reported on the specific effects of the LMS on learners (Mabed & Köhler, 2012), it was not known how the three common types of LMS organizational structure – *time, topic,* and *tool,* would affect overall mental effort (ME); disorientation (DIS), system usability (SU); and navigational efficiency (NE).

Research Question

This study was designed to addressed the central question of how a course should be organized within the LMS to reduce potential extraneous load. This was done by identifying instruments designed to measure various sources of extraneous load from the domain of instructional design and system design or human computer interaction. Mental effort (ME) as measured by the mental effort scale (Paas, 1992) and disorientation as measured by the perceived disorientation scale (Ahuja & Webster, 2001) were selected from the domain of instructional design. From the domain of human computer interaction or system design, the two selected measures were system usability (SU) as measured by the system usability scale (Brooke, 1996) and navigational efficiency as measured by the average time of task completion divided by the number of correct responses (Sauro, 2011a). Thus, this study was designed to answer the following research question:

- Are there significant differences in extraneous cognitive load (as measured by the combination of ME, DIS, SU, and NE) for three different organizational structures with the LMS (time, topic, and tool)?

Research Design

This study used a one-way within-subjects multivariate experimental design (see Table 1). The study took place in a lab setting with volunteer undergraduate students and followed the procedures of a comparative usability test with participants completing real tasks within three courses with different organizational structures (treatment) (Bindal et al., 2014). Participants were randomly assigned to one of nine counterbalanced course and task versions and completed three unique tasks within each course. After completing each task, participants were asked to rate their ME and DIS for the specific task. After completing the three tasks within the course, participants rated SU. NE was determined via screen recordings using the total time on task in seconds, divided by the number of correct responses. Participants completed this process for each of the three courses.

Table 1

Research design for the proposed study

		Course A	Course B	Course C
All Participants	R	X_i O_{1i} O_{2i} O_{3i} O_4	X_i O_{1i} O_{2i} O_{3i} O_4	X_i O_{1i} O_{2i} O_{3i} O_4

Note. The specific sequence of the courses varied for each participant. *R* represents the random assignment to one of the counterbalanced versions, X_i represents the tasks each participant completed, O_1 represents the ME measurements reported for each task, O_2 represents the DIS measurements taken after each task, O_3 represents the NE measurements calculated for each task, and O_4 represents the SU measurement taken for each organizational structure.

A one-way within-subjects multivariate analysis of variance (MANOVA) was planned to answer the research question. However, due to violations of normality and linearity, four separate non-parametric Friedman tests were performed with a Bonferroni correction ($\alpha = .0125$). The organizational structure (time vs. topic vs. tool) served as a within-subject factor, and the four measures of (a) ME; (b) DIS; (c) SU; and (d) NE were used as dependent measures (see Figure 2).

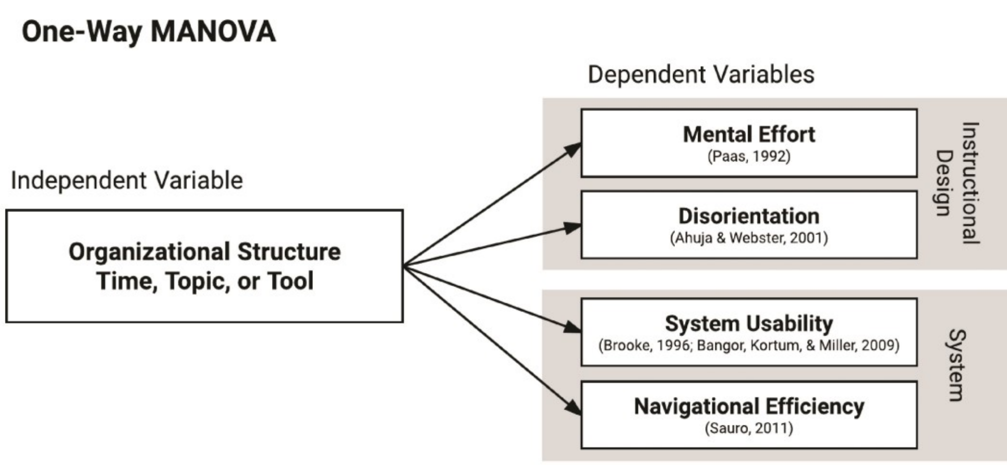

Figure 2. Research model with one independent variable of organizational structure and four dependent variables of ME, DIS, SU, and NE.

Definition of Terms

Learning management system. An LMS is a hypermedia environment used to manage course creation, learner enrollment, course content, and provide reports for teachers (Mabed & Köhler, 2012). In addition, LMS provide tools to create interactive components such as discussions, submitting assignments, surveys, tests, announcements, and grading (Gautreau, 2011). Other names for hypermedia learning systems have been used in the research such as course management systems (CMS), virtual learning environments (VLE), online learning environment (OLE) or learning management systems (LMS). For the purposes of this study *learning management system* (LMS) was used as an all-encompassing term.

Organizational structure. The organizational structure refers to the ordering of course materials by sequence (time), hierarchy (topic), or function (tool). This organization is communicated with signals in the form of headings and navigational menu titles.

Mental effort. According to Paas and van Merriënboer (1993), "mental effort may be defined as the total amount of controlled cognitive processing in which a subject is engaged. Measures of mental effort can provide information on the cognitive costs of learning, performance, or both" (p. 738). In the context of this study, mental effort is the cognitive cost of learning the organizational structure of the course.

Disorientation. "Disorientation in hypermedia refers to the fact that the user loses his or her place in the whole environmental structure and does not know how to go to a desired place" (Firat & Yurdakul, 2010, p. 5). This disorientation can be due to "an ill-conceived mental representation" of either content or the structure of the system

(Amadieu, van Gog, et al., 2009). For the purposes of this study, disorientation is focused on the structural aspect of the course materials.

System usability. Usability is "the extent to which a product can be used by specified users to achieve specified goals, with effectiveness, efficiency and satisfaction in a specified context of use" (International Organization for Standardization, n.d.). The system or product in this study are the three variations of organizational structure with the LMS.

Navigational efficiency. Castro, Meliá, Genero, Poels, and Calero (2007) define navigation as "the efficiency, effectiveness and satisfaction with which a user navigates through the system in order to fulfill her goals under specific conditions" (p. 420). For the purposes of this study this measure was the ratio of time on task and the correct response (Mifsud, 2015).

Limitations and Delimitations

The validity of any research can be threatened by a variety of factors. Limitations are to the *internal validity* of the study, and delimitations are threats to the *external validity* of the study (Jolley & Mitchell, 2007).

Limitations. "The internal validity of an experiment is the extent to which extraneous variables have been controlled by the researcher" (Gall, Gall, & Borg, 2007, p. 383). The most common factors that threaten *internal validity* are history, maturation, testing, instrumentation, statistical regression, differential selection, experimental mortality, and selection-maturation interaction (Gall, et al., 2007). As this study took place in a lab setting during one 60-minute period, with participants randomly assigned to a treatment order, the majority of the threats to internal validity were minimized (history, maturation, instrumentation, statistical regression, differential selection, and selection-maturation). However, two factors need to be addressed – testing and experimental mortality.

The challenge of testing exists, as the measurements are administered close together in time (Gall et al., 2007). While this was not a pretest/posttest research design, there was a possibility that the tasks and exploration within the courses would influence later measurements. In addition to counterbalancing the order of the treatments, the tasks were grouped and counterbalanced to minimize effects due to practice, fatigue, carry-over, and sensitization (Jolley & Mitchell, 2007).

Experimental mortality is the loss of participants over the course of the study. While this study did not use a control group, nor was it a longitudinal study, participants could quit in the middle of a task, or even leave the study at any time, which would result in the loss of data. The design of the study was not limited to a specific course or term and thus facilitated the ability to recruit new participants in order to meet the power requirements of the study.

Delimitations. "External validity is the extent to which the findings of an experiment can be applied to individuals and settings beyond those that were studied" (Gall et al., 2007, p. 388). As this was a within-subjects experiment, there are limitations to the generalizability of the study; however, the within-subjects design reduced the natural variance associated with differences between individuals and the power of the study was increased. The three factors of individuals, population, and environment (Gall et al., 2007) that threaten external validity still needed to be considered.

As discussed in Chapter II, all of the dependent variables in this study are known to be influenced by prior knowledge and experience. The pure within-subjects design of this study was specifically selected to remove subject-to-subject variation, as each participant will act as his own "control" (Seltman, 2012). Additionally, as learners normally take courses developed by different faculty and are exposed various organizational structures in real-life, this also supports the appropriateness of a pure within-subjects design (Jolley & Mitchell, 2007). In order to assist future research, detailed demographics are reported so similarities to other individuals may be easily identified.

The population targeted for this study were undergraduate volunteers from a four year public university in the Northwest. The requirement that participants need to not have taken nor be currently enrolled in Anthropology 1100 meant that the sample may not be representative of the population. As detailed demographics were collected, this enables other researchers to compare their populations to the participants in this study.

As this study took place in a lab setting with multiple treatments presented close together, there are threats to ecological validity. To support the limited generalizability of this study to real-life settings a detailed description of the development of the experimental treatments, the counterbalancing process, and the development of the tasks used in the study are provided in the following chapters and appendices. This detailed information addressed the ecological validity concerns of the description of the treatments; multiple treatment interference; pretest/posttest sensitization; history and treatment interaction; measurement of the dependent variables; and measurement and treatment interaction (Gall et al., 2007).

In addition, the selection of headers and navigational menu titles within one LMS (Moodle) may also limit the generalizability to other LMSes and other types of signals. This is especially true due to the constant updates to LMSes. During timeline of this study, Blackboard, Brightspace/D2L, and Moodle all released updates with changes in their interface or template selection process.

Lastly, while the participants were aware that they were in a study setting, and were most likely able to discern the independent and dependent variables, the invitations to participate in the study focused on soliciting overall feedback for the improvement for courses within Moodle (the LMS used in the study). The invitation to participate was not connected to a specific course or instructor so the beliefs of the researcher were distanced from the participants. This addressed the concerns of the Hawthorne effect, novelty and disruption, and experimenter bias (Gall et al., 2007).

Significance of the Study

Research within the context of the LMS has been limited (Mabed & Köhler, 2012). The research on cognitive load has focused mainly on learning objects, individual lessons, and website navigation (Amadieu, van Gog, et al., 2009; Brünken, Plass, & Moreno, 2010; Cheon & Grant, 2012; de Jong, 2010; Sung & Mayer, 2012). This study adds to the body of literature on cognitive load within the context of the LMS. In addition, LMS programmers, institutions, and LMS administrators can use the results of this study to inform the decisions made on default settings and flexibility available to instructional designers and faculty within the LMS.

This study drew upon research from a variety of domains – education, psychology, human computer interaction, information architecture, information systems, and instructional design. This cross-disciplinary approach provides depth that has not previously been available in any one domain.

Signals (headings) were used to communicate the three types of organizational structure. Research on signals has focused mainly on written text, hypertext documents, and websites (Lemarié, Eyrolle, & Cellier, 2008; Wang, Yang, Liu, Cao, & Ma, 2014; Waniek, 2012). This study adds to the body of literature by applying SARA theory in a detailed description of the signals as well as, exploring the effect of signals within the context of an LMS.

Previous studies have reported a significant influence on cognitive load and overall performance due to prior knowledge with both the content and the system (Amadieu, van Gog, et al., 2009; Mátrai & Kosztyán, 2012; Swanson, 2012). The design of this study focused on one aspect of the LMS and collected specific data in order to reduce confounding the results with prior content and system knowledge. This provided a focused perspective on the impact of the organizational structures.

Most importantly, this study informs how instructional designers should use the navigational and organizational structures of *time*, *topics*, and *tools*, to design courses within an LMS to optimize extraneous load. The end goal is to reduce the negative impacts of the system and instructional design upon working memory, so the learner can focus on learning the content.

CHAPTER II

Review of Literature

The learning management system (LMS) is at an intersection of various domains. As an educational tool it is influenced by the domains of instructional design and educational technology. As a technology its functionality is influenced by information sciences and human computer interaction. As an organizational tool it is influcenced by information architecture. Each of these domains were searched for relavant literature on the effects of organizational structures within the LMS,

The research literature was reviewed with a focus on higher education to understand what questions have been asked and how the research has been conducted. Terms related to content sequencing, learning management systems, navigating in hypermedia, and cognitive load were used to search the domains of educational technology, instructional design, psychology, human computer interaction, and information architecture.

Each of the domains identified above provide insight into the research on the LMS and organizational structure; however, no research was located which looked specifically at the impact of the organizational structure within the LMS on extraneous cognitive load.

Learning Management Systems

The LMS is a hypermedia environment designed to manage course creation and administration (Mabed & Köhler, 2012). During the creation of a course, faculty and instructional designers make decisions on how to organize course materials. Common organization follows the resources and contexts of course in higher education. For example, courses have been organized similarly to textbooks, using the topics of the course to create a hierarchical organization. Alternatively, many faculty think of courses in relation to the semester and how the course is distributed across time (Lane, 2008), creating a sequential organization for the course. In addition to the hierarchal and sequential organizational structures of topic and time, the LMS presents another type of organization based on the technological function (e.g., resources, quiz, assignment, etc.), thus presenting a course organized by tool.

Within each LMS, there is flexibility to modify and adjust the organizational structure to match learning theories, course content, and/or personal preferences; however, faculty tend to rely on the default settings (Goh et al., 2014). The default organizational structures of the top five LMSes in higher education in the United States were analyzed (see Figure 3 for a timeline of the LMS market share for higher education in the United States and Canada). Blackboard, Canvas, and Sakai all have a default navigation menu on the left, populated with the commons tools available – discussions/forums, content/resources, quizzes, etc. Brightspace displays a tool-based menu across the top as the default. The Moodle default includes a left hand navigation menu that is determined by the headings of the center section, with the default of weeks (see Appendix A for screenshots of the default structures of the top five LMS). Four out of the top five LMSes, present a default organizational structure of tools.

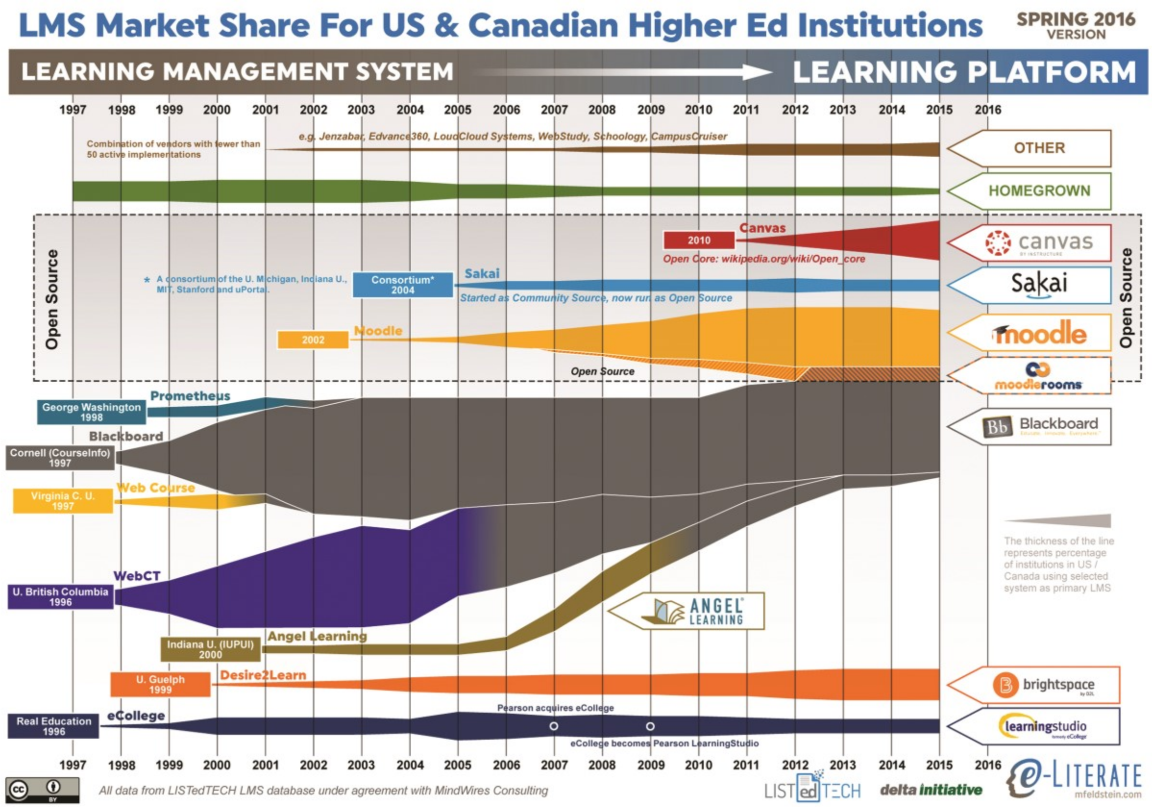

Figure 3. Trends in the LMS market share for higher education in the United States and Canada (Hill, 2016).

Much of the research related to the LMS, has focused on whether or not faculty and students would use such a system (Arteaga Sánchez & Duarte Hueros, 2010; Fathema, Shannon, & Ross, 2015). The Technology Acceptance Model (TAM) has been a common instrument to evaluate both student and faculty behavioral intentions in using the LMS. From the research using TAM, the two strongest predictors of LMS are perceived ease of use and perceived usefulness (Šumak, Heričko, & Pušnik, 2011). In addition, the perceived ease of use will increase the amount of working memory available for learning the content (Sun, Tsai, Finger, Chen, & Yeh, 2008).

Tomita (2011) found that while the high density of information inherent in hypermedia can prove overwhelming for the learner, providing appropriate structure can bring about meaningful learning. Structure is the invisible way the site is organized, and navigation is the visible way to communicate that structure to the learner (Nielsen, 2009). The instructional design practices of organizing or structuring a course within an LMS relies upon the available navigation inherent in the design of the LMS. Hence the organization of the information, along with the underlying design of the system need to work together to support learners and improve the perceived usefulness and ease of use of a course in the LMS (Nielsen, 2009; Waniek, 2012).

Disorientation in hypermedia environments. Disorientation is the feeling of being lost and not knowing how to get to a desired location (Firat & Yurdakul, 2010). The need to make navigational decisions within a hypermedia environment may increase feelings of DIS and the cognitive load imposed on the learner, thus interfering with the learning process (Amadieu, Tricot, & Mariné, 2009). Rouet, Vörös, and Pléh (2012) noted a higher cognitive load in a hypermedia context when compared to print text, supporting the idea that the additional navigation requirement reduces the amount of cognitive resources available for learning. Sandberg (2013) suggested that disorientation is the result of "overtaxing" working memory with the multiple goals of comprehension, selection of links, navigation, and coherence decisions.

Wojdynski and Kalyanaraman (2015) noted that the logic of structure had a significant impact on navigation within a hypermedia environment and that variations in the structure of a website can significantly affect the user's perceptions. For example, the hierarchical navigation tends to provide the best results in terms of comprehension, recall, and disorientation (Morozov, 2009). However, Chen, Lin, Yen, and Linn (2011) noted that deep hierarchical structures and unfamiliar titles on navigational options increase disorientation in novices. Moreover, when navigation reveals the underlying complexity, perceptions of learning are reduced. Cuddihy and Spyridakis (2012) suggested that the greater knowledge of the complexity decreased the learner's confidence.

The number of elements (e.g., words, images, and links) on a page determines the visual complexity of a website (Wang et al., 2014). Many of the pages within the LMS contain a high number of elements that cannot always be easily reduced. Through a series of studies, Harper, Jay, Michailidou, and Quan (2013) reported that in addition to reducing the number of links, other structural elements such as font, colors, blocks, and images can help reduce the perceived visual complexity of a webpage. Visual navigational aids such as breadcrumbs, highlighting, pagination, and progress bars have also been shown to reduce disorientation (Ruttun & Macredie, 2012).

While some navigational behaviors have been seen to be indicators of disorientation (e.g., use of the back button), Brouwers (2014) stated that some navigational behaviors could be more indicative of mismanagement of cognitive load. Sandberg (2013) suggested that problems of disorientation are a combination of low prior knowledge along with problems in efficient use of working memory due to high cognitive load. Thus, the suggestion to include disorientation, along with other cognitive load measures to better describe the learner experience (Longo & Dondio, 2015).

Cognitive Load Theory

According to Brünken, Seufert, et al. (2010), "cognitive load simply means that something non-automatic happens in the mind, which causes the consumption of mental resources" (p. 194). The five principles of CLT describe how information moves through working memory to long-term memory for later retrieval (Leppink et al., 2015). As individuals interact with information it is process through working memory and added to previously stored patterns of information called schema. As working memory is limited, how much information can be processed depends upon how previous schema was created, how information in currently stored, and how it connects to the new information (Kalyuga & Singh, 2015).

Cognitive load can be divided into three types of information; *intrinsic*, information inherent in the content; *germane*, information required to learn the content; and *extraneous*, information that adds to the cognitive load but does not support learning (Sweller, 2010a). In terms of learning within the LMS an "interface that yields lower extraneous load with higher usability [should] provide the higher germane cognitive load that aids schema construction and automation" (Cheon & Grant, 2012, p. 51). Hollender, et al. (2010) proposed that extraneous cognitive load can be induced by both instructional design practices and the usability of elearning interfaces. In order to minimize extraneous load, a portion of CLT research has focused on how to measure these three types of cognitive load.

Measuring cognitive load. Cognitive load is challenging to measure directly; however, many indirect measures have been used such as time on task, navigation behaviors, overall performance, and error profiles (Brünken, Plass, & Leutner, 2003; Leppink et al., 2015; Schmeck, Opfermann, van Gog, Paas, & Leutner, 2015; Schmeck et al., 2015). Physiological measures such as heart rate, functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and eye-tracking have shown promise but require specialized equipment (Brünken, Seufert, et al., 2010; Leppink et al., 2015). Secondary tasks such as the Stroop test, auditory signals, and screen color changes help to provide continuous measures during a task but can be complex in their implementation

(Schmeck et al., 2015). The most commonly used method has been self-reported ratings of overall mental effort as it is quick and easy to administer (de Jong, 2010). The mental effort (ME) scale developed by Paas (1992) has been shown to be sensitive to changes in overall cognitive load (Brünken, Seufert, et al., 2010) and changes in extraneous load in particular (Wiebe, Roberts, & Behrend, 2010); especially when measured immediately following an individual task (Leppink & van Merriënboer, 2015).

While new instruments and methods to measure the three different types of cognitive load are currently being developed, tested, and validated, the research has provided several recommendations in measuring cognitive load (Antonenko & Niederhauser, 2010; Leppink, Paas, van der Vleuten, van Gog, & van Merriënboer, 2013). Brünken, Seufert, et al. (2010) summarized the recommendations as follows, 1) use repeated measures synchronized with the aspect of the learning to be measured and 2) combine several measures, especially when using one of the subjective rating scales.

The literature has suggested the use of multiple measures in order to provide a more complete picture of cognitive load, and to differentiate between the three types of load (DeLeeuw & Mayer, 2008; Leppink et al., 2013). In a study that compared mental effort ratings from the domain of instructional design with a common usability measure from the domain of human computer interaction, Longo and Dondio (2015) noted that changes in the perceived usability required higher mental effort. Although the data indicated the two constructs were related, they were non-overlapping such that the authors suggested they could be used together to better describe the user experience.

Multimedia principles. Many studies in CLT have looked at the design of instruction for individual modules, learning objects, and self-contained lessons (Amadieu, Tricot, et al., 2009). Clark and Mayer (2011) developed six principles for multimedia learning based on CLT research to guide the design of these types of multimedia instructional materials. These principles look at the interactions between audio, video, text, and image content within the context of the content of an individual lesson or learning object. The focus is on the presentation of the content within an individual lesson. These principles have guided researchers in developing materials that focus on specific aspects of one of the areas of cognitive load. For example, complex content can be chunked into segments, or simulations used to reduce the intrinsic load (Mayrath, 2009); germane load can be changed through the difficulty of the tasks (DeLeeuw & Mayer, 2008); and extraneous load can be introduced by redundant or excess stimuli (Kushnir, 2009).

In addition to the creation of course content, the design of a complete course within an LMS includes sequencing and organizing the material to "provide guidance to the learner on how to build knowledge structures" (De Smet, Schellens, De Wever, Brandt-Pomares, & Valcke, 2014, p. 9). The ability of students to navigate freely makes the LMS hypermedia environment different from a linear learning object or lesson and one of the main reasons the application of multimedia principles in a hypermedia learning environment is a simplictic approach (Gerjets, Scheiter, Opfermann, Hesse, & Eysink, 2009). It is also one reason why it is difficult to examine a single feature of the LMS to the exclusion of others (Morozov, 2009).

Therefore, in order to examine extraneous load specifically, the literature suggests multiple measurements along with careful manipulation of research materials to focus on either intrinsic, germane, or extraneous load. These two approaches help provide a more complete picture of the learner's experience in relation to extraneous load.

Prior Knowledge and Schema Creation

"In order to efficiently reason about knowledge and information, humans have evolved efficient strategies for organizing complex concepts in order to form connections between and recall information" (Aguinaga, Nambiar, Liu, & Weninger, 2015, p. 38). The creation of patterns and connections, called schema, facilitates how previous information is recalled and how new information is integrated into long-term memory. Individuals can maximize working memory by drawing upon schema in long-term memory, thus prior knowledge affects how working memory processes new information (Beker, Jolles, Lorch Jr, & van den Broek, 2016).

When new information is not well-structured or not represented well, the extraneous load of processing the new information can hinder the creation of well-structured schema in long-term memory (De Smet et al., 2014). Fang and Holsapple (2011) explored how different types of navigational indicators influenced the formation of schema and noted that when learners interact with a content-oriented navigation, they are more likely to adopt a structural mental model of the information. Whereas with a system-oriented navigation, they are more likely to develop a functional mental model of the system. Thus, the influence of prior knowledge applies whether it is knowledge is related to the content, system, or previous success.

Prior content knowledge. Prior content knowledge has been shown to reduce feelings of disorientation, and improve navigation coherence (Amadieu, Salmerón, et al., 2015) and to improve learning outcomes (Waniek & Schäfer, 2009). The coherence in navigation is facilitated as learners use the signals from the environment to draw upon schema in their long-term memory.

Teaching strategies such as advance organizers have been used to activate a learner's previous knowledge and improve learning outcomes for both low and high prior content knowledge (Sullivan & Puntambekar, 2015). However, differences between low and high prior knowledge groups can still be seen in measures of disorientation, navigation coherence, and mind-mapping supporting the use of multiple measures related to cognitive load (Amadieu, Salmerón, et al., 2015).

In addition, the type of structure provided has been shown to support low and high prior content knowledge differently when using content specific navigation identifiers. For example, a hierarchical navigation improved learning performance for low prior content knowledge over a networked structure, but high prior knowledge showed no difference across the two structures (Amadieu, Tricot, & Mariné, 2010). The differences between the low and high prior knowledge indicates that learners with high prior content knowledge are able to overcome the added cognitive demands of a network structure by drawing upon schema in their long-term memory.

Yet, Sullivan and Puntambekar (2015) suggest that the effect of prior content knowledge is complex and may not support good navigational decisions, as learners with high prior knowledge still struggled to make good navigational choices. What's more, prior knowledge can also prevent learners in achieving deep understanding when there are inconsitencies between the current schema and the new information. Ihme and Wittwer (2015) reported that learners were biased towards the first explanation presented, although the inclusion of headers lessened this bias.

Prior system knowledge. System knowledge relates to previous experiences with a specific elearning technology, or in hypermedia, an in depth understanding of how the system organizes or structures the information. Whereas domain knolwedge may provide insight into content connections, system knowledge supports better navigation (Waniek & Schäfer, 2009, p. 235).

Waniek and Schäfer (2009) reported that in information search tasks prior system knowledge improved search times and the number of correct answers. The more efficient navigation is likely related to a "faster visual recognition" of helpful hypermedia elements (Dikbas Torun & Altun, 2014). Kuzu and Firat (2010) reported that individuals with more experience browsing on the internet use more navigational aids, resulting in more effective and efficient navigation.

In contrast, those with little or no prior system knowledge spend more time reading to navigate, which imposes a higher demand on working memory (Waniek, 2012). Thus, to increase the effectiveness of hypertext, navigation should be more intuitive (Amadieu, Tricot, et al., 2009; Kaptelinin, 2014). Zanjani (2015) stated that easy navigation in the LMS was repeatedly emphasized in a review of the literature on LMSes; thus, supporting the suggestion that a learner should be able to interact with an elearning technology with very little instruction (Park & Song, 2015).

Prior system knowledge has also been shown to decrease feelings of disorientation and a trial-and-error navigation behavior (J. V. Chen et al., 2011). Cheon and Grant (2012) recommended that faculty and instructional designers consider the role signals such as structural cues and learning content clues in the interface have in supporting schema creation in relation to germane cognitive load.

Prior experience. In relation to previous success, Hachey, Wladis, and Conway (2012) found a distinct relationship between success and retention when students (N = 880) had at least one successful prior online learning experience; suggesting that "as soon as a student has at least one successful online course experience, barriers to learning decrease" (p. 19). In a follow-up study (N = 292), they noted that successful prior online learning experience was a stronger predictor of successful completion of an online course than G.P.A (Hachey, Wladis, & Conway, 2014).

Related to previous experience, in a comparison study between two LMSes – WebCT and Moodle, Porter (2013) discovered that the majority of users reported a preference for the current LMS (WebCT) due to familiarity. Those that reported a preference for the newer LMS (Moodle) indicated that the interface quality and organization overcame the easy, familiar path.

In summary, prior knowledge in relation to the content, the system, and other related experience influence how schema forms in long-term memory. The environmental organizing and linking principle from CLT states that signals from the environment will enable learners to maximize working memory as they draw upon schema in long-term memory. Learners are able to draw upon their schema in long-term memory related to either content, system usage, or previous success. Therefore, prior knowledge in all three of these areas will influence learner behavior.

Signal Available Relevant Accessible Theory

Signals from the environment facilitate connections to schema in long-term memory in order to maximize the use of working-memory (Leppink et al., 2015). Lemarié, Lorch Jr, et al. (2008) proposed the signal available relevant accessible (SARA) theory to explain the effects of signals. SARA theory states that signals will have an effect when they are available and relevant to the cognitive processing goals of the reader. The effects are moderated by the accessibility of the signals such as efforts to access or language level used in the signal.

Defining signals. Across the literature, there is an abundance of evidence to support the use of signals in everything from expository text in print format to multimedia elearning modules. However, the definition of signals is equally varied. Ho-Dac, Lemarié, Péry-Woodley, and Vergez-Couret (2012) defined signals broadly as "traces of the writer's cognitive processes, as cues revealing the author's intentions…" (p.1). In the research, signals have been described as static devices such as headers (Clariana, Rysavy, & Taricani, 2015), navigational buttons (Sung & Mayer, 2012), sentence previews (Lorch Jr et al., 2011a), navigational overviews (Bezdan, Kester, & Kirschner, 2013), hierarchical maps (Bezdan et al., 2013), and breadcrumbs (Ruttun & Macredie, 2012). Dynamic devices have also been identified such as highlighting (Scheiter & Eitel, 2015), suggested next steps/pages (Jamet, 2014), link leads (Antonenko & Niederhauser, 2010), progress bars (Sung & Mayer, 2012), and page previews (Cuddihy, Mobrand, & Spyridakis, 2012). In addition, typographical characteristics such as color, font type and size, italics, bold, underlining, and the use of white space have been identified as signals (Lemarié, Lorch Jr, et al., 2008; Sandberg, 2013). Thus making it difficult to not only compare the research related to signals, but to also make inferences about how and why signals work.

The three-step analysis proposed by the SARA theory involves a thorough analysis of 1) the signals and their characteristics; 2) the relationship of the information to the goals of the learner; and 3) the cognitive limitations of the learner (Lemarié, Lorch Jr, et al., 2008). The following seven characteristics provide a thorough analysis of the signals and their characteristics: 1) a demarcation in the structural boundaries; 2) the hierarchical organization; 3) the sequential organization; 4) a label; 5) the identification of the topic; 6) the function; and/or 7) an emphasis on a specific portion (p.140-141). These seven characteristics provide a mechanism to enable comparisons across the research on signals.

Signals in hypermedia. The research on signals has been shown to be beneficial to learning with linear text. Naumann, Richter, Flender, Christmann, and Groeben (2007) suggested that signals may play an even more important role in learning with hypermedia in reducing the load on working memory. Hypermedia environments require learners to make navigational decisions in addition to learning the content. Ruttun and Macredie (2012) confirmed that navigational signals in a hypermedia environment did reduce disorientation; and the effects were consistent across individual differences such as cognitive styles, domain knowledge, and computer experience.

Equally important to the navigational support, signals have been shown to influence learning outcomes of comprehension and recall. Cuddihy and Spyridakis (2012) reported that hypermedia with high levels of signals supported higher levels of learning. Sung and Mayer (2012) studied the effects of signals (headings, highlights, summaries, and key terms) and navigational aids (page numbers, progress bars, and forward/back buttons) within an elearning module across eight usability scales. The aids of headers, highlights, font size, summaries, and key terms had significant and large effect on both comprehension and learning.

Ihme and Wittwer (2015) suggested that the overt information signals provide about the structure reduces the impact on cognitive load, as the learner does not need to infer the structure of the text. In expository text, the structure of a "passage allows the reader to distill the most important ideas" (Wijekumar & Meyer, 2013, p. 127). Similarly, the structure of a course communicates the most important learning activities. Amadieu, Lemarié, and Tricot (2015) also suggested that content focused overviews acted as guides to fill in gaps created by incoherent jumps in hypermedia navigation, especially for novices

Moreover, signals have been shown to extend the visual perception span to improve overall search times (Cauchard, Eyrolle, Cellier, & Hyönä, 2010). This indicates that headers facilitate a larger view of the overall structure within a hypermedia environment. Furthermore, Sung and Mayer (2013) noted that the simple addition of non-informational headers and segmenting the content into smaller pieces in a multimedia lesson improved learner performance on a transfer test.

The organization of the menus also affects how users approach search tasks and in how schema is created in long-term memory. In comparing sequential and hierarchical headings in expository text, the information in the headings influenced outlining and search tasks differently (Lorch Jr et al., 2011a). Galilee (2013) reported that more efficient network navigational strategies were used when spatial signals were present. Swanson (2012) also supported the use of signals within the context of learning, suggesting that signals helped identify "attention-worthy elements" for novice users to support learning (p. 20).

Findability and navigation. Findability is “the ease with which a given information object can be found” (Azzopardi, Wilkie, & Russell-Rose, 2013, p. 3). If content is finable, then it is more likely to be accessed. “The systems, structures, and content used to provide relevant information to web users play a major role in shaping what information is findable” (Azzopardi et al., p.3). Simunich, Robins, and Kelly (2015) reported that participants struggled to locate course materials when they were not “grouped into logical categories” (p. 182) and recommended that “future studies could focus on what design aspects most impact findability and whether findability is of greater impact for certain items in an online course” (p. 183).

Evidence suggests that the interface design influences findability, comprehension, information processing, and the user’s overall perceptions of the experience (Wojdynski & Kalyanaraman, 2015). For example, “in situations where users engage with a website with a specific task in mind, it can be expected that impediments to completion of the task will lead to more negative attitudes toward the site” (p.5). In other words, ability and ease of navigation within a hypermedia system influences perceptions of the system.

Castro et al. (2007) defined navigation as “the efficiency, effectiveness and satisfaction with which a user navigates through the system in order to fulfill her goals under specific conditions” (p. 420). Puerta Melguizo, Vidya, and van Oostendorp (2012) observed that when there is semantic overlap between the goals and the menu labels, users make better navigational decisions. In terms of learning, more efficient navigation within the system would enable learners to spend more time on learning (Hoffman & Schraw, 2010).

One of the factors related to navigation which influences cognitive load is the amount of available time (Chen, Pedersen, & Murphy, 2012). Due to the complexity of hypermedia, learners who have difficulties are likely to spend excess time trying to locate the information needed (Firat & Yurdakul, 2010); and time spent finding information means less time for learning. While navigational efficiency includes a component of "less time to accomplish the goal," it is also important to consider successful completion, as learners have been known to simply quit if the task is taking too long (Azzopardi et al., 2013).

Comparative Usability Testing

Usability is "the extent to which a product can be used by specified users to achieve specified goals, with effectiveness, efficiency and satisfaction in a specified context of use" (ISO, n.d.). Usability incorporates a number of factors including interface aesthetics, navigational efficiency, availability of information, and indicators for the next step in the process (Mason, Cooper, Wilks, & others, 2015).

Usability testing is different from instructional design or system development, in that real users complete authentic tasks in relation to specific concerns. A comparative usability test has participants experience two or more designs in order to compare them to each other (Bindal et al., 2014). Usability testing could be a way to discover ways to avoid learner confusion and frustration (Monaco, 2012); however, due to time constraints and a perception of low importance, usability testing has not often been used in instructional design or elearning system development (Zaharias, 2011).

Both prior knowledge and experience have both been shown to significantly affect reported system usability (Orfanou, Tselios, & Katsanos, 2015; Papastergiou, 2010). What's more, the concept of usability is related to the two strongest predictors of technology use – perceived ease of use and perceived usefulness (Davids, Halperin, & Chikte, 2015). Usability is commonly measured based on users' perceptions, although studies involving additional measures have often shown differences in user reported usability in contrast to actual performance (Fang & Holsapple, 2011). For example, satisfaction is a measure that has been show to vary even when there is no significant difference in time on task or learning outcomes, supporting the conclusion that usability is a very complex construct (Kauffman, 2015). Fang and Holsapple (2011) suggested the need for a better understanding of the factors that affect usability.

Gaps in the Literature

From the literature, we know that both system and instructional design factors have the potential to influence both germane and extraneous load (Hollender et al., 2010). In terms of success, a learner needs to be able to locate appropriate resources and tools (Simunich et al., 2015). Thus, the findability of content and activities can support or hinder a learner's success (Azzopardi et al., 2013). Moreover, hypermedia systems are complex; and even when best practices have been followed, learners sometimes report low usability scores, indicating that usability is also complex (Orfanou et al., 2015).

Furthermore, the LMS, with the added task of making navigational decisions, can increase the overall cognitive load resulting in reports of disorientation (Amadieu, Lemarié, et al., 2015). While high mental effort can indicate improved learning, in that the learner is focused and engaged with the content (Brouwers, 2014), high mental effort due to ill-designed instruction and systems will cause extraneous load (Cheon & Grant, 2012), limit available working memory (Kuldas et al., 2015; Sweller, 2010b), and decrease learning outcomes (Kalyuga, 2010).

The research consistently reports that structure and signals help alleviate the negative impacts of increased extraneous load in hypermedia environments (Cheon & Grant, 2012; Lemarié, Lorch Jr, & Péry-Woodley, 2012; Song, 2011). This is evident in more efficient navigation (C. Y. Chen et al., 2012), increased overall comprehension (Amadieu & Salmerón, 2014; Lorch Jr et al., 2011a), and improved learning outcomes (Sullivan & Puntambekar, 2015). In line with the organizing and linking principle of CLT, signals from the environment can connect with prior knowledge in both content and system domains to aid in accessing information from long-term memory (Leppink et al., 2015).

Several gaps in the research have also emerged. The definition of signals is varied making it difficult to compare studies and to discern how and why signals work. In addition, the majority of the CLT studies have focused on learning objects and multimedia lessons; very little CLT based research within the context of the LMS has been reported. Lastly, while CLT has influenced both instructional design and human computer interaction, little research has drawn from both areas.

This study addressed these gaps by using the LMS as the context. SARA theory provided an explicit description of one feature – the organizational structure communicated through the section headers and the navigational menu. Furthermore, this study combined multiple measures of extraneous load drawn from instruments in both instructional design (ME and DIS), and human computer interaction (SU and NE).

CHAPTER III

Methodology

This one-way within-subjects multivariate analysis of variance quantitative experiment was designed to answer the following research question:

- Are there significant differences in extraneous cognitive load [as measured by the combination of mental effort (ME), disorientation (DIS), system usability (SU) and navigational efficiency (NE)] for three different organizational structures with the LMS (time, topic, and tool)?

The goal of the experiment was to determine if there is an impact on extraneous load due to the organizational structure of a course within an LMS. The multiple measures of ME, DIS, SU, and NE were used to provide a larger picture of possible influences on extraneous load. All participants completed three tasks within each organizational structure with ME, DIS, and NE measured after each task. SU was measured after each organizational structure. Data analyses using a multivariate analysis of variance (MANOVA) was planned to determine if one of the organizational structures would maximize the navigational efficiency, minimize the impact on extraneous load, and if there is a difference in system usability; or a combination of effects.

Research Design

A one-factor within-subjects multivariate experimental design was used for this study. This design was selected to reduce the effects of individual differences, a potential Type I error with multiple univariate ANOVA, and to include the combined effects of the dependent variables. However, as the data did not meet the assumptions of linearity for MANOVA and normal distribution (due to extreme outliers) for both ANOVA and

MANOVA analysis, separate non-parametric Freidman tests were performed with a Bonferroni correction ($\alpha = .0125$). The within-subjects factor consisted of three types of organizational structure in an LMS: (a) time, (b) topic, and (c) tool. The dependent measures consisted of (a) ME, (b) DIS, (c) SU, and (d) NE. This study followed the procedures of a comparative usability test with participants completing authentic tasks within three courses, each with one of the organizational structures of time, topic, or tool in a lab setting (Bindal et al., 2014).

Potential Participants and Sampling Criteria

The population of interest was undergraduate students. Individuals who were 18 years or older, undergraduate students at a public university in the Northwestern United States, who had not previously taken nor were currently enrolled in ANTH 1100, and were not Anthropology majors were eligible to participate in the study. Participants were recruited through course announcements, posts on the electronic student bulletin, flyers placed across campus, contacts with student organizations, a table in the student union, and word of mouth from other students. Snacks were provided during each study session and participants were offered the option to enter a drawing for a $50 Amazon gift card. A sample of 10 participants were recruited. According to the results of a *G*Power 3.1* a priori power analysis (Faul, Erdfelder, Lang, & Buchner, 2007), for a moderate effect size of 0.35 (measured using Cohen's *f*), the total sample size should have been 18 participants to have 80% power. The smaller size of the actual sample along with the reported effect sizes in Chapter IV indicate a strong probability of a Type II error.

Materials

In order to examine the effects of different organizational structures on ME, DIS, SU, and NE the following materials were needed: a course, a list of tasks, and the creation of a usability study process.

The course. A course was modified to match each of the organizational structures. An online ANTH 1100 course was selected as the content matter is not too difficult or out of the ordinary to cause undue hurdles for the participants. The original course had been taught by the same faculty for four years. The LMS used for the original course was Moodle (see Appendix B for more details about the original course and the development of the courses used in this study).

Before setting up the three organizational structures, the course was evaluated in order to anonymize the instructor information, and ensure that all the materials were easily accessed within the context of the study. Three courses were created, with each one modified to match one of the organizational structures of time, topic, or tool. The location, size, color, and style of the section headers were identical across all the courses. To distract from the differences in organization, the three courses were titled Basalt (time), Jasper (topic), and Quartz (tool) rather than by the type of organizational structure.

For the organizational structure of *time*, the section headers were set to display the weeks (e.g., August 21 – August 27). Labels in the original course containing the topic for the week, Lecture Related Materials" and "Quizzes" were eliminated. The assignments and exams were moved to the appropriate week in the term. Exam study guides were also moved to the week of the exam. Thanksgiving and "closed week" were indicated in the appropriate week with the original labels. All course identifiers were changed to ANTH1100 General Anthropology Basalt Course (see Figure 4).

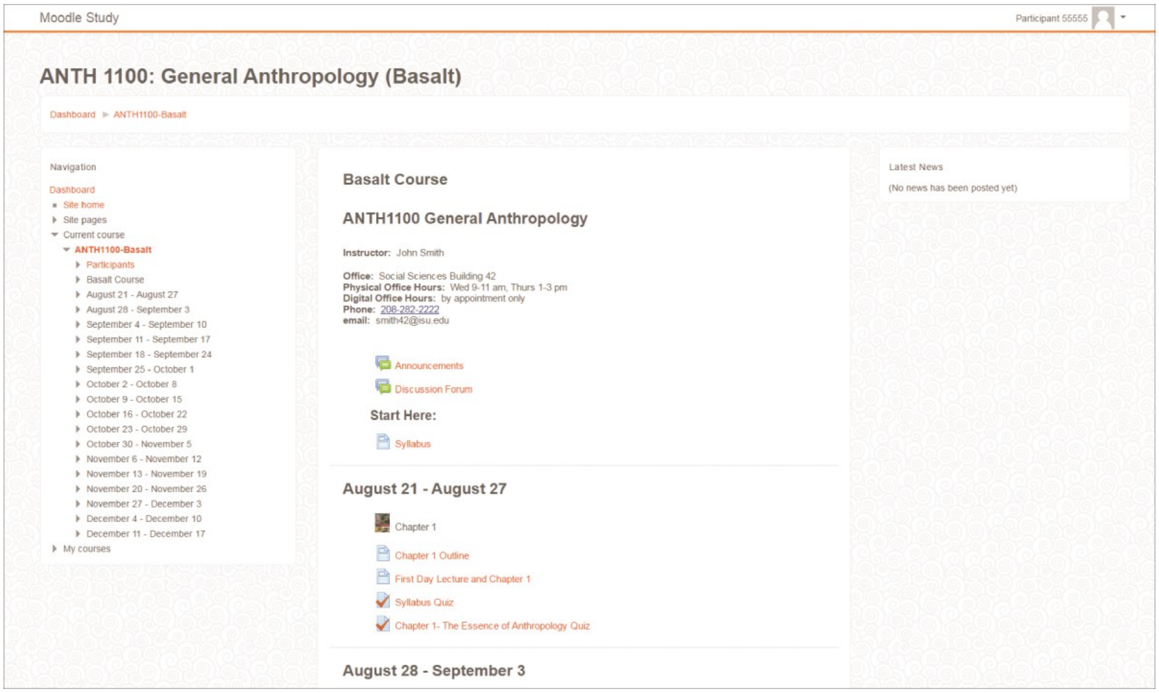

Figure 4. Basalt Course showing the organization structure based on time.

For the organizational structure of *topic*, the section headers were set to display topics (e.g., The Neolithic Revolution). The original labels of "Lecture Related Materials" and "Quizzes" were eliminated. The assignments were moved to the appropriate topic section. The exams were each given their own section and placed after the topics the exams covered. The sections concerning Thanksgiving and closed week were eliminated. All course identifiers were changed to ANTH1100 General Anthropology Jasper Course (see Figure 5).

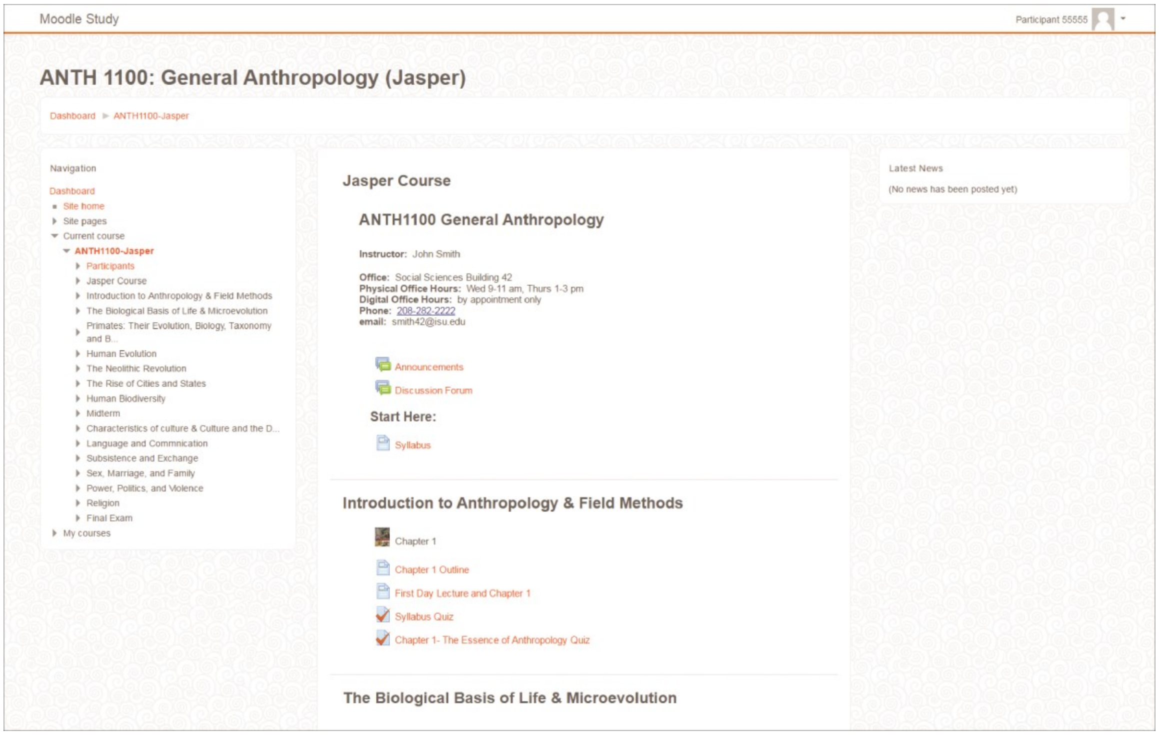

Figure 5. Jasper Course showing the organization structure based on topic.

For the organizational structure of *tool*, the section headers were set to display the tool (e.g., Forums, Chapter Outlines). The labels containing the topic for the week, "Lecture Related Materials," and "Quizzes" were eliminated. Course materials were moved into their appropriate section, all the forums were moved to the forum section, all the assignments were moved to the assignment section, etc. The sections concerning Thanksgiving and closed week were eliminated. All course identifiers were changed to ANTH1100 General Anthropology Quartz Course (see Figure 6).

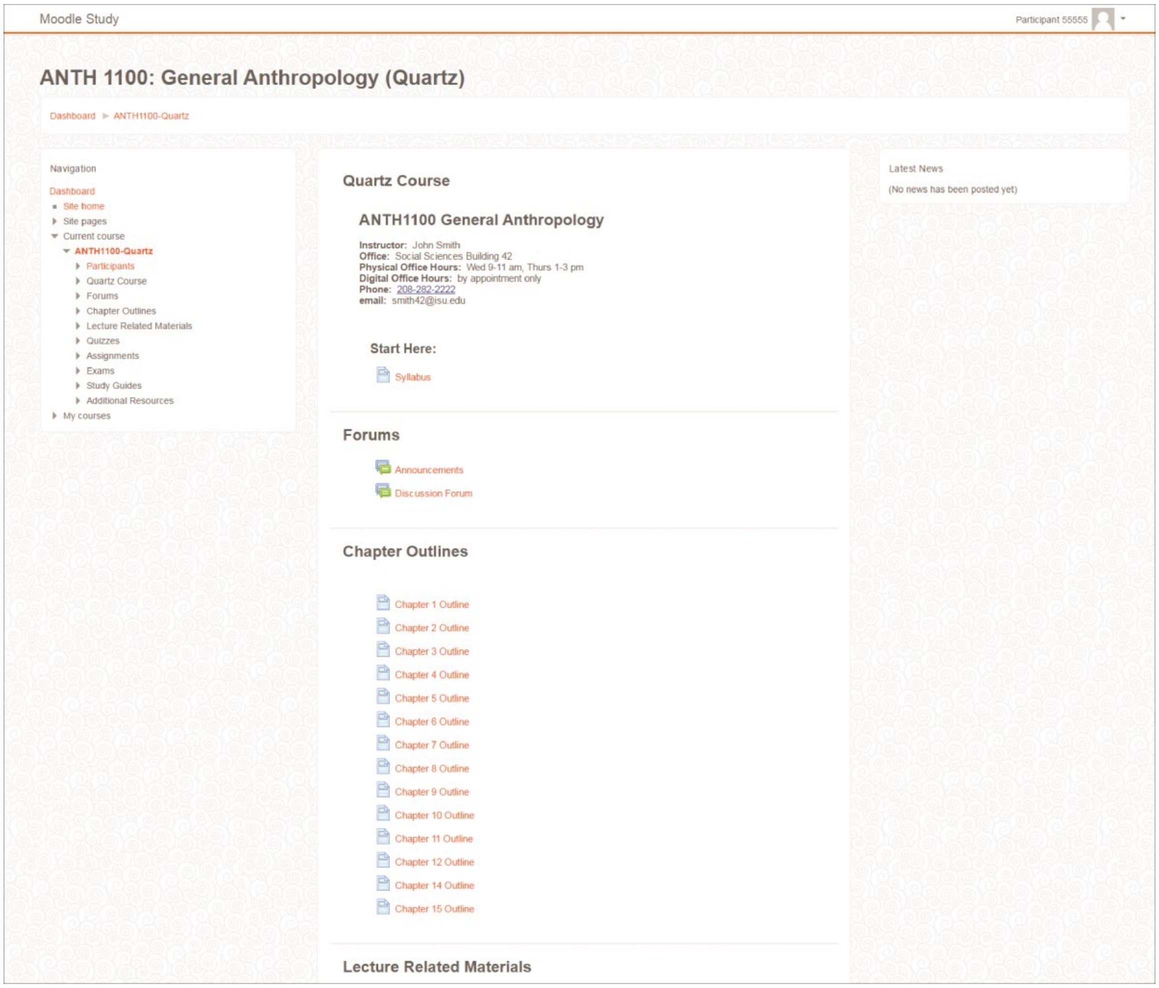

Figure 6. Quartz Course showing the organization structure based on tools.

The top section for all courses included the instructor information, along with the syllabus under a "Start Here" label (see Appendix B for more detailed images of the three different courses).

Tasks. A list of tasks was created for the participants to complete during the comparative usability study. As the participants needed to complete three tasks for each course, nine tasks were created. Tasks were presented to the participants in the form of a question asking participants to locate specific information within the course. The nature of the tasks have the potential to influence the outcomes based on semantic similarity (Blackmon, 2012) and difficulty (Schmeck et al., 2015). In addition, the within-measures design has the potential to introduce order effects based on the courses, or carry over from the tasks (Gall et al., 2007). The tasks were developed, evaluated for difficulty, and counterbalanced with the treatments, to reduce the effects due to semantic similarity, difficulty, carryover, and order effect (see Appendix C for the development of the tasks).

Usability study process. The usability study process was created in Articulate Storyline 2 to guide participants through the study. Nine versions of the process were created to counterbalance the tasks and treatments (see Appendix D for a description of the counterbalancing).

The storyline guided participants in completing each questionnaire described in the instruments section. Participants were also able to read and answer the task prompts using the specific course embedded within the storyline (see Figure 7).

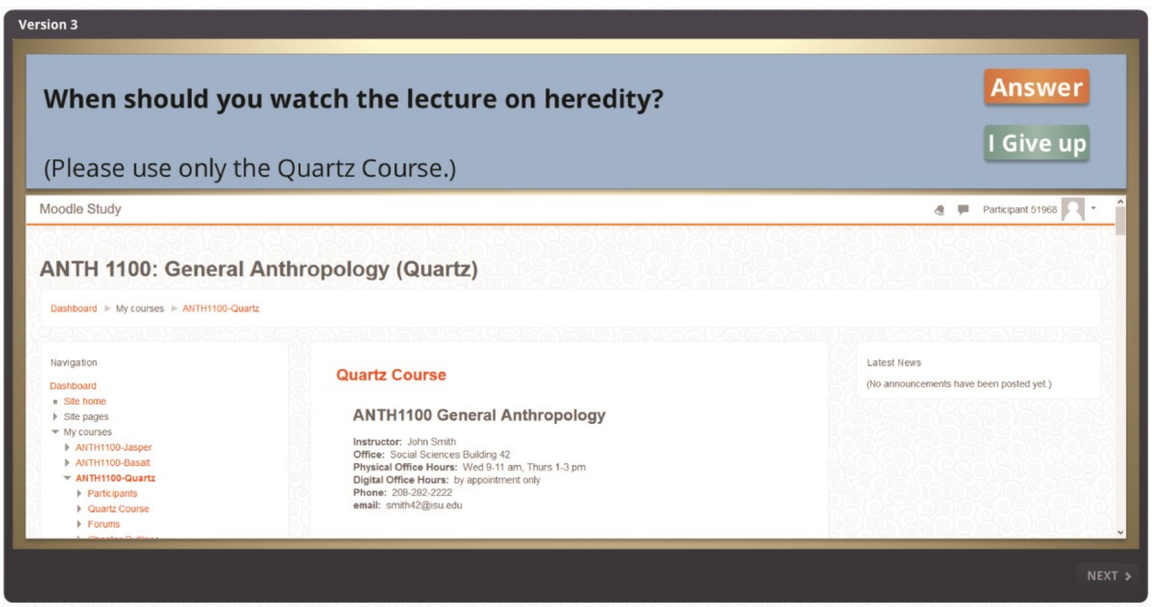

Figure 7. The task screen in the Articulate storyline showing the task prompt, the buttons to answer or quit, along with the course embedded below the task prompt.

The storyline was published as a SCORM 1.2 package with settings to in full screen mode and report all responses back to Moodle under the unique participant ID number (see Appendix E for details on the development of the Articulate Storyline).

Instrumentation

The independent variable of organizational structure was indicated by the type of information contained in the section headers and the navigation block – time (i.e., chronological sequence), topic (i.e., hierarchy), and tool (i.e., function) as described in the materials section.

Instruments. This study used the following questionnaires as instruments – demographic; mental effort; disorientation; and system usability scale.

Participant demographic questionnaire. In order to describe the sample, a demographics (DEM) questionnaire was created based on demographic information collected in similar studies (Alshare, Freeze, Lane, & Wen, 2011; Henderson, Selwyn, Finger, & Aston, 2015). The undergraduate student population at this public four-year institution in the Northwest is diverse with non-traditional students and international students. Standard demographics were included such as gender, age, and class level. In addition, information about general academic performance, discipline of study, domicile (international or domestic), and first language were included to describe the sample.

As prior knowledge and experience have been shown to influence cognitive load, several questions asked about the participants' experience with LMS. After a brief explanation of an LMS along with some examples and non-examples, participants were shown a list of the top LMSes across higher education, along with the LMSes used in the region, and asked to mark which ones they had used in their courses. Brightspace was listed twice, once with the current name of Brightspace and again with the previous name of Desire2Learn. Participants were also asked to indicate the depth of use based on the frequency of interaction with a list of the top six student actions within the LMS pulled from our institution's LMS logs by marking one of seven-point items from 1 (never 0%) to 7 (always 100%). Lastly, participants were asked to indicate how often their previous courses were organized by weeks (time), topics, or activities (tool) by marking one of seven-point items from 1 (never 0%) to 7 (always 100%). The DEM questionnaire was completed at the beginning of the session (see Appendix F for the participant demographic questionnaire).

Computer self-efficacy questionnaire. The computer self-efficacy (CSE) questionnaire consisted of a Likert scale developed and validated by Howard (2014) containing 12 items. The CSE scale has demonstrated high internal reliability (Cronbach's alpha, .96) (Howard, 2014). To complete this scale, participants responded to positively worded statements by marking their responses to seven-point items ranging from 1 (strongly disagree) to 7 (strongly agree). Participants completed the CSE questionnaire after completing the demographic questionnaire. CSE is a score between 1 and 7, calculated by the average of the 12 items on the CSE questionnaire (Howard, 2014) (see Appendix G for the CSE questionnaire).

Mental effort questionnaire. The ME scale was developed by Paas (1992) and has been shown to be a reliable and valid measure (Cronbach's alpha of .90) (Tuovinen & Paas, 2004). Participants indicated their mental effort by marking one nine-point item from 1 (very, very low mental effort 0%) to 9 (extremely high mental effort 100%).

As the literature has demonstrated that immediate measures more accurately reflect the mental effort of the specific task (Schmeck et al., 2015; van Gog, Kirschner, Kester, & Paas, 2012), the mental effort questionnaire was completed after each task.

ME is a score between 1 and 9, calculated by the average of the three tasks for each organizational structure questionnaire (see Appendix H for the ME questionnaire).

Disorientation questionnaire. The DIS scale was developed by Ahuja and Webster (2001) and has been shown to have high reliability (Cronbach's alpha of .90). The DIS scale includes seven positively worded statements related to both conceptual and structural disorientation. Participants indicated the frequency of experiencing each item by marking one of seven-point items from 1 (never 0%) to 7 (always 100%). Participants also completed the DIS questionnaire after each task. DIS is a score between 1 and 7, calculated by the overall average of the three tasks for each organizational structure (see Appendix I for the DIS questionnaire).

System usability questionnaire. The SU scale developed by Brooke (1996) is a "measure of people's subjective perceptions of the usability of a system" (Brooke, 2013, p. 33). The SU scale has previously been used in the evaluation of LMS usability and demonstrated reliability consistent with other studies using this instrument (Cronbach's alpha of .82) (Lewis & Sauro, 2009; Orfanou et al., 2015). The SU scale includes five positively worded, and five negatively worded statements. Participants indicated their agreement with the statements using a five-point scale from 1 (strongly disagree) to 5 (strongly agree).

To provide additional system usability information Bangor, Kortum, and Miller (2009) added a "seven-point-adjective-anchored" (p. 114) scale to the SUS. Participants indicated their overall rating of the "user-friendliness of the product" by marking one of seven-point items ranging from 1 (worst imaginable) to 7 (best imaginable). Participants completed the system usability questionnaire after each organizational structure.

According to Brooke (1996), system usability (SU) is calculated by taking the scores from items 1, 3, 5, 7, and 9 and subtracting 1; subtracting the scores from items 2, 4, 6, 8, and 10 from 5; adding all these scores and multiplying by 2.5 for an SU score out of 100. The adjective scale score was used to confirm the calculated SU score. All other measures were scores of 1-7 or 1-9 with lower numbers indicating better outcomes, the SU was divided by 10 and reverse coded so that a lower number indicates better system usability. The reversed system usability (rSU) is a score between 1 and 10, calculated following the guidelines from Brooke (1996), then divided by 10 and reverse coded for each organizational structure (see Appendix J for the SUS questionnaire).

Post questionnaire. At the conclusion of the study there was an optional open ended question for participants to comment about their experience. Participants completed this questionnaire at the conclusion of the session (see Appendix K for the post questionnaire).

Performance measurement. One performance measurement was assessed in the study. This measurement was calculated after the usability study, using the screen recordings and thus, did not impact participants during the usability study.

Navigational efficiency measurement. NE was measured per task, using a screen recorder (Cattura CaptureCast Chrome extension, https://www.catturavideo.com/). Time began when the participant clicked the next button from the previous screen and ended when the participant clicked either the “Answer” or the “I Give Up” button (see Figure 8 for a screenshot of the task screen). Each screen recording was reviewed to document the time per task using a video player that displayed the time to the milliseconds (Avidemux, http://fixounet.free.fr/avidemux/). All answers and screen recordings were reviewed to determine if the participant found the correct information for each task. NE is a score in seconds, calculated by the sum of the seconds of the three tasks divided by the number of correct responses for each organizational structure (Sauro, 2011b).

Procedure

The study took place in a computer lab with each participant at identical Chromebooks with a regular mouse. The Chromebooks were setup, logged in to the Moodle research course, and the screen recorder up and ready to begin recording. The study sessions took 45-60 minutes, including the study orientation.

Upon entering the computer lab, participants randomly selected a card with a unique ID. Participants reviewed the consent forms, asked any questions, signed, and indicated which ID they selected. This was the only place participant names were kept in conjunction with the unique ID numbers. All other data collected during the study was connected to the unique ID.

Participants were oriented to the study and the use of the equipment as a group. After responding to any questions from the group, participants went to the Chromebook with their unique ID label, clicked the record button to begin recording their screen and then proceeded through the storyline for the study (see Figure 8 and Appendix E for the sequence of the study).

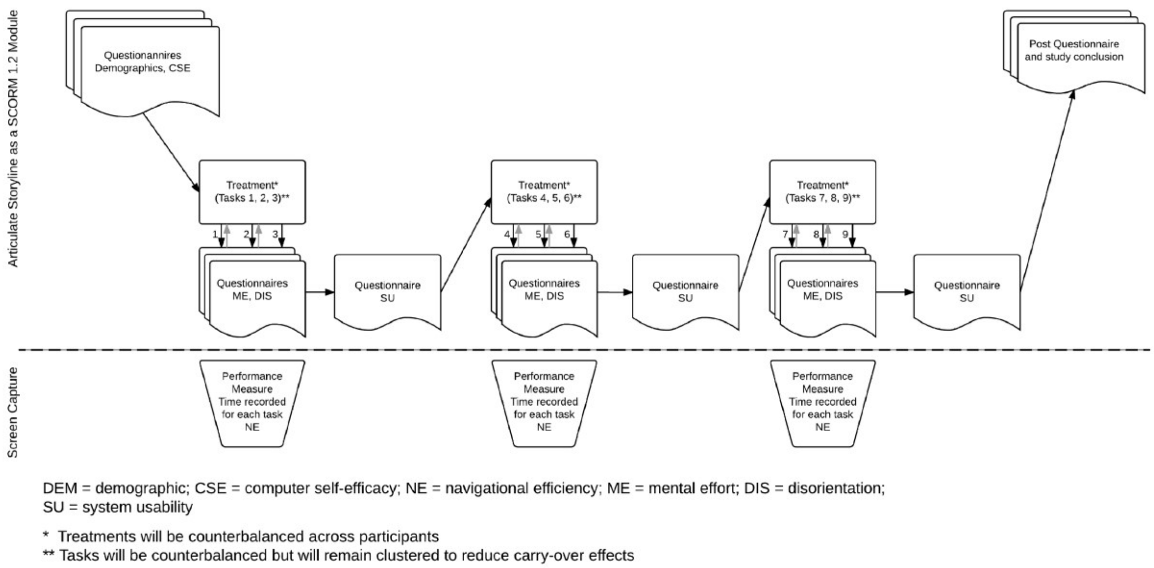

Figure 8. Sequence of the questionnaires, tasks, and instructions for the comparative usability study.

Participants were instructed to wait quietly or browse the Internet until all the participants had completed the study or 60 minutes had elapsed. Snacks were provided upon entering the computer lab and sessions with more than four participants had pizza. All participants had the opportunity to place their name in a drawing for a gift card.

Data Analysis

The data were analyzed to ensure that all the assumptions of a within-subjects MANOVA were met – normality, homogeneity of variance-covariance matrices, linearity, and multicollinearity (Tabachnick & Fidell, 1996). As there were violations of normality and linearity, a MANOVA analysis could not be performed. Due to the extreme outliers, four separate non-parametric Friedman tests with a Bonferroni correction were used to analyze each dependent variable separately. Wilcoxon tests were used to follow up on the results (Field, 2013).

CHAPTER IV

Results

This study was designed to determine if the organizational structure of a course affects participants' extraneous cognitive load. In particular, participants rated their mental effort, disorientation, perceived system usability, and navigational efficiency was measured across three different organizational structures (time, topic, and tool).

The main research question was

- Are there significant differences in extraneous cognitive load [as measured by the combination of mental effort (ME), disorientation (DIS), system usability (SU) and navigational efficiency (NE)] for three different organizational structures with the LMS (time, topic, and tool)?

Separate non-parametric Friedman tests were performed with a Bonferroni correction of $\alpha = .0125$ for each dependent variable as the data did not meet the assumptions of MANOVA. The dependent variables were mental effort (ME), disorientation (DIS), system usability (SU), and navigational efficiency (NE). The independent variable was the organizational structure of the course (time, topic, or tool).

Description of the Sample

The sample consisted of 10 volunteer undergraduate students at a public university in the Northwestern United States during Fall 2016. The volunteers were not majoring in anthropology and had not taken ANTH 1100, thus they were novices in relation to the content of the example course.

General demographics. Table 2 provides demographic information for the sample of 10 participants included in the final data analysis. The sample was evenly split between males and females, and none of the participant were international students with a majority as native English speakers. Half the participants were in the traditional undergraduate age range of 19-23 years old and majoring in a humanities field (social work, sociology, psychology and history). The majority of participants were seniors with self-reported above average academic performance.

Table 2

Demographic information for the sample of 10 students included in the data analysis

Category	**Number**	**Percentage**
Male	5	50%
Female	5	50%
International	0	0%
Non-international	10	100%
First Language: English	7	70%
First Language: Other	3	30%
Age: 19-23	5	50%
Age: 24-30	2	20%
Age: 31-42	3	30%
Major: Humanities	5	50%
Major: STEM	3	30%
Major: Health Sciences	2	20%
Freshman	1	10%
Sophomore	2	20%
Junior	0	0%
Senior	7	70%
Academic Performance: A	1	10%
Academic Performance: B	8	80%
Academic Performance: C	0	0%
Academic Performance: D	1	10%
Academic Performance: F	0	0%

Computer self-efficacy and learning management system experience.

Participants self-reported their computer self-efficacy (CSE) on a scale of 1 (strongly disagree) to 7 (strongly agree) and previous experience with learning management systems (LMS) using a frequency scale of 1 (never) to 7 (always) (see Appendix F for details about the LMS experience questionnaires and Appendix G for the CSE questionnaire). The mean CSE was 5.05 (*SD* 1.69) indicating participants were confident in their computer self-efficacy, but not overly so. Participants indicated which LMS they had previously experienced (type); along with how often an LMS was used in their courses (frequency), and how often they performed the top six activities within those courses (depth). As seen in Table 3, the majority of participants had experience with one to two LMS and their courses in higher education frequently used an LMS. Participants reported that time was the most frequent type of organization used in their previous courses with tool organization encountered the least often. Time organization had a mean of 6.10 (*SD* 1.20) indicating that participants' previous courses were usually organized by time (above 82% of the time) and tool organization had a mean of 1.90 (*SD* 1.29), indicating that very few to some of their previous courses were organized by tool (less than 32%).

Table 3

CSE and LMS experience for the sample of 10 students included in the data analysis

Category	**Mean**	***SD***
CSE	5.05	1.69
Types of LMS Previously Used	1.80	.51
Frequency of LMS Usage in HE Courses	6.30	2.91
Depth of LMS Usage in Courses	5.65	.48
Frequency of Courses Organized by Time	6.10	1.20
Frequency of Courses Organized by Topic	2.70	1.50
Frequency of Courses Organized by Tool	1.90	1.29

Questionnaire and Performance Measure Results

Several questionnaires were used in this experiment along with one performance measure. After each task participants completed the ME and DIS questionnaires. After completing three tasks in one of the organizational structures, participants were asked to complete the SU questionnaire for that specific organizational structure. Participants' performance, in terms of time on task and successful completion of each task, was measured and combined into the NE score. The results for each of these instruments are discussed below.

Mental effort. Participants rated their ME after each individual task using the mental effort scale developed by Paas (1992). ME was indicated by marking one of nine-point items from 1 (very, very low mental effort) to 9 (extremely high mental effort). A lower score means that less mental effort was reported. In terms of extraneous load, a lower score means less extraneous load (see Appendix H for the ME questionnaire).

To reduce the effects of semantic similarity between the task and the organizational structure, the ME scores for three tasks for each organizational structure were averaged for an overall ME score for each organizational structure. Table 4 summarizes the median and mean ME ratings along with standard deviations for each organizational structure. The means and standard deviations for each organizational structure are very evenly distributed across the three organizational structures, with the time organizational structure having the lowest mental effort.

Table 4

Summary of mental effort ratings

Organizational Structure	***N***	***Mdn***	**Mean**	***SD***
Time (ME-TM)	10	3.67	3.80	1.48
Topic (ME-TP)	10	4.00	4.20	1.25
Tool (ME-TL)	10	4.33	4.00	1.34

Disorientation. DIS scores were reported after each individual task across seven prompts, on a frequency scale of 1 (never) to 7 (always). A lower score means that there was less disorientation reported. In terms of extraneous load, a lower score means less extraneous load (see Appendix I for the DIS questionnaire).

The seven positively worded prompts were averaged for one disorientation score per task (Ahuja & Webster, 2001). In order to reduce the effects of semantic similarity between the task and the organizational structure, the DIS scores for three tasks for each organizational structure were averaged for an overall DIS score for each organizational structure. Table 5 summarizes the median and mean DIS ratings along with standard deviations for each organizational structure. The means and standard deviations for each organizational structure are very similar across the three organizational structures, with the time organizational structure having the lowest disorientation.

Table 5

Summary of disorientation ratings

Organizational Structure	***N***	***Mdn***	**Mean**	***SD***
Time (DIS-TM)	10	1.05	1.60	1.03
Topic (DIS-TP)	10	1.45	2.04	1.32
Tool (DIS-TL)	10	1.83	1.99	0.78

System usability. System usability (SU) scores were reported after completing three tasks in one of the organizational structures. A total of 10 items were rated on an agreement scale of 1 (strongly disagree) to 5 (strongly agree). Individual items were coded following the guidelines provided by Brooke (1996) resulting in an overall score out of 100. A lower SU score indicated lower usability. In terms of extraneous load, a low score on Brooke's scale would indicate higher extraneous load (see Appendix J for the SUS questionnaire).

However, as the SU scale is the reverse of all the other measures, with a higher score indicating better system usability, and the calculated score being out of 100, the overall score was divided by 10 and reverse coded to create an rSU score out of 10 with a lower score indicating better usability, thus lower extraneous load. Table 6 summarizes the median and mean rSU ratings along with standard deviations for each organizational structure. The means and standard deviations for each organizational structure followed a pattern similar to both mental effort and disorientation ratings, with the time organizational structure having the better system usability

Table 6

Summary of system usability ratings (reversed)

Organizational Structure	***N***	***Mdn***	**Mean**	***SD***
Time (rSU-TM)	10	1.38	3.03	2.98
Topic (rSU-TP)	10	3.38	4.58	2.75
Tool (rSU-TL)	10	3.50	4.90	2.90

Navigational efficiency. NE was calculated per organizational structure. The times for each of the three tasks per organizational structure were added together and then divided by the number of successfully completed tasks. A lower time indicates better navigational efficiency, as it took less time to successfully complete the task. In terms of extraneous load, a lower time means less extraneous load.

The mean time per task across all organizational structures was 86.41 seconds (*SD* 121.56). The unusually large standard deviation is due to three participants who had one time on task measurement between seven and twelve minutes. There was one instance per organizational structure and each occurred in the first organizational structure presented to the participant. Two of these instances occurred on the same task.

In terms of responding to the tasks, participants were told that there were many ways to respond to the question; for example, for the task “When should you watch the lecture on heredity?” acceptable answers included “with chapter 2,” “August 28-September 3,” “Week 2,” or “with the Biological Basis of Life and Microevolutions.” Overall, participants successfully completed 78% of the tasks. One participant had a low successful completion of 44% of the tasks while two participants successfully completed 100% of the tasks. With the majority of participants having at least one incorrect response, the mean navigational efficiency is much higher than the time on task as it takes into account successful completion of the task.

Table 7 summarizes the median and mean NE ratings along with standard deviations for each organizational structure. There is a larger variation in mean navigational efficiency times and large standard deviations indicating positive skewness in the data. The time organizational structure had the most efficient navigation with the smallest standard deviation.

Table 7

Summary of navigational efficiency scores (in seconds)

Organizational Structure	***N***	***Mdn***	**Mean**	***SD***
Time (SU-TM)	10	81.68	112.70	109.44
Topic (SU-TP)	10	95.64	194.80	293.77
Tool (SU-TL)	10	97.59	111.83	80.39

Assumptions

The assumptions for MANOVA include random sampling, independence, multivariate normal distribution on all dependent variables, a linear relationship among all pairs of dependent variables, and covariance matrices for the dependent variable in each group must be equal (Mertler & Reinhart, 2005). As a repeated-measures design, participants were randomly assigned to counterbalanced versions of the usability study in order to address the assumption of independence as well as to reduce carryover and order effects (Tabachnick & Fidell, 1996).

The data were evaluated and found to have violated the assumptions of normal distribution due to extreme univariate outliers, and the correlations were either too high or too low for several of the dependent variables. MANOVA is robust to violations of normality, but not when due to extreme outliers (Tabachnick & Fidell, 1996). Thus, four separate non-parametric Friedman tests were used to evaluate the data (Warner, 2008).

Results for Research Question

Four separate Friedman tests were conducted to determine the effect of organizational structure on ME, DIS, rSU, and NE. A Bonferroni correction of $\alpha = .0125$ per dependent variable was used to determine significance.

No significant difference was found for ME, SU, or NE due to the three different organizational structures. ME differed across the three organizational structures with the best ratings for time organization ($Mdn = 3.67$), the worst times for tool organization topic tool ($Mdn = 4.33$), and topic organization in the middle ($Mdn = 4.00$); but the differences were not statistically significant, $\chi^2\ (2) = 1.95$, $p = .378$. Wilcoxon tests were used to follow up on this finding. It appeared that the effect on ME did not significantly change between time and topic, $T = 32$, $r = .25$, nor between time and tool, $T = 35$, $r = .17$, nor between topic and tool, $T = 18$, $r = .12$.

The reversed SU measure also differed across the three organizational structures beginning with the best scores for time organization (*Mdn* = 1.38), middle scores for topic organization (*Mdn* = 3.38), and slightly worse scores for tool organization (*Mdn* = 3.5); but the differences were not statistically significant, χ^2 (2) = 4.67, $p = .097$. It appeared that the effect on rSU did not significantly change between time and topic, $T = 45$, $r = .40$, nor between time and tool, $T = 34$, $r = .31$, nor between topic and tool, $T = 29.5$, $r = .05$. The effect sizes in relation to the organizational structure of time indicate that the sample size was too small to detect the effects on rSU.

NE differed across the organizational structures with the best scores for time organization (*Mdn* = 81.68), middle scores for topic organization (*Mdn* = 95.64), and slightly worse scores for tool organization (*Mdn* = 97.59); but the differences were not statistically significant, χ^2 (2) = .000, $p = 1.00$. It appeared that the effect on NE did not significantly change between time and topic, $T = 28$, $r = .01$, nor between time and tool, $T = 29$, $r = .03$, nor between topic and tool, $T = 26$, $r = .03$. See Figure 9 for a comparison of the median ratings and scores.

Figure 9. Comparison of medians of ME, DIS, rSU and NE scores across the three organizational structures of time, topic, and tool.

The Friedman test for DIS was statistically significantly different for three organizational structures, χ^2 (2) = 9.05, *p* = .011. Pairwise comparisons revealed statistically significant differences in DIS between the organizational structure of time (*Mdn* = 1.05) and tool (*Mdn* = 1.83) (*p* = .011). Wilcoxon tests were used to follow up this finding. The difference between time and tool revealed a medium effect size (*T* = 45, *r* = .40). No statistically significant differences were found between time and topic, *T* = 31, *r* = .41, nor between tool and topic, *T* = 27, *r* = .01 (see Figure 10 for a comparison of mean ranks across all three organizational structures).

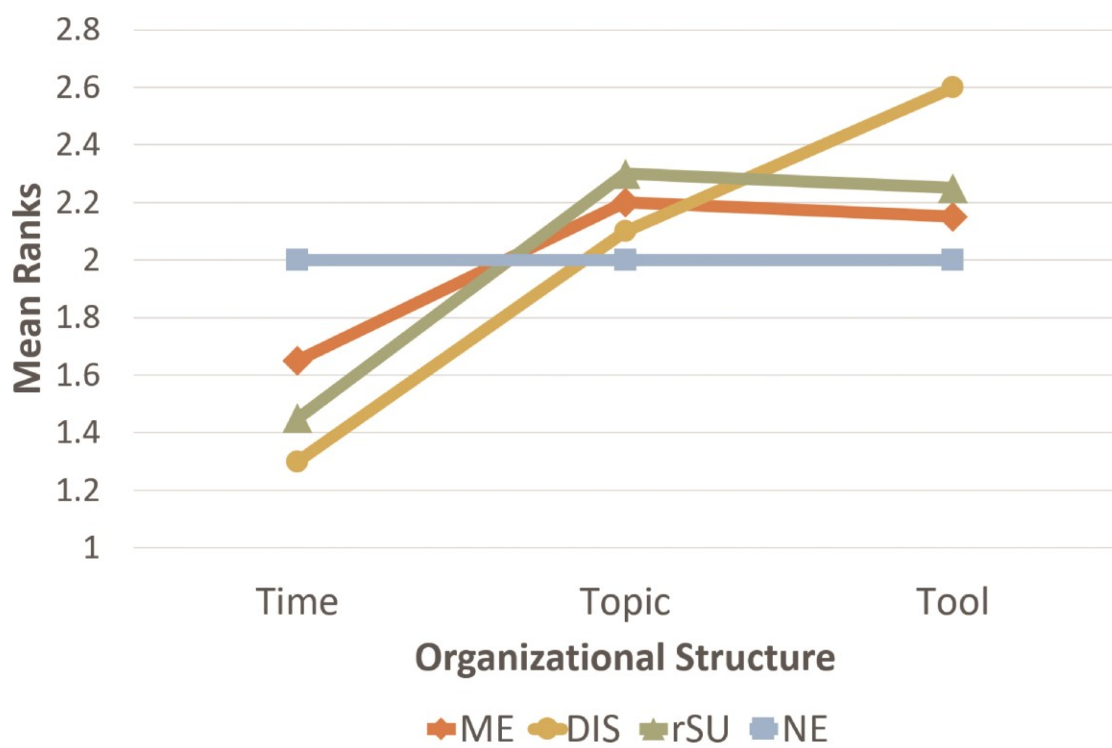

Figure 10. Comparison of mean ranks of ME, DIS, rSU and NE across the three organizational structures of time, topic, and tool.

Summary of Results

This experiment examined the effect of organizational structure on the combination four measures of possible extraneous load. The dependent measures were evaluated separately using a non-parametric Friedman test as the data had extreme outliers and did not meet the assumptions of normality nor linearity for MANOVA. The results of the experiment showed that the organizational structure did not have a significant effect on mental effort, system usability, or navigational efficiency. There was a significant difference in disorientation between the organizational structures of time and tool.

CHAPTER V

Conclusions

The purpose of this study was to examine the effect of organizational structure of a course within an LMS on the combined extraneous load measures of mental effort (ME), disorientation (DIS), system usability (SU), and navigational efficiency (NE). An anthropology course was modified to be organized using headers of time, topics, and tools. In a lab setting, participants experienced all three organizational structures as they completed common course tasks (see Appendix C for a list of tasks used in this study). The focus of this study was on the within-subjects effects as reported by ME and DIS ratings after each task; SU ratings after each organizational structure; and the performance measure of NE based on time on task and successful completion of the task.

The signals used in this study were static headers with the same characteristics of indicating structural boundaries, acting as labels, providing identification of sections and navigation, and emphasizing a header through typographical means. The three organizational structures differed in the words used to indicate sequence (time), hierarchy (topic), and function (tool) (Lemarié, Lorch Jr, et al., 2008).

Discussion of Results

Extraneous load can come from both instructional and system design (Hollender et al., 2010). In this study, two measures from instructional design (ME and DIS) and two measures from human computer interaction (SU and NE) were selected to examine the differences between three organizational structures of an online course in an LMS. The results of this study showed no significant differences in ME, SU or NE for the organizational structures of time, topic, and tool; however, there was a significant difference in DIS ratings between the organizational structures of time and tool.

A Friedman test, which compared the ranks between the three organizational structures, was used for analysis. For DIS, the organizational structure of time consistently ranked first, as in the least frequent feelings of disorientation, while the organizational structure of tool consistently ranked third (see Figure 11 for a comparison of ranks across all three organizational structures). In other words, participants experienced feelings of being lost or of not knowing how to get to their desired location most often in the organizational structure of tool. Fang and Holsapple (2011) reported that learners with low prior content knowledge relied upon usage-oriented navigational indicators. The results of this study indicated that the usage-oriented or functional signals used in the tool organizational structure proved to be more disorienting than either the hierarchical structure of the topic organization or the sequential structure of the time organization. The significant difference between time and tool organization indicates that the participants relied on their prior experience with the organizational structure of time.

In contrast, NE showed absolutely no difference between the organizational structures, indicating that although participants reported higher DIS with the organizational structure of tools, the higher DIS ratings did not influence the time spent or successful completion of the task. The lack of difference in NE seems to indicate that time-on-task is a construct with additional factors not related to DIS. This supports the suggestion in the literature that a more complete picture of cognitive load and learner experience requires multiple measures (Fang & Holsapple, 2011; Leppink et al., 2013; Longo & Dondio, 2015).

Patterns in the data. A comparison of the median scores across the three organizational structures revealed several patterns that support previous findings from the literature. The better ratings and scores for the time organization across all four measures along with the LMS experience survey demographic information, exemplifies the influence of prior experience. Previous studies have noted that a high level of prior experience improves interaction and outcomes (Amadieu, Salmerón, et al., 2015; J. V. Chen et al., 2011; Sullivan & Puntambekar, 2015). The higher level of prior experience with the time organization is reflected in the best ratings and scores for the time organization (see Figure 10 for a comparison of the median ratings and scores).

In selecting the dependent variables, correlation was expected as each measure was related to sources of potential extraneous load. The instructional design measures (ME and DIS) exhibited a similar pattern when looking at the median ratings. The system design measures (SU and NE) also exhibited a similar pattern, but different from the pattern of the instructional design variables (see Figure 10). The similar, but different patterns from each of the domains of instructional design and human computer interaction, point to a need to incorporate measures from both domains. These similar, but different patterns in the data also support the recommendation from Longo and Dondio (2015) that research should incorporate both mental effort and system usability to provide a better picture of cognitive load.

Task responses and post comments. During the study participants were prompted to provide a brief explanation, if they decided to quit a task; in addition they were each given an opportunity to comment on the study and their overall experience. The patterns in the numerical data illustrate similar impacts to extraneous load by the topic and tool organizations with time showing the best results. However, the comments put the topic organization below both time and tool. The difference between the numerical data and the qualitative comments indicates additional factors outside of ME, DIS, SU, and NE that influence the perceptions of the "best" organizational.

Goal-oriented navigational indicators. In addition to the content-oriented indicators found in the topic organization, and the usage-oriented indicators found in the tool organization, a third category of navigational indicator became clear – goal-oriented indicators. Whereas the content-oriented indicators were clearly seen in the topic organization, and usage-oriented indicators in the tool organization, goal-oriented indicators were reflected in comments related to both time and tool organization. The preference for goal-oriented indicators provides additional information on how individuals use the displayed information with mental schema (Zibetti, Chevalier, & Eyraud, 2012).

Two participants suggested dynamic or alternative navigation options between time and tool organization, which supports current research on the use of dynamic and personalized navigation options (for example, Katuk, Kim, & Ryu, 2013). This suggested option for alternative methods of navigation reflects the two goals of completing work on-time and getting to the work that needs to be completed; as participant 58758 suggested, "a way to organize the material by type so that maybe you could easily access your assignments that are due once you've looked over the course overall." Other participants' comments reflected these two goals when stating a clear preference for either time or tool. Expressing a higher priority for the goal of completing work on time, participant 11777 stated, "The by-activity organization of the course was the least user-friendly to me, because you had to actively find what was due each week." Participant 66051 expressed a higher priority for getting to the work with the statement, "I felt that having all the resources in each block made it all easier to find."

Yet, the courses with the time and topic organization were very similar (see Appendix B for screenshots of the different organizational structures). The materials and activities are in the exact same order with the only difference in the section headers and no mention of time related events like Thanksgiving break in the topic organization. The conflicts in the ratings and performance, and expressed preference seem to indicate that although the impacts by topic and tool were similar in the numerical data, the participants felt that the signals of time and tool to be more relevant to their own goals than the content-related signal of topics. This supports SARA theory, in that the signal needs to be relevant to the learner's goals.

Reliance on prior experience. When confronted with the "mounds of text" (participant 66051) to sort through, or a feeling that a task was "taking too long" (participant 44501), participants would often go back to the syllabus to look for answers. Statements like "Syllabus does not have it" (participant 44501), and "I even checked the syllabus" (participant 58758) illustrate how the participants relied on their previous course experience. The signals in the course did not provide content-oriented, usage-oriented, nor goal-oriented connections, pushing the participant to rely on the general schema of "*taking a course*."

In other comments, previous experience hinted at the importance of the instructor. For example, participant 98886 stated, "When you are in the class it would make more sense," illustrate that during the delivery of a course, the expected interaction would provide additional support. Thus, along with the design of the course and the system used to present the course, teacher presence is important (Baker, 2010).

In conclusion, the comments reveal that the usage-oriented and goal-oriented signals were preferred, indicating that they were better able to optimize working-memory by relying on prior experiences. It was clear that the topic organization was the least preferred. Participant 78777 called the topic organization, “the worst” adding the explanation that “I don’t think that it is that important to organize material by chapter.” This explanation may point to why Ihme and Wittwer (2015) reported a lack of deeper understanding in the content. The stronger connect to schema related to prior system knowledge and prior experience may have resulted in higher preferences for those types of signals; but they may also prevent a more content-oriented schema from developing.

Recommendations for Future Practice

This study provided an example of how a comparative usability study could be used in the context of instructional design. In addition to current instructional and system design processes, usability studies can provide valuable information in optimizing working-memory for learners. This supports the recommendation of Zaharias (2011) to incorporate usability studies within the context of elearning environments.

In many LMS, the navigation is set by the system or selected via template. In some cases, like with Moodle, the faculty or instructional designer can provide alternate navigational options through widgets or blocks. Unfortunately, in most LMS, the learner must use the navigation set by the LMS administrator, the faculty, or the instructional designer. Instructional designers and faculty should consider alternate navigational options and signals that include goal-oriented language.

Recommendations for Future Research

This was the first reported study to apply SARA theory within the context of an LMS. SARA theory provided useful guidance in the description of the signals used to differentiate the three organizational structures. In addition, participant comments supported SARA theory, in that the signals seen as more *relevant* to the participants' goals were preferred. Future research using signals should be informed by SARA theory.

The study found a significant difference in DIS ratings between the organizational structures of time and tool. This indicates that the DIS scale by Ahuja and Webster (2001) is a useful measure of extraneous cognitive load imposed by navigational decisions in an LMS.

Patterns in the data showed a relationship between previous experience with courses organized by time and the time organization. Future research should consider the influence of the different types of prior knowledge related to content, system, and experience. Moreover, the results supported the use of usage-oriented signals over content-oriented signals for novices in content knowledge; however, research should explore how to provide signals to support the creation of content-structured schema, especially for novices.

The next steps for related research will include a larger sample size with varying levels of prior content knowledge and experience. In addition, the next study will include a purposeful inclusion of qualitative data such as a think aloud process commonly employed in usability studies (Salmerón, Naumann, García, & Fajardo, 2016) or follow-up interviews.

Summary

This study was designed to examine how different organizational structures of a course in an LMS affected learners. Using both cognitive load theory (CLT) and the signal available relevant accessible (SARA) theory as frameworks, the organizational structures were determined by clearly described signals and four measures of potential extraneous load were selected. Mental effort (ME) and disorientation (DIS) were selected from the domain of instructional design and system usability (SU) and navigational efficiency (NE) were selected from human computer interaction.

Data analysis for each dependent variable using a Friedman test showed a significant difference in DIS between the organizational structures of time and tool. No significant differences were found in ME, SU, and NE. However, patterns in the numerical data supported previous research that indicated that prior system knowledge and experience would influence performance. For all measures, the best ratings and scores were for the organizational structure of time, with which all participants had high prior experience. The participants low prior experience with the organizational structure of tool, is also reflected in the scores and ratings.

In contrast, the response and post comments revealed an overall preference for both organizational structures of time and tool. The qualitative comments support SARA theory, in that both of these organizational structures used signals *relevant* to the participants' goals of either 1) knowing when an activity is due; or 2) getting to the activity quickly. These results highlight the complex nature of extraneous load and the need for multiple measures, including quantitative and qualitative methods.

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Appendix A

Default Views of the Top Five LMS in Higher Education

Blackboard

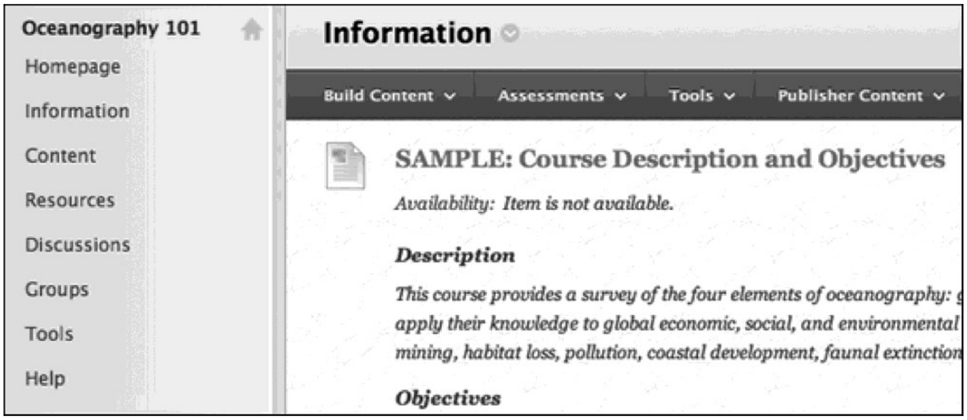


Figure 11. Default structure for Blackboard Learn 9.1 *(Blackboard, n.d.)*.

Blackboard provides navigation using a menu on the left-hand side of the screen, displaying the course tools. The main homepage window is set to the information page.

Desire2Learn / Brightspace

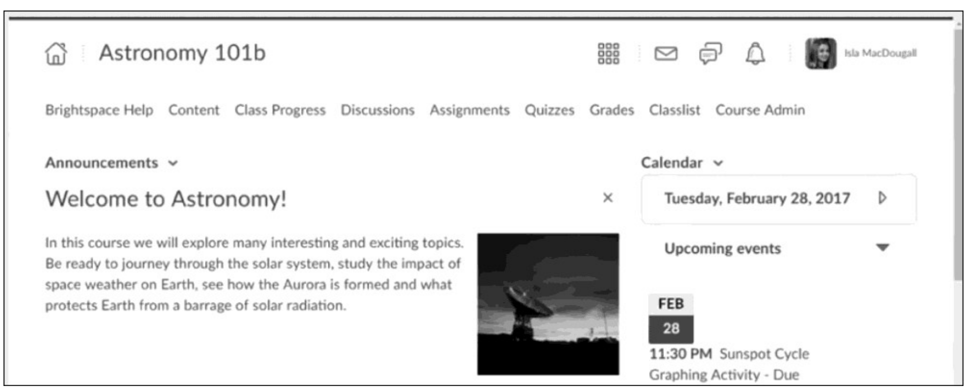


Figure 12. Default structure for Brightspace *(Tutorials, 2017)*.

Brightspace provides navigation using a bar across the top of the course, displaying the course tools. The main left-hand column showing announcements and the right-hand column includes a block with the calendar and upcoming events.

Canvas

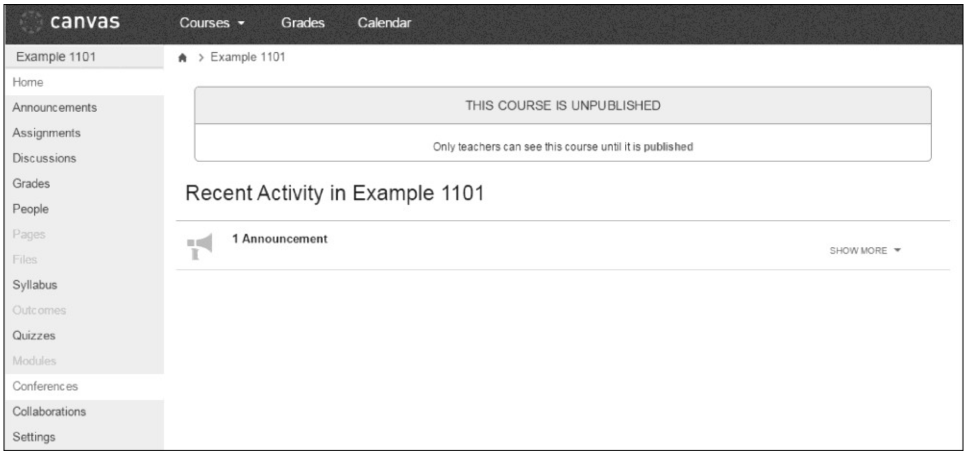


Figure 13. Default structure for Canvas.

Canvas provides navigation using a menu on the left-hand side of the screen, displaying the course tools. The main homepage window is set to the recent activity. The module link creates pages that collect the various tools and resources used for each designated module.

Moodle

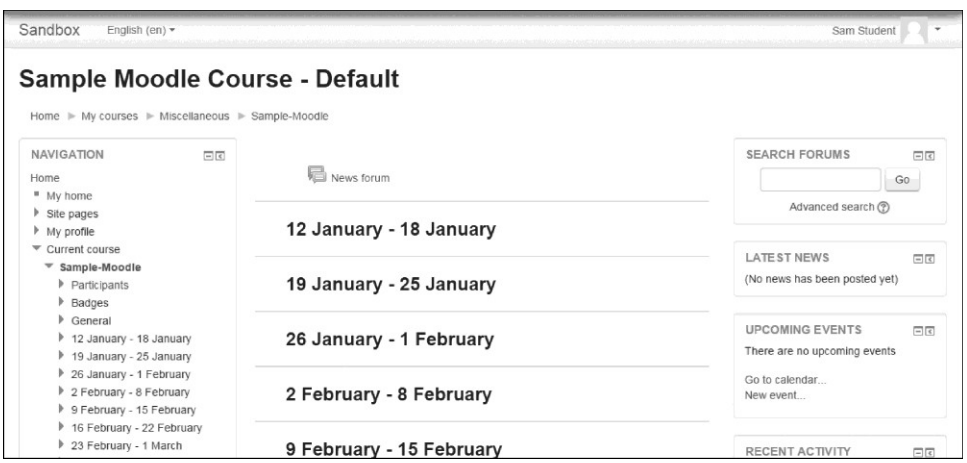


Figure 14. Default structure for Moodle.

Moodle provides navigation using a menu on the left-hand side of the screen, displaying weeks. The main course content is in the middle section. Additional blocks on the right include search forums, latest news, upcoming events, and recent activity.

Sakai

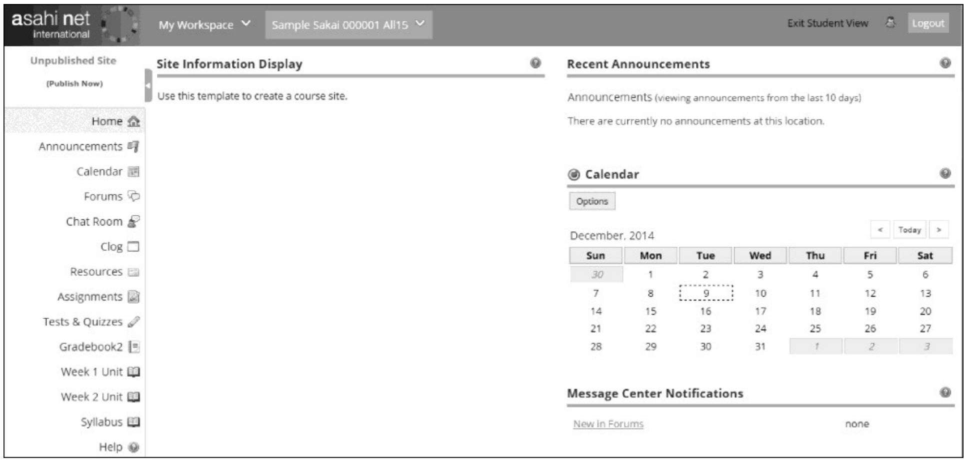


Figure 15. Default structure for Sakai.

Sakai provides navigation using a menu on the left-hand side of the screen displaying the course tools. The main center section is a description of the course. The right hand widgets include announcements, the calendar, and message notifications.

Appendix B

Development of the Courses

The original course was organized by weeks, with a section at the top dedicated to the major assignments, exam study guides, and exams (see Figure 16 for a view of the original course).

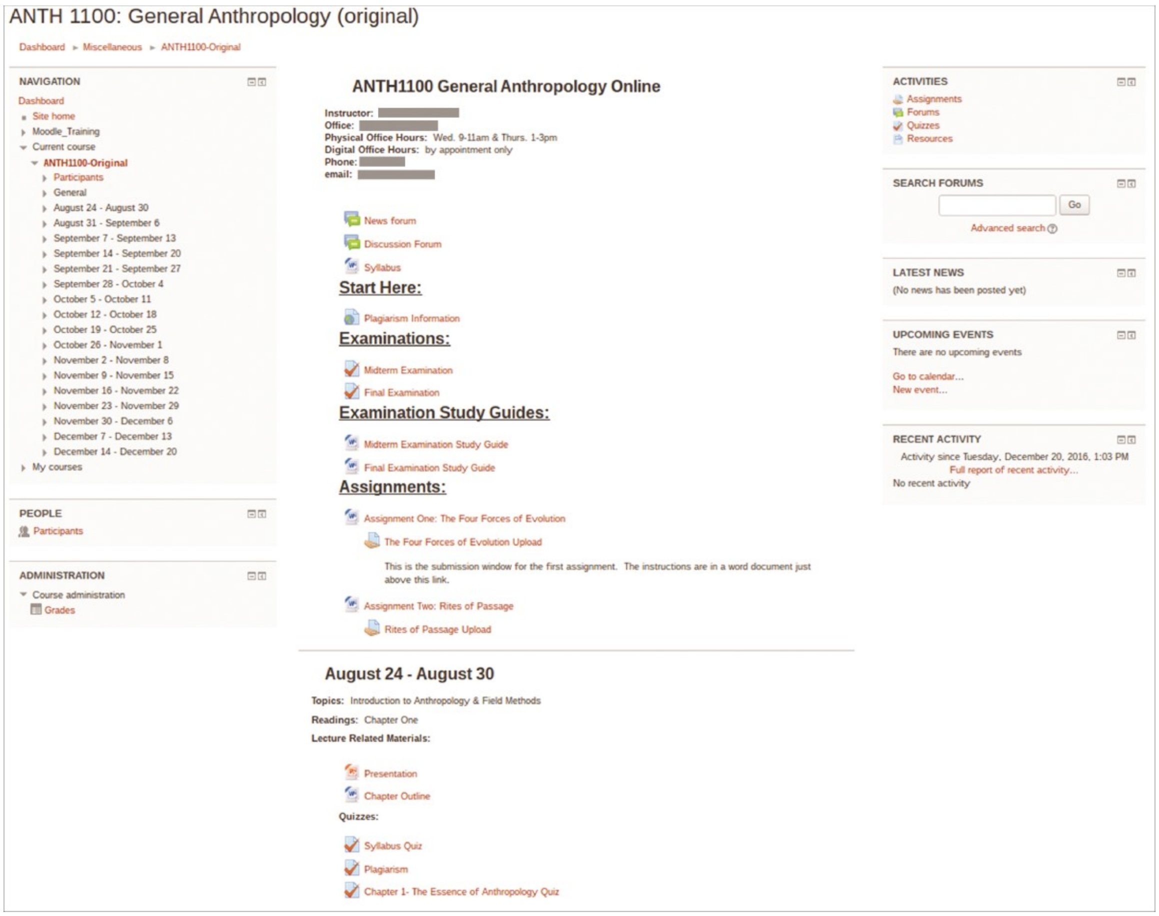


Figure 16. Original Anthropology course.

All the materials in the original course were examined, and when necessary, converted so none of the content would require additional software during the usability study session. Word documents were converted to PDFs, video files were converted to mp4 format, uploaded into YouTube, and all content set to embed within Moodle. After the creation of the tasks, two resources that would not embed in the course, a video with copyright issues, and the library plagiarism tutorial, were removed, as they were not required for any of the tasks.

The syllabus was reviewed for personal identifying information and date specific information. The instructor information was anonymized with the name "John Smith" along with a fictitious email and phone number. The name and year of the term were also removed. The original course syllabus did not contain a calendar or schedule or other date related information, so no other modification were made to the syllabus.

The instructor information in the general section was changed to match the fictitious information in the modified syllabus. A textbook icon was added to the chapter labels. All titles for lecture materials, assignments, quizzes, exams, and supplemental materials remained the same with slight modifications for consistency (e.g., capitalization, all numbers written as numbers). All supplemental materials were modified to match the format of the supplemental material in week three.

All blocks were removed except for the Navigation block and the Latest News. The gradebook was turned off as well, as it was not needed for the study, and this removed the Administration block from the student view. The labels associated with the exams included information on alternate ways to access the exams; this information was removed as it pointed the students to a block that did not exist in the modified version.

Three separate courses were created from the original, one for each organizational structure – *time* (Basalt), *topic* (Jasper), and *tool* (Quartz). The course start date and due dates were set for the Fall 2017 semester. The section headers in Moodle automatically populate the navigation block on the top left (see Figure 17 for a comparison of the navigation blocks and Figure 18 for a comparison of example sections).

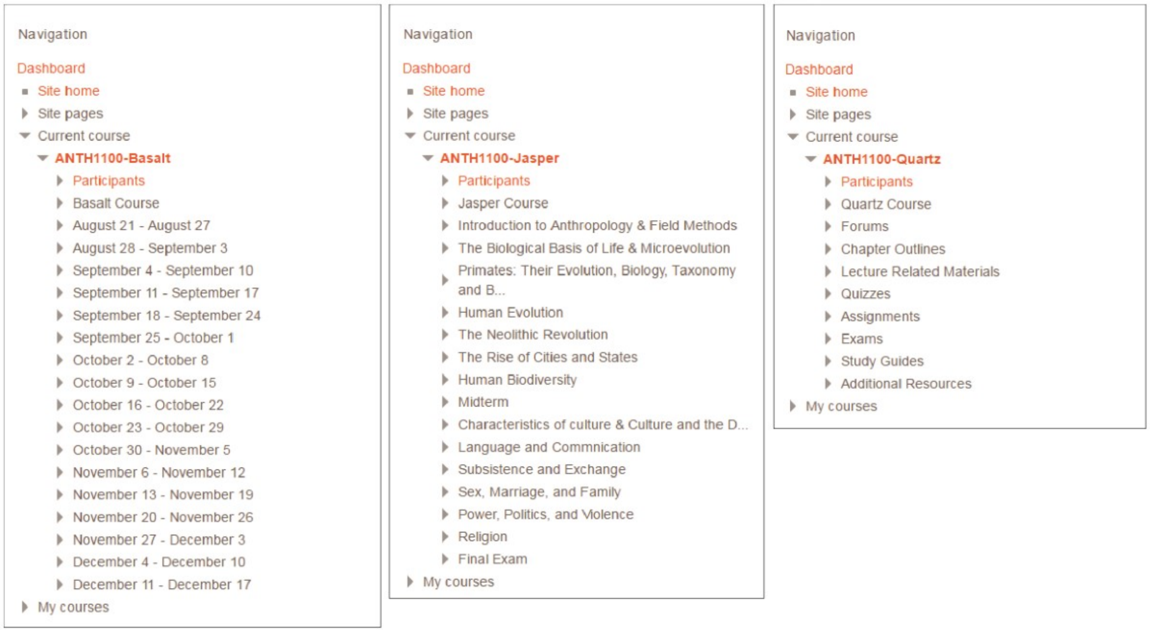


Figure 17. The navigation menus for each organizational structure

Figure 18. A comparison of sections from each course. On the top left is time, the top right is topic, and the bottom is tool

Appendix C

Development of the Tasks

1. How many assignments are in the course?
2. What are the supplemental materials for human evolution?
3. When should you watch the lecture on heredity?
4. Which assignment covers the processes of evolution?
5. Which chapters are covered in the midterm exam?
6. When will you be learning about language?
7. Which chapter in the textbook do you **NOT** have to read?
8. Which chapter covers power, politics, and violence?
9. When is Assignment 2 due?

Creation of the tasks

The study required nine tasks. From the research, the semantic similarity between the wording of the tasks and the organizational structures would affect the outcome (Blackmon, 2012). In addition, variations in the difficulty of the tasks could also have the potential to influence the outcome (Goldhammer et al., 2014). The repeated measures design needed to consider carry over and order effects (Gall et al., 2007). The tasks were created, evaluated, and selected to reduce the effects of these four areas.

The original course was explored by myself and a student assistant to create a list of 50 tasks students would do within the normal context of taking the course. Blackmon (2012) reported that the similarity between the goal of a task and the information contained in potential links influenced participants to select items which were semantically similar. The nature of the tasks was that one of the treatments could appear to be semantically similar to the goal of the question, thus being likely “easier” to locate within a specific treatment. For example, “When is assignment 2 due?” is semantically related to the organizational structure of time and “How many quizzes are there for Chapter 12?” is semantically related to the organizational structure of tools. After two questions were eliminated due to their close similarity with other questions, the remaining 48 were divided into the three categories based on their semantic similarity to the organizational structures of time, topic, and tool. There were 24 questions in the time category, 19 questions in the topic category, and 5 questions in the tool category. This would allow each course to be explored with one task from each category (see Figure 19 for an illustration of the tasks needed for each course).

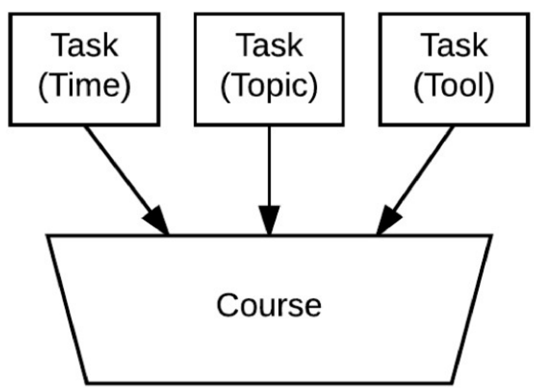


Figure 19. One task from each category (*time, topic,* and *tool*) was used to explore the course.

In order to reduce the effects of carry over, where participants happen to come across the answer to a task later in the study (Gall et al., 2007). The tasks were divided into three groups based on the related chapters from the course – chapters 1-5 (including the syllabus), chapters, 6-9, and chapters 10-15.

A list of 17 unique tasks was selected from the list of 48 from across the three semantically similar categories. These tasks were numbered and categorized by the relationship to the chapters (see Figure 20 for the distribution of the 17 tasks).

	Time	**Topic**	**Tool**
Chapters 1-5 +syllabus	Task #3	Task #4 Task #5 Task #6	Task #1 Task #2
Chapters 6-9	Task #9 Task #11 Task #12	Task #7 Task #10	Task #8
Chapters 10-15	Task #14 Task #17	Task #15	Task #16 Task #13

Figure 20. Distribution of 17 potential tasks across the chapters in the textbook.

As task complexity affects mental effort (Schmeck et al., 2015), student assistants evaluated the list by finding the answers using one version of the course and rating the difficulty of each on a scale of 1 (very difficult) to 5 (very easy). The answers were also collected to identify possible variations. Six student assistants were each assigned one course and evaluated the difficulty of each of the 17 tasks. The overall group had a mean difficulty rating of 4.25 (SD = 1.20). Nine tasks were selected so that they with a similar difficulty across the three organizational structures with three tasks related to each of the organizational structures related to each chapter section. The final nine tasks were renumbered and had a mean difficulty rating of 4.29 (SD = 0.96) (see Figure 21 for the distribution across both categories of semantic similarity and chapter of final tasks).

Task	Task Question	Answer(s)	Semantic Similarity	Relationship to Chapters
1	How many assignments are in the course?	Two 2	Tool	Chapters 1-5, and syllabus
2	What are the supplemental materials for human evolution?	Walking with Cavemen	Topic	Chapters 1-5, and syllabus
3	When should you watch the lectures on heredity?	With Chapter 2 August 28-September 3 Week 2 With Biological Basis of Life and Microevolutions	Time	Chapters 1-5, and syllabus
4	Which assignment covers the processes of evolution?	#1 One The Four Forces of Evolution	Tool	Chapters 6-9
5	Which chapters are covered in the midterm exam?	Chapters 1-7	Topic	Chapters 6-9
6	When will you be learning about language?	With Chapter 9 Week 10 October 23-29	Time	Chapters 6-9
7	Which chapter in the textbook do you **NOT** have to read?	Chapter 13	Tool	Chapters 10-15
8	Which chapter covers power, politics, and violence?	Chapter 14	Topic	Chapters 10-15
9	When is Assignment 2 due?	Friday, December 1 at 5:00 pm	Time	Chapters 10-15

Figure 21. Distribution of the final nine tasks with answers, semantic similarity, and relationship to chapters

Appendix D

Counterbalancing of Tasks with the Treatments

To reduce the order effects of a repeated measures design, both the tasks and the courses were counterbalanced. This resulted in nine variations of the usability study process. The process used to create the counterbalanced versions is described below.

The tasks were first organized into groups based on their relationship to the chapters in the course. Each group contained three tasks, with one semantically similar task for each organizational structure. The groups were then sequenced to create three counterbalanced sets of tasks (See Table 8 for details on counterbalancing the order of the tasks).

Table 8

Counterbalancing the tasks

	Task Order		
Relationship to Chapters	**Set 1**	**Set 2**	**Set 3**
1-5	1, 2, 3	2, 3, 1	3, 1, 2
6-9	4, 5, 6	5, 6, 4	6, 4, 5
10-15	7, 8, 9	8, 9, 7	9, 7, 8

The order of the courses were counterbalanced with the task sets, creating nine variations for use during the study. Ten participants were recruited for the study. Participants were randomly assigned to a version during the orientation to the study. The counterbalancing of the tasks and the course per participant can be seen in Table 9.

Table 9

Counterbalancing of the courses and tasks per participant

Participant	**Version**	**First Course**	**Second Course**	**Third Course**
65267	1	Tool (1, 2, 3)	Time (4, 5, 6)	Topic (7, 8, 9)
71326	2	Tool (2, 3, 1)	Time (5, 6, 4)	Topic (8, 9, 7)
53372	3	Tool (3, 1, 2)	Time (6, 4, 5)	Topic (9, 7, 8)
66051	4	Time (1, 2, 3)	Topic (4, 5, 6)	Tool (7, 8, 9)
11777	5	Time (2, 3, 1)	Topic (5, 6, 4)	Tool (8, 9, 7)
78777	6	Time (3, 1, 2)	Topic (6, 4, 5)	Tool (9, 7, 8)
98886	7	Topic (1, 2, 3)	Tool (4, 5, 6)	Time (7, 8, 9)
44501	8	Topic (2, 3, 1)	Tool (5, 6, 4)	Time (8, 9, 7)
18062	9	Topic (3, 1, 2)	Tool (6, 4, 5)	Time (9, 7, 8)
58758	9	Topic (3, 1, 2)	Tool (6, 4, 5)	Time (9, 7, 8)

Note: Numbers in parentheses are the tasks in the order they appeared.

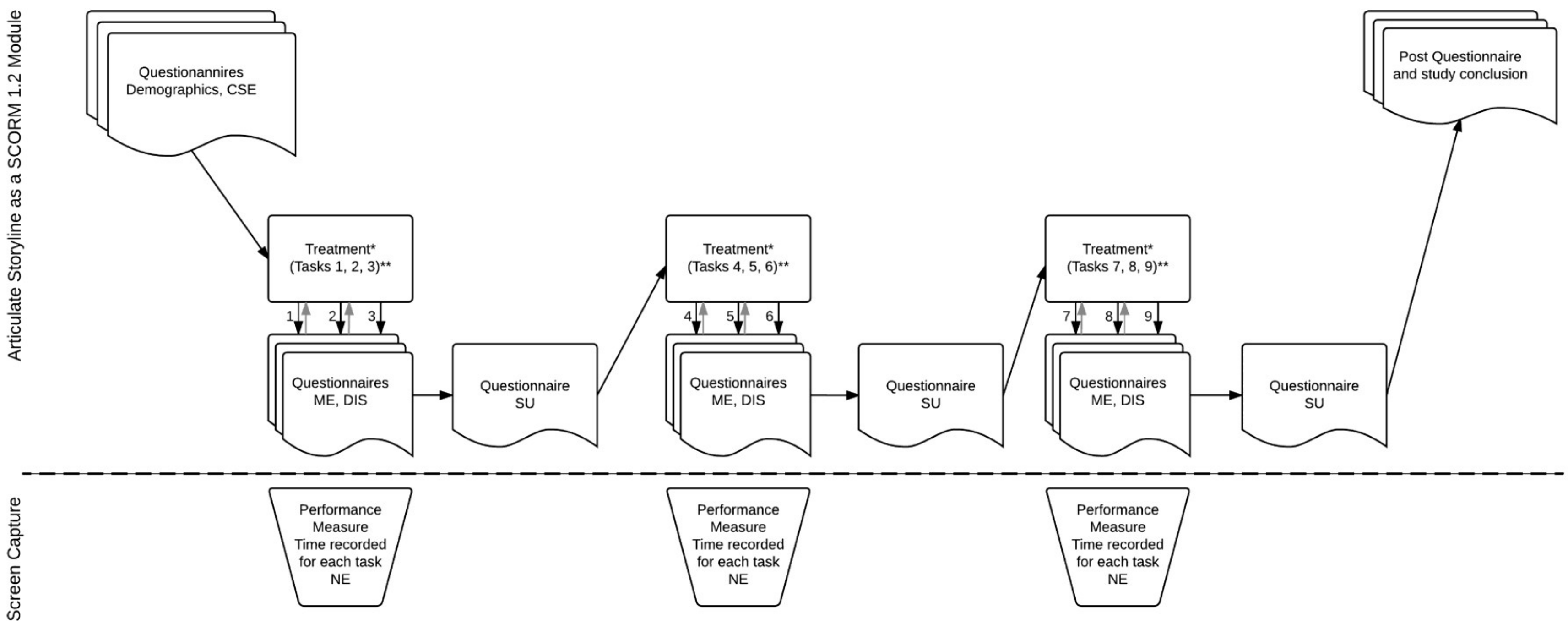
Appendix E

Development of Articulate Storylines

All questionnaires and tasks were created within Articulate Storyline. The storyline guided participants in completing the demographic questionnaire (DEM), and the computer self-efficacy (CSE) scale. The nine tasks needed to be presented with the specific course embedded so the participant could see the task while navigating the course. On the task screens, there were two buttons – one to answer the question in the task, along with the option to "give up." Upon clicking the answer button participants would enter the information required by the task. If the participant decided to quit, a prompt was presented asking for an explanation for the decision to quit.

After each task participants would complete the mental effort (ME) and disorientation (DIS) questionnaires. After completing three tasks for a course, participants would complete the system usability (SU) questionnaire. After completing all nine tasks, participants would complete the post questionnaire.

The storyline was published as a SCORM 1.2 package and placed within Moodle. The activity displayed full screen and reported all responses back to Moodle. The sequence of the study can be seen in Figure 22.



DEM = demographic; CSE = computer self-efficacy; NE = navigational efficiency; ME = mental effort; DIS = disorientation; SU = system usability

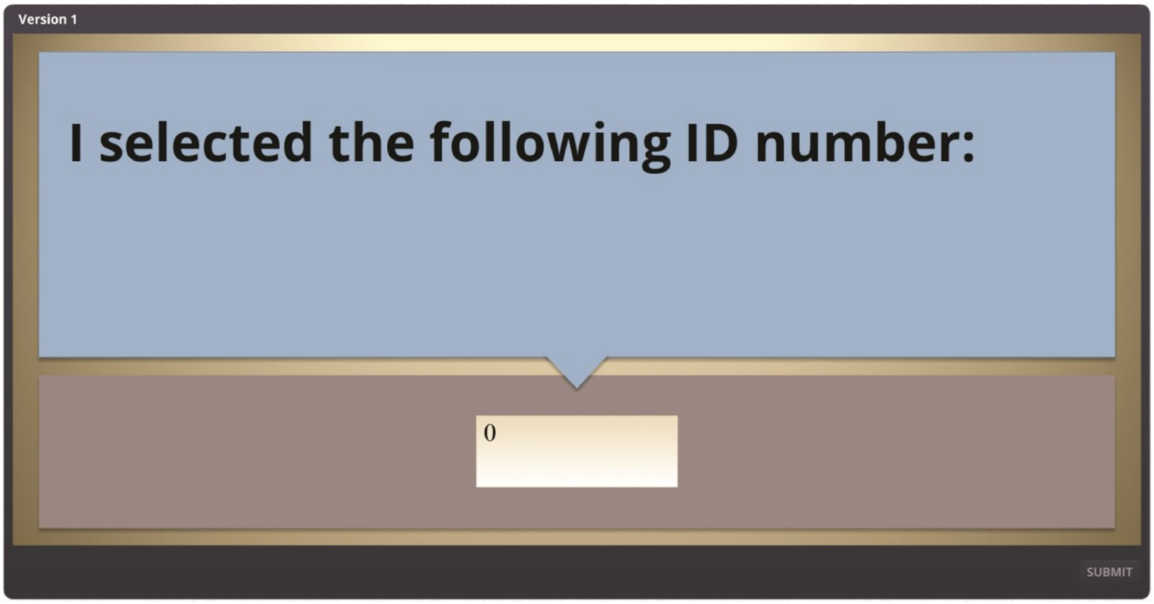
* Treatments will be counterbalanced across participants

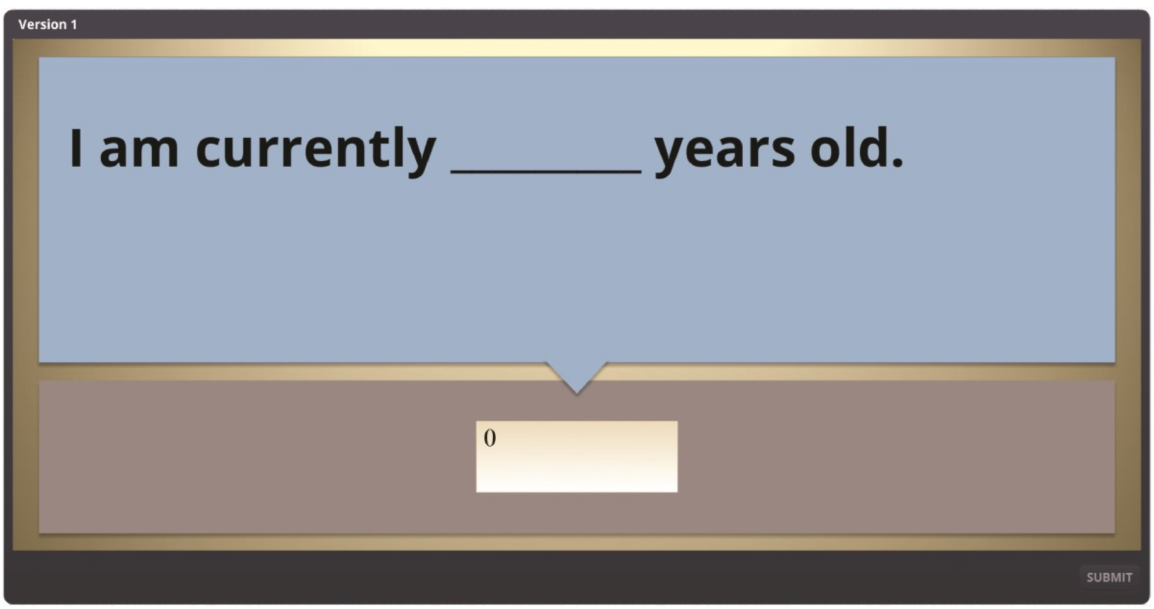
** Tasks will be counterbalanced but will remain clustered to reduce carry-over effects

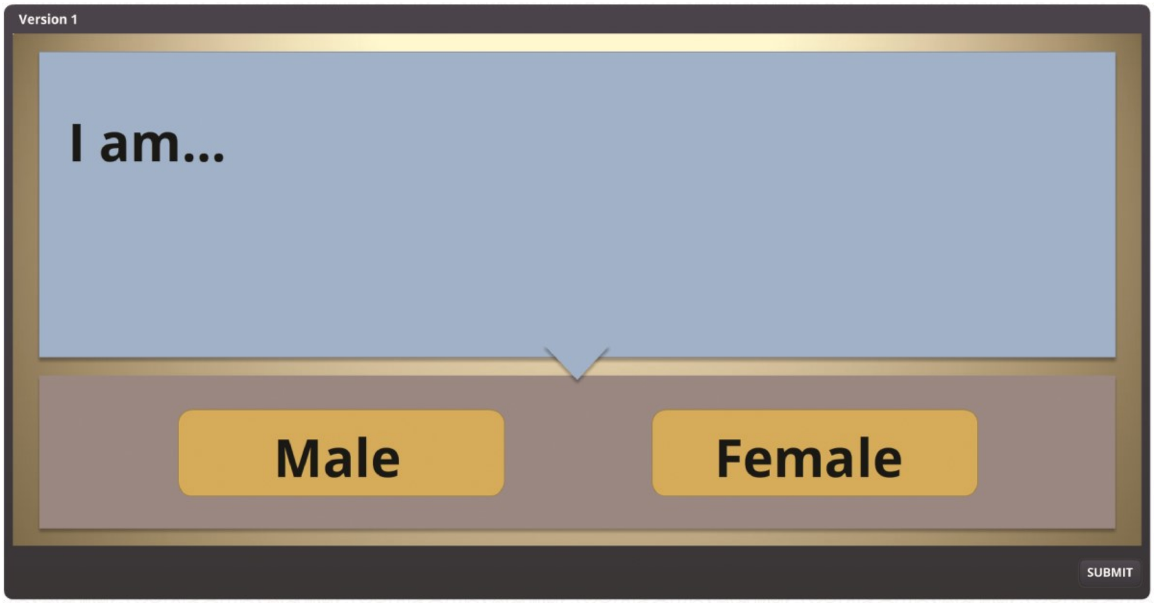
Figure 22. Flowchart for the creation of the Articulate storyline.

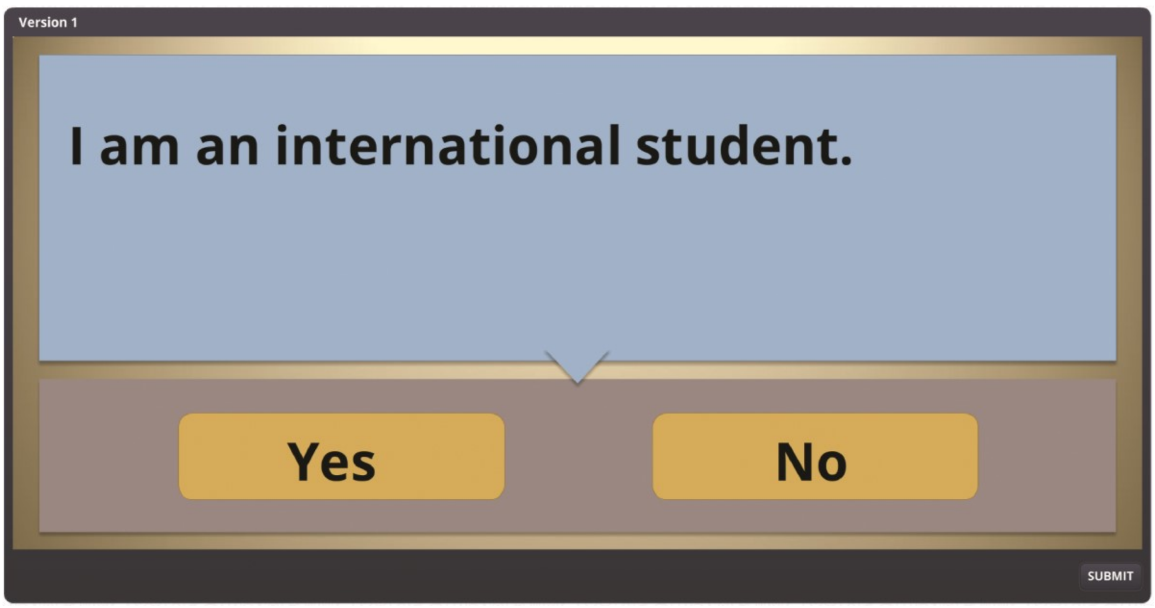
Appendix F

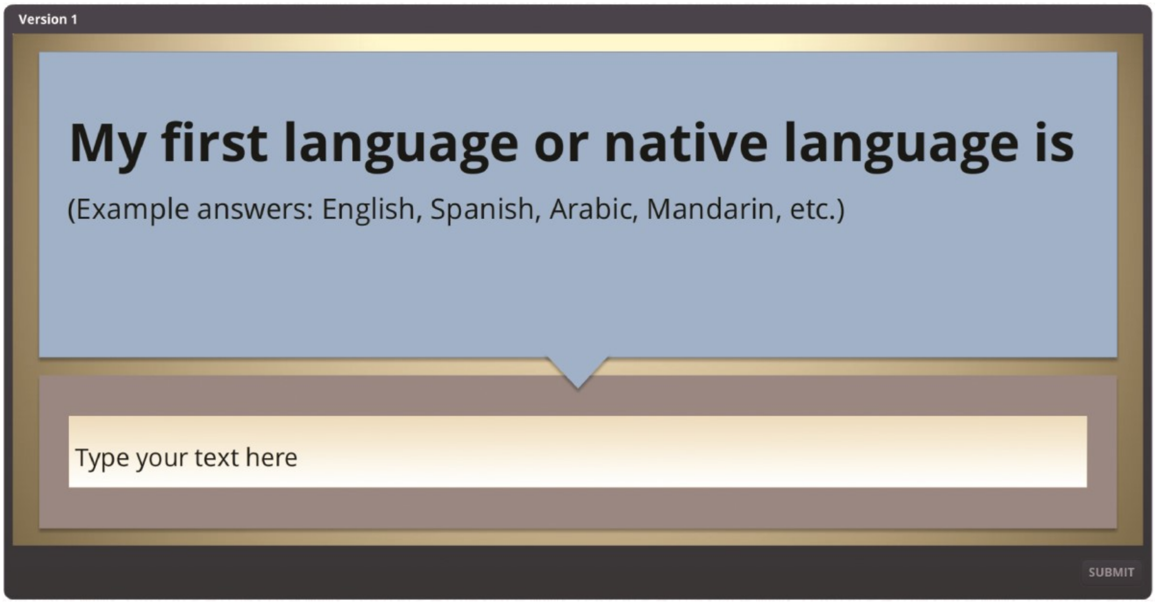
Participant Demographics Questionnaire

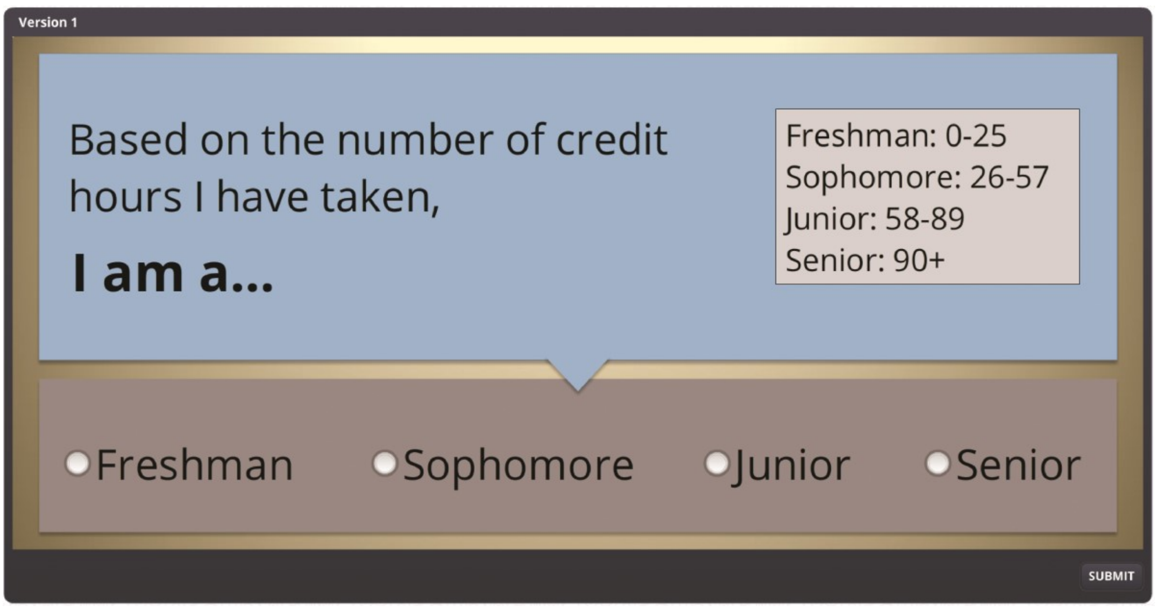


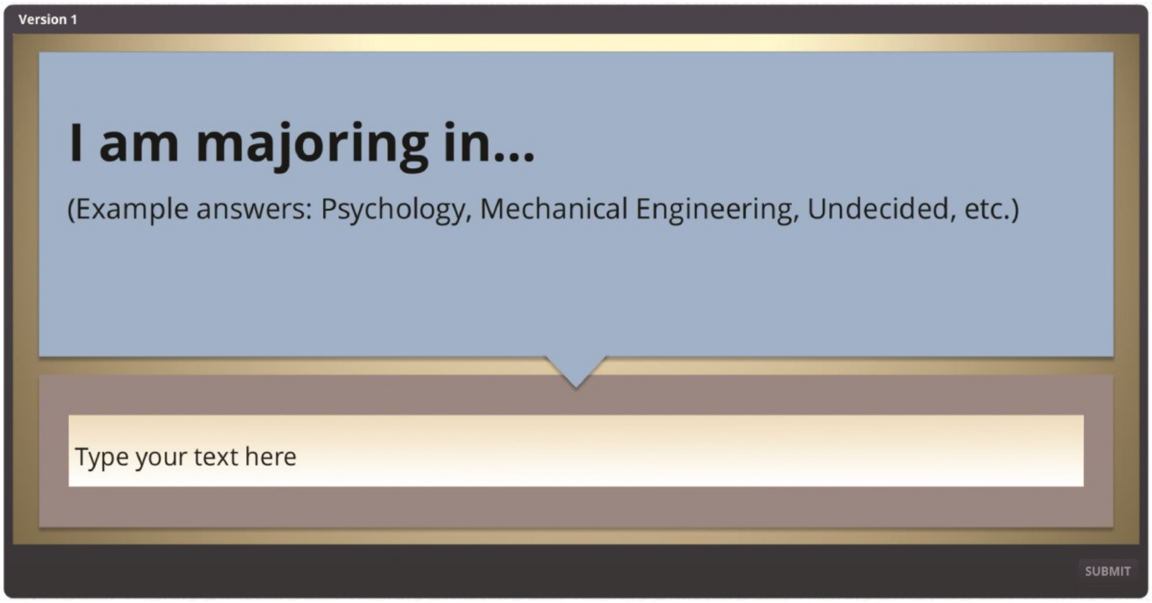


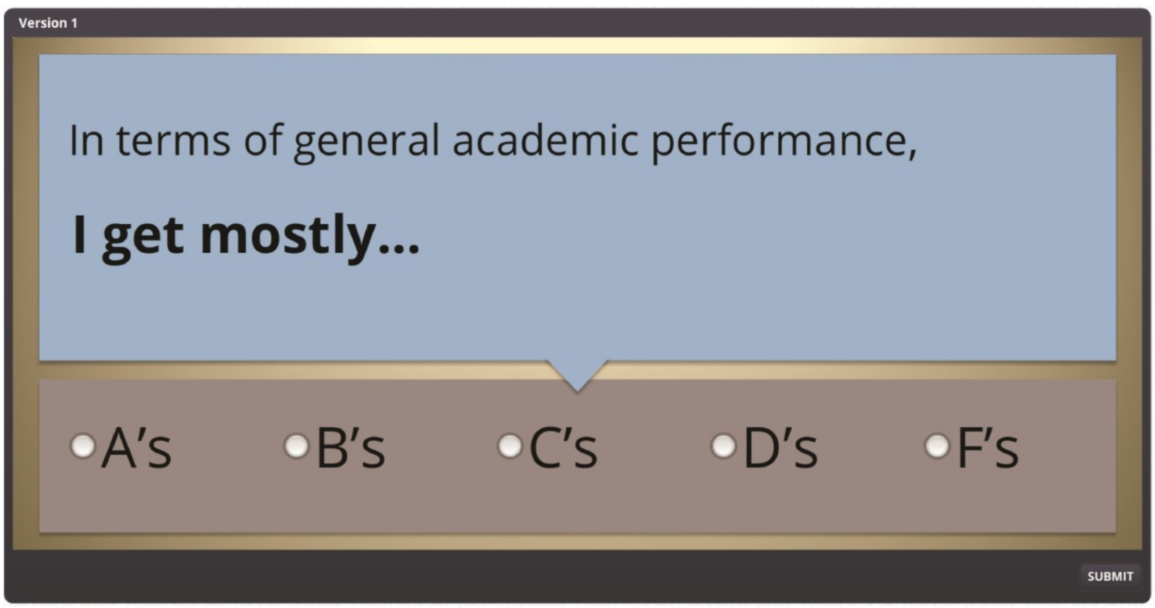

Version 1
I am...
Male
Female
SUBMIT

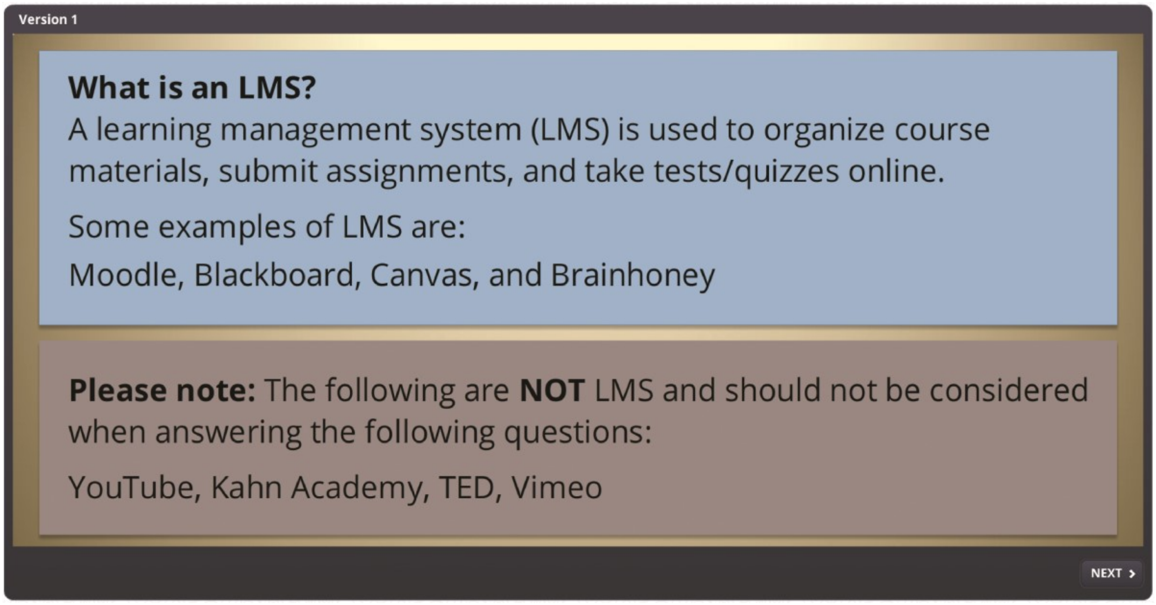

Version 1
I am an international student.
Yes
No
SUBMIT

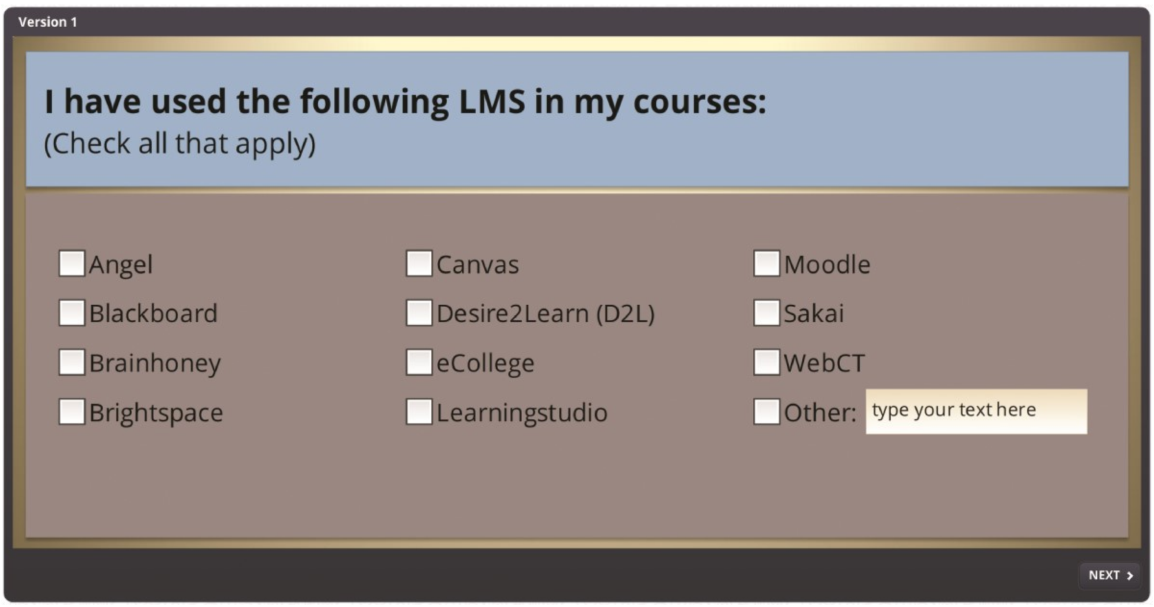

Version 1
My first language or native language is
(Example answers: English, Spanish, Arabic, Mandarin, etc.)
Type your text here
SUBMIT

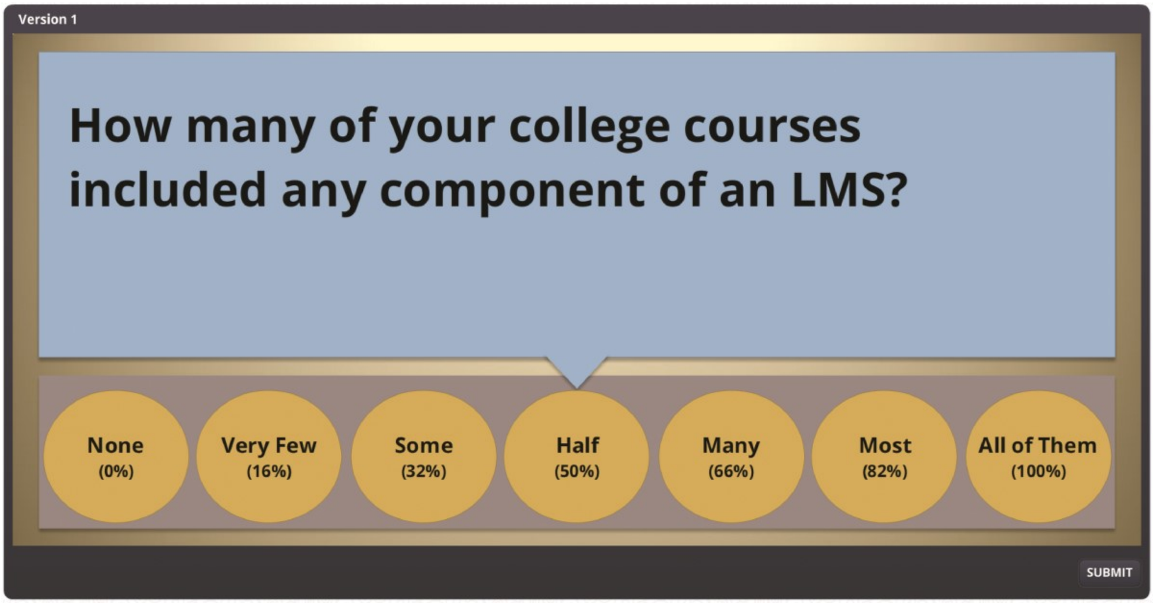

Version 1
Based on the number of credit hours I have taken,
I am a...
Freshman: 0-25
Sophomore: 26-57
Junior: 58-89
Senior: 90+
Freshman
Sophomore
Junior
Senior
SUBMIT

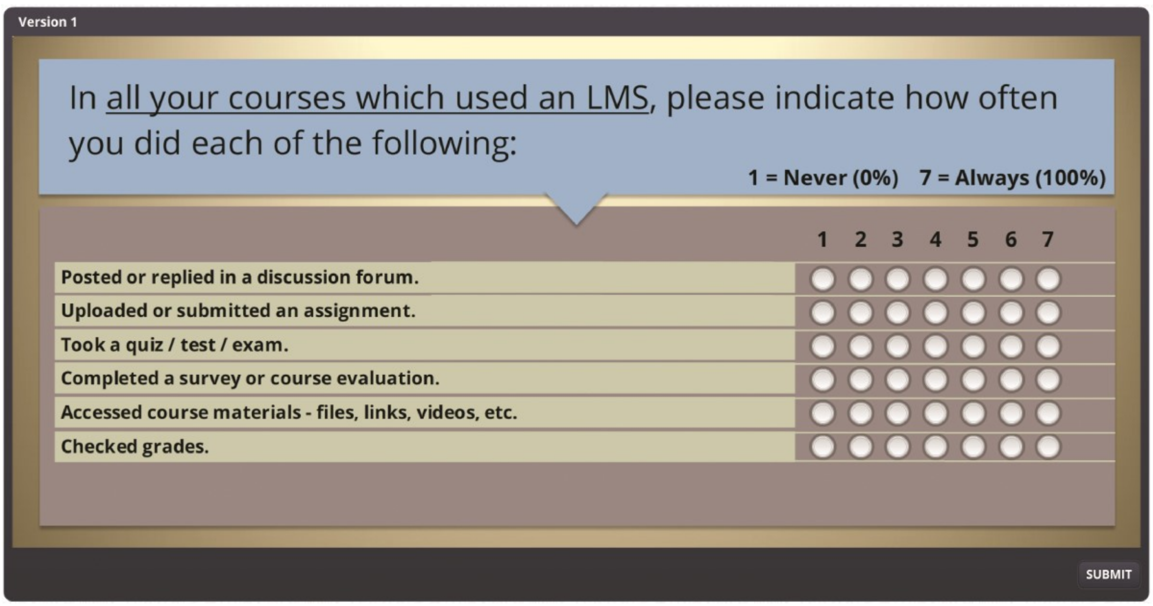

Version 1
I am majoring in...
(Example answers: Psychology, Mechanical Engineering, Undecided, etc.)
Type your text here
SUBMIT

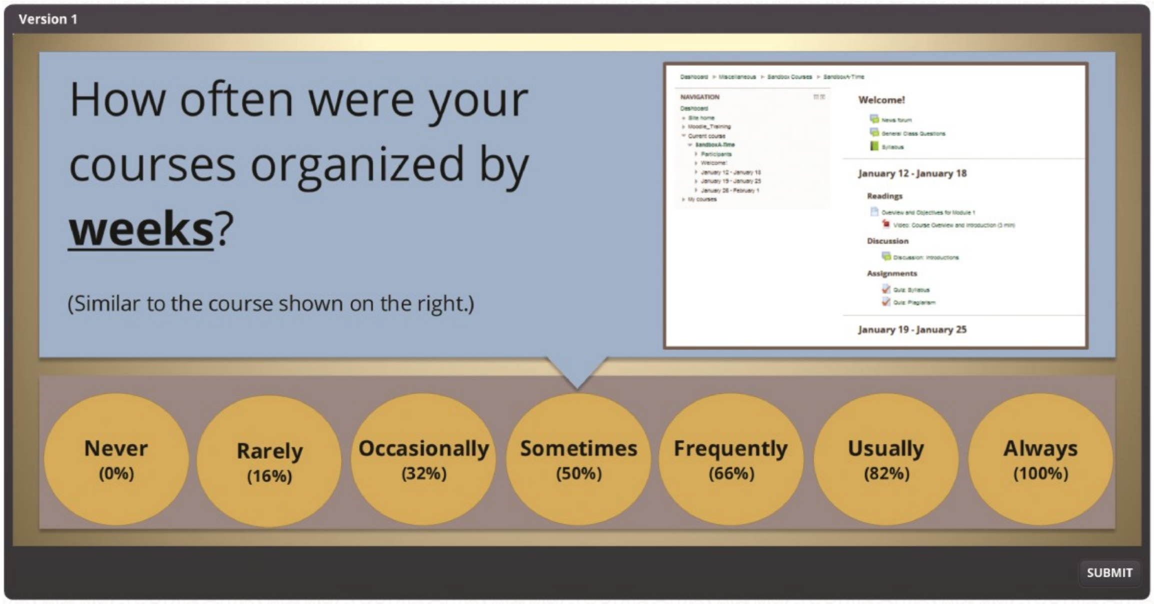

Version 1
In terms of general academic performance,
I get mostly...
A's
B's
C's
D's
F's
SUBMIT

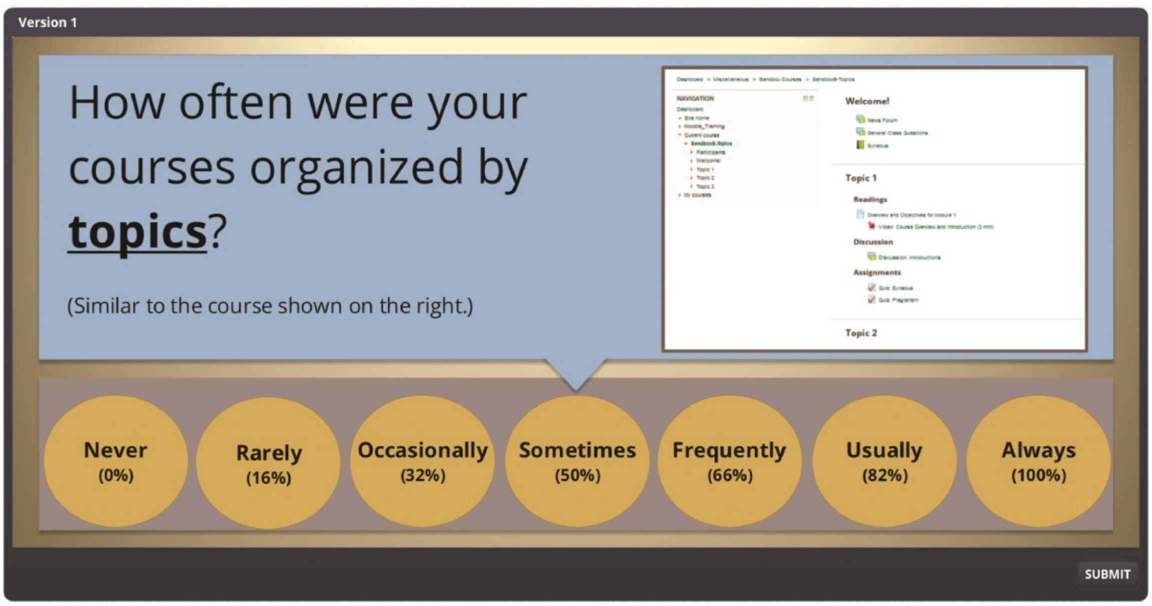

Version 1
What is an LMS?
A learning management system (LMS) is used to organize course materials, submit assignments, and take tests/quizzes online.
Some examples of LMS are:
Moodle, Blackboard, Canvas, and Brainhoney
Please note: The following are NOT LMS and should not be considered when answering the following questions:
YouTube, Kahn Academy, TED, Vimeo
NEXT

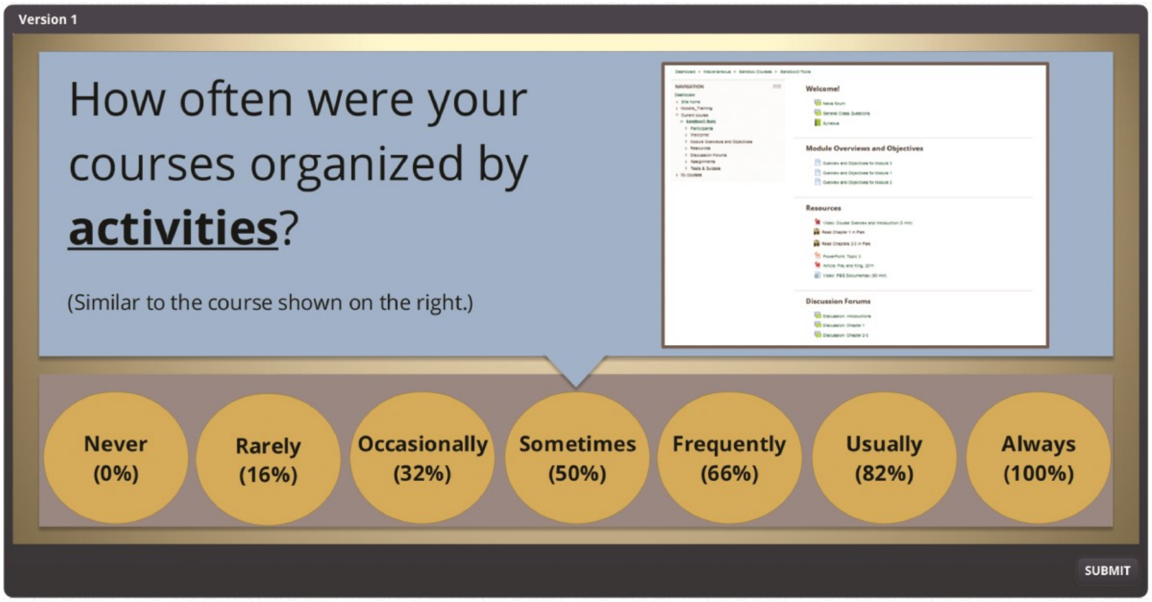

Version 1
I have used the following LMS in my courses:
(Check all that apply)
Angel
Blackboard
Brainhoney
Brightspace
Canvas
Desire2Learn (D2L)
eCollege
Learningstudio
Moodle
Sakai
WebCT
Other:
type your text here
NEXT


Version 1
How many of your college courses included any component of an LMS?
None (0%)
Very Few (16%)
Some (32%)
Half (50%)
Many (66%)
Most (82%)
All of Them (100%)
SUBMIT


Version 1
In all your courses which used an LMS, please indicate how often you did each of the following:
1 = Never (0%) 7 = Always (100%)
1 2 3 4 5 6 7
Posted or replied in a discussion forum.
Uploaded or submitted an assignment.
Took a quiz / test / exam.
Completed a survey or course evaluation.
Accessed course materials - files, links, videos, etc.
Checked grades.
SUBMIT

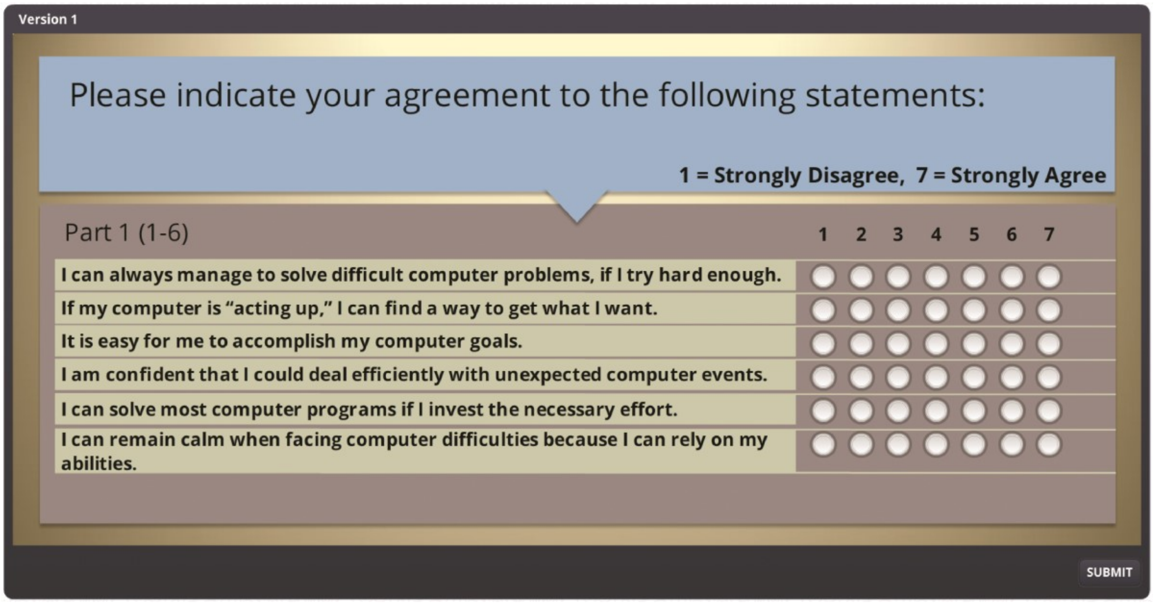

Version 1
How often were your courses organized by weeks?
(Similar to the course shown on the right.)
Welcome!
January 12 - January 18
Readings
Discussion
Assignments
January 19 - January 25
Never (0%)
Rarely (16%)
Occasionally (32%)
Sometimes (50%)
Frequently (66%)
Usually (82%)
Always (100%)
SUBMIT


Version 1
How often were your courses organized by topics?
(Similar to the course shown on the right.)
Welcome!
Topic 1
Readings
Discussion
Assignments
Topic 2
Never (0%)
Rarely (16%)
Occasionally (32%)
Sometimes (50%)
Frequently (66%)
Usually (82%)
Always (100%)
SUBMIT


Version 1
How often were your courses organized by **activities**?
(Similar to the course shown on the right.)
Welcome!
Module Overviews and Objectives
Resources
Discussion Forums
Never (0%)
Rarely (16%)
Occasionally (32%)
Sometimes (50%)
Frequently (66%)
Usually (82%)
Always (100%)
SUBMIT

Appendix G

Computer Self-Efficacy Questionnaire

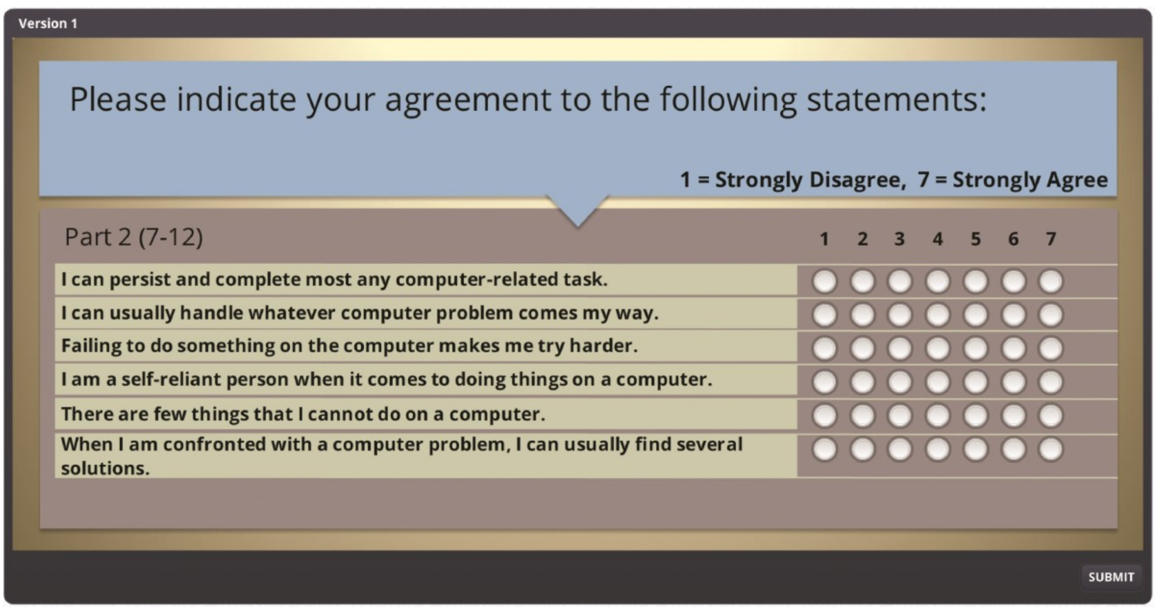

Version 1

Please indicate your agreement to the following statements:

1 = Strongly Disagree, 7 = Strongly Agree

Part 1 (1-6)	1	2	3	4	5	6	7
I can always manage to solve difficult computer problems, if I try hard enough.							
If my computer is "acting up," I can find a way to get what I want.							
It is easy for me to accomplish my computer goals.							
I am confident that I could deal efficiently with unexpected computer events.							
I can solve most computer programs if I invest the necessary effort.							
I can remain calm when facing computer difficulties because I can rely on my abilities.							

SUBMIT


Version 1

Please indicate your agreement to the following statements:

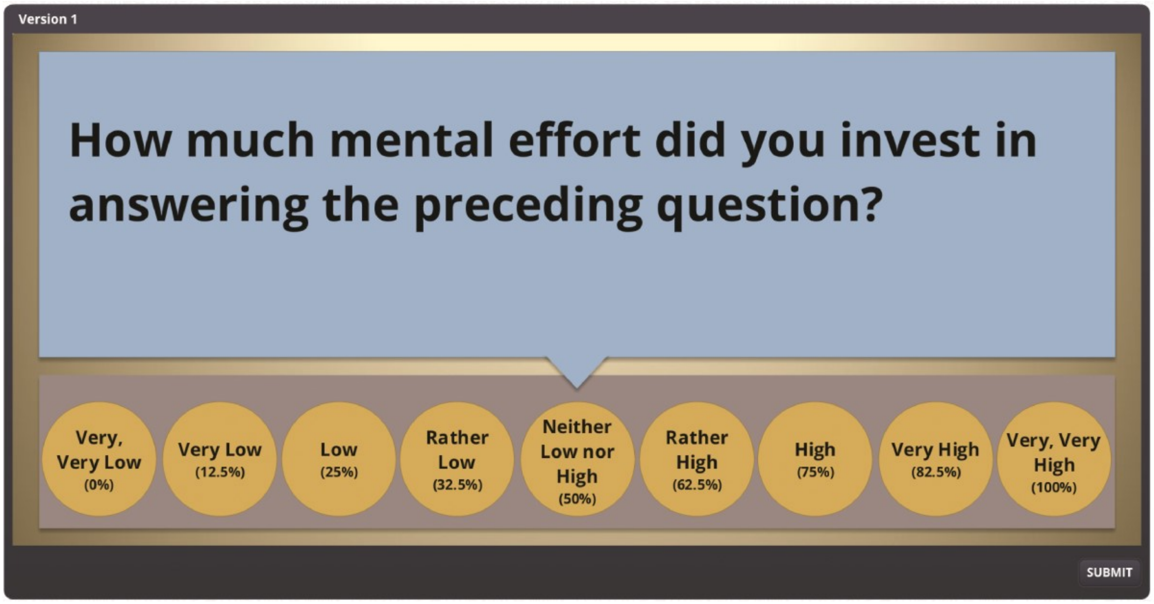
1 = Strongly Disagree, 7 = Strongly Agree

Part 2 (7-12)	1	2	3	4	5	6	7
I can persist and complete most any computer-related task.							
I can usually handle whatever computer problem comes my way.							
Failing to do something on the computer makes me try harder.							
I am a self-reliant person when it comes to doing things on a computer.							
There are few things that I cannot do on a computer.							
When I am confronted with a computer problem, I can usually find several solutions.							

SUBMIT

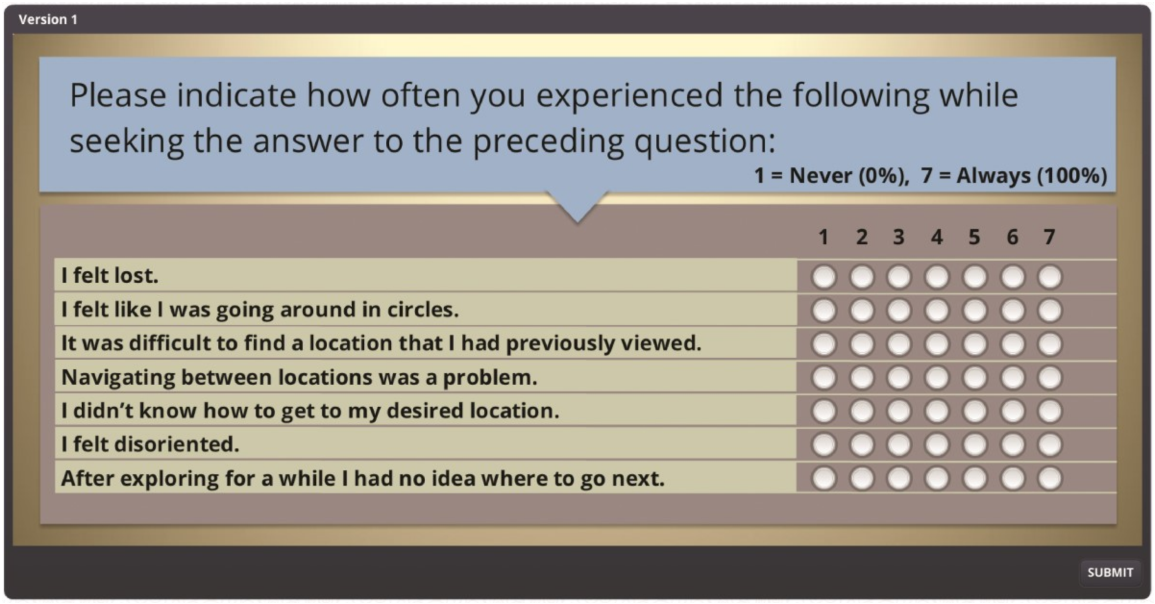
Appendix H

Mental Effort Questionnaire



Appendix I

Disorientation Questionnaire



Version 1

Please indicate how often you experienced the following while seeking the answer to the preceding question:

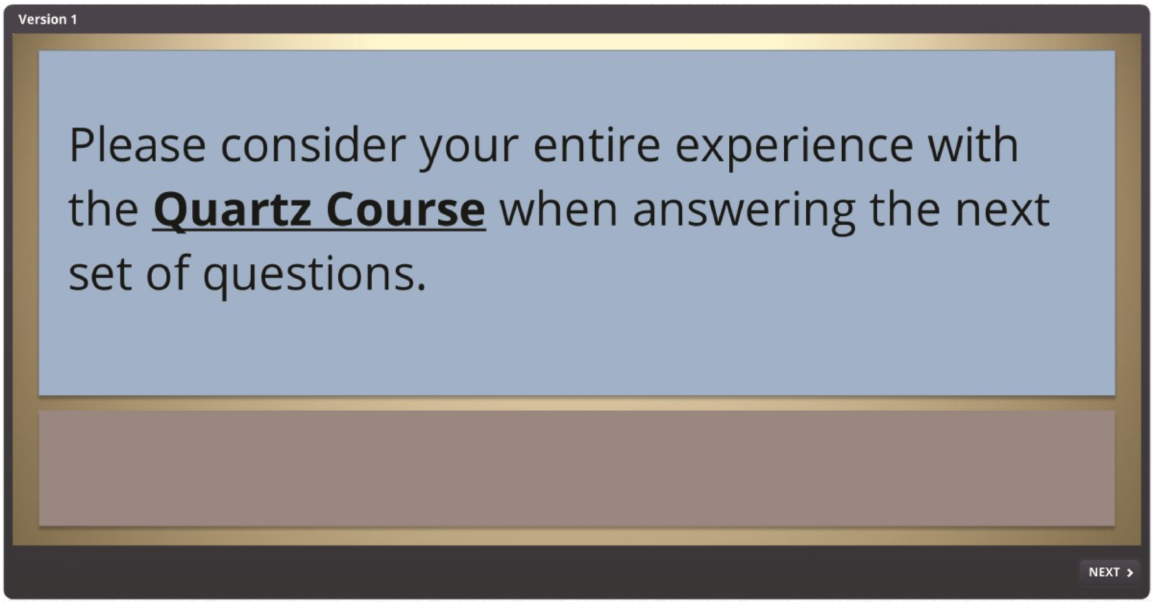
1 = Never (0%), 7 = Always (100%)

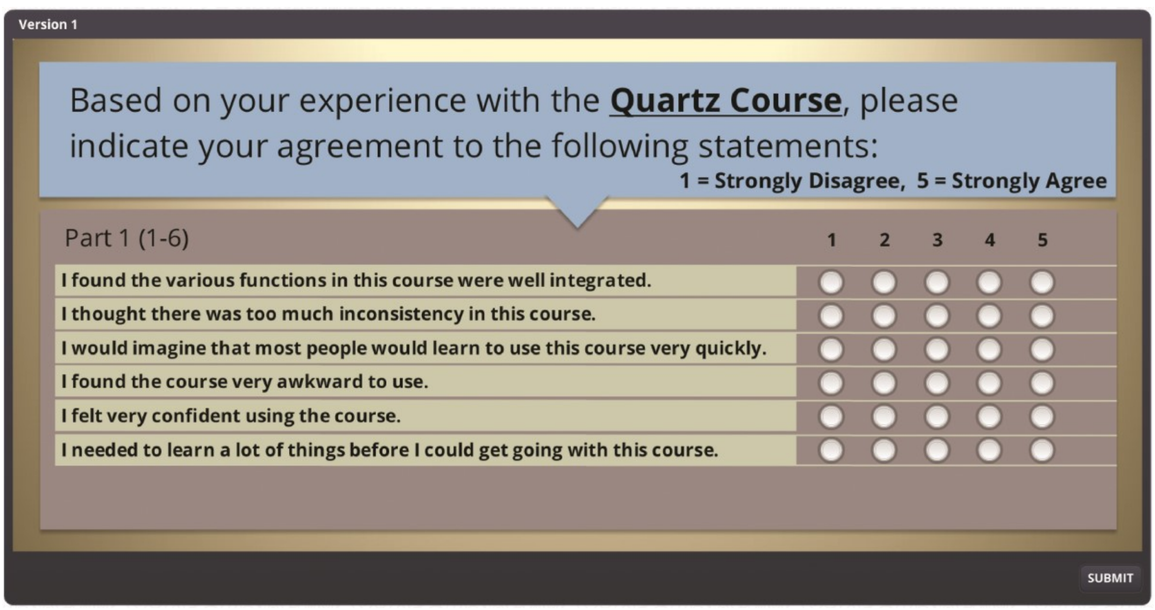
	1	2	3	4	5	6	7
I felt lost.	○	○	○	○	○	○	○
I felt like I was going around in circles.	○	○	○	○	○	○	○
It was difficult to find a location that I had previously viewed.	○	○	○	○	○	○	○
Navigating between locations was a problem.	○	○	○	○	○	○	○
I didn't know how to get to my desired location.	○	○	○	○	○	○	○
I felt disoriented.	○	○	○	○	○	○	○
After exploring for a while I had no idea where to go next.	○	○	○	○	○	○	○

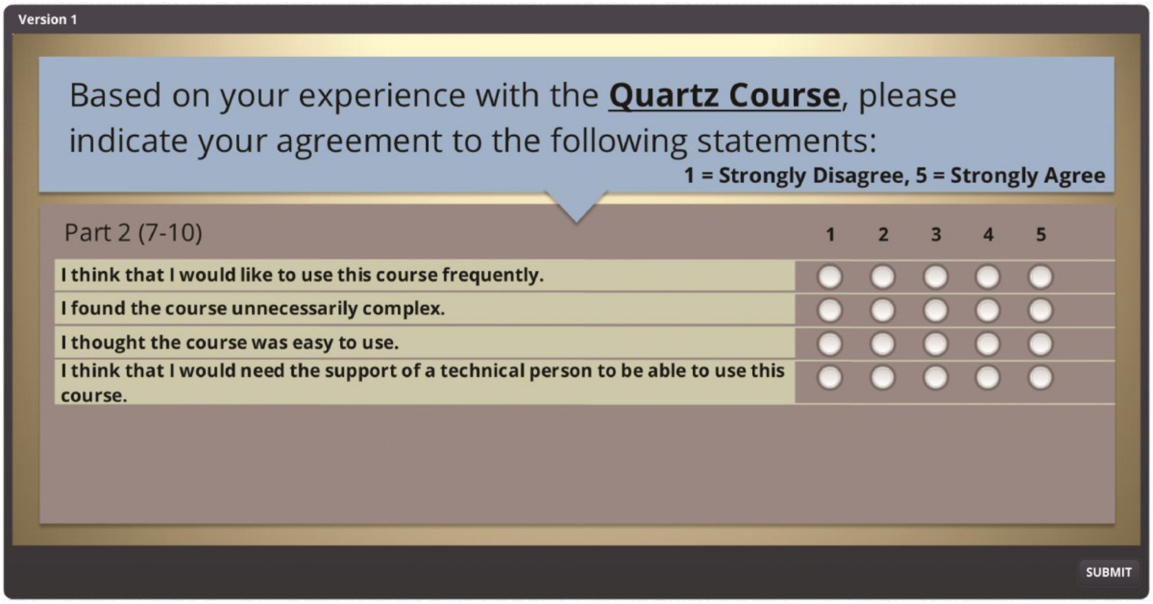
SUBMIT

Appendix J

System Usability Questionnaire



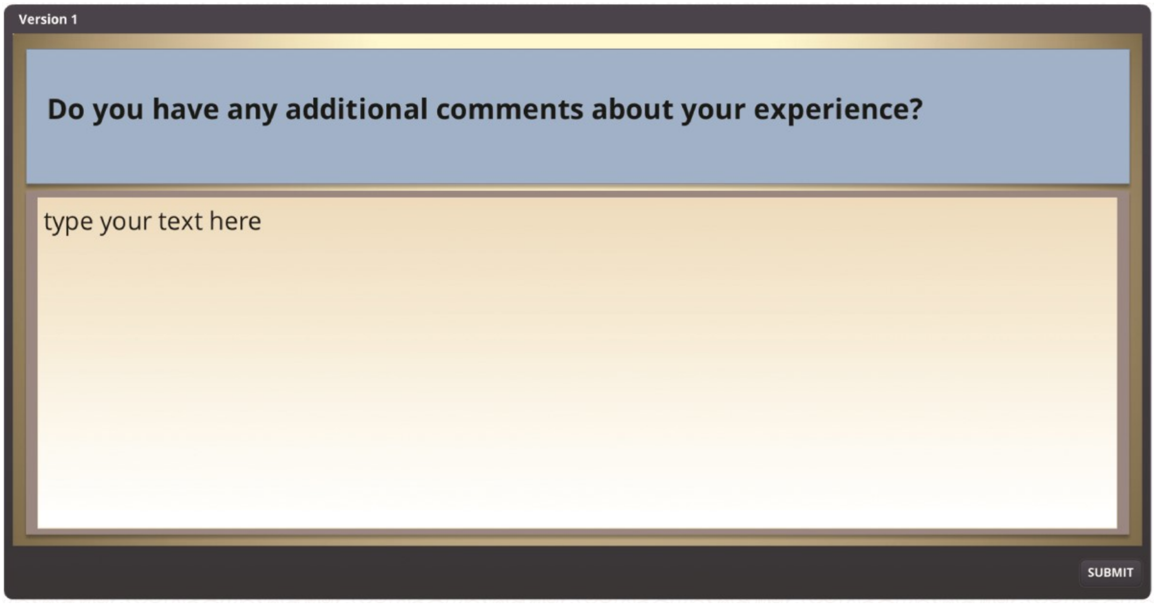



Version 1
Based on your experience with the Quartz Course, please indicate your agreement to the following statements:
1 = Strongly Disagree, 5 = Strongly Agree
Part 2 (7-10)
1
2
3
4
5
I think that I would like to use this course frequently.
I found the course unnecessarily complex.
I thought the course was easy to use.
I think that I would need the support of a technical person to be able to use this course.
SUBMIT


Version 1
Overall,
I would rate the user-friendliness of the Quartz Course as:
Worst Imaginable
Awful
Poor
Fair
Good
Excellent
Best Imaginable
SUBMIT

Appendix K

Post Questionnaire



Appendix L

Letter of Invitation

Title of Study: Navigating in Moodle

Principal Investigator: Lisa Kidder, Instructional Design, Idaho State University

Faculty Supervisor: Dotty Sammons, Professor, Organizational Leadership & Performance, Idaho State University.

I, Lisa Kidder, a doctoral student in the Instructional Design program at Idaho State University, invite you to participate in a research project entitled Navigating in Moodle.

The purpose of this study is to examine how the organization of course materials in Moodle may affect student's use of the course.

Should you choose to participate, you will be asked to use Moodle to perform a variety of tasks that students might perform in accessing their course materials. Following the tasks you will be asked a variety of questions about your experience. Screen capture software will be used to record your session. This will only include your screen movements. No video or audio of you will be recorded. This is expected to take approximately 90 minutes.

This research will help inform faculty on how to best organize course materials in Moodle. It will also help inform programmers on how to improve Moodle.

As the study times will occur near dinner or lunch, food will be available. You may also opt-in to drawing for a $50 Amazon gift card.

To apply to participate please go to http://moodlestudy.weebly.com/

If you have any pertinent questions about your rights as a research participant, please contact the Human Subjects Committee Chair, Ralph Baergen, 208-282-2179 or humsubj@isu.edu

If you have any questions, please feel free to contact me (see below for contact information).

Thank you,

Lisa Kidder
208-282-2502
kiddlisa@isu.edu

Appendix M

Consent Form

Researcher's Statement

You are invited to participate in a usability study. The purpose of this form is to give you the information you will need to help you decide whether or not to participate in the study. Please read the information carefully. You may ask questions about the purpose of the study, what we would ask you to do, the possible risks and benefits, your rights as a volunteer, and anything else about the study or this form that is not clear. When all your questions have been answered, you can decide if you want to be in the study or not. This process is called 'informed consent.'

Purpose of the Study

The purpose of this study is to examine how the organization of course materials in Moodle may affect student's use of the course. This study will specifically examine the effects of organizational structure (i.e., *time vs. topics vs. tools)* within Moodle on navigational efficiency, system usability, mental effort, and disorientation for undergraduate learners.

Study Procedures

In the computer lab in B17 of the Oboler Library, at the time scheduled with the researcher, you will be asked to work through a variety of tasks that students might normally do in accessing their course materials on Moodle. Following the tasks you will be asked a variety of questions about your experience. Screen capture software will be used to record your session. This will only include your screen movements, no video or audio of you will be recorded. In addition, the Moodle logs may be used to provide additional data about your session. This is expected to take approximately 60 minutes.

Risks, Stress, or Discomfort

This study will not expose its participants to risk, stress, or discomfort beyond that normally associated with accessing course materials in Moodle.

Benefits of the Study

This research will help inform faculty on how to best organize course materials in Moodle. It will also help inform programmers on how to improve Moodle.

Compensation

As the study times coincide with either lunch or dinner, food will be available. You may also opt-in to drawing for a $50 Amazon gift card.

Other Information

Names and personally identifying information will not be used in the tabulating and reporting of the results in order to ensure both anonymity and confidentiality. You are free to refuse to participate in the study and may withdraw at any time without penalty.

Subject's Statement

I verify that

- ☐ I am 18 years of age or older.
- ☐ I have not taken nor am I currently enrolled in ANTH 1100.
- ☐ I am not an Anthropology major.
- ☐ This study has been explained to me.
- ☐ I volunteer to take part in this research.
- ☐ I have had the chance to ask questions.

If I have questions later about the research, I can ask the researcher listed above. If I have questions about my rights as a research subject, I can contact the Human Subjects Committee Chair, Ralph Baergen, 208-282-2179 or humsubj@isu.edu

Name (Print): ____

Signature: ____

ID Number Selected:____