1-1-2013

The Effects Of Applying Authentic Learning Strategies To Develop Computational Thinking Skills In Computer Literacy Students

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THE EFFECTS OF APPLYING AUTHENTIC LEARNING STRATEGIES TO DEVELOP COMPUTATIONAL THINKING SKILLS IN COMPUTER LITERACY STUDENTS

by

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DISSERTATION

Submitted to the Graduate School

of Wayne State University,

Detroit, Michigan

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

2013

MAJOR: INSTRUCTIONAL TECHNOLOGY

Approved By:

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Advisor Date

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ACKNOWLEDGEMENTS

Needless to say, this was a long, long journey. It started almost ten years ago when I decided to look into the Instructional Technology department at Wayne State University because it sounded like a pretty interesting field at the time. My journey in this program lasted longer than most marriages, interest rates and fashion trends but I greatly appreciate how much the experience has matured me as a person. This accomplishment comes with a number of people that I owe my deepest gratitude. Before thanking anyone, I would first like to thank my Lord and Savior Jesus Christ for carrying me from the beginning to the end of this journey.

I have a number of Wayne State University faculty members to thank starting with my awesome dissertation committee. My dissertation chairman, Dr. Monica Tracey, welcomed me back with open arms and accepted me as her student when I returned to the program. Furthermore, she worked diligently with me on a very complex study providing the wisdom and guidance that was necessary to successfully get me through. Dr. Tracey, thank you for the precious and valuable time that you spent with me!

I enjoyed taking the interactive technology classes under the direction of Dr. Timothy Spannaus. I never imagined that I would actually use the learning experiences from every class I had with him to create the prototype for my dissertation. Dr. Spannaus, thank you for years of preparing me and providing me the technological guidance for my study!

Dr. James Moseley's meticulous attention to detail was instrumental in making my dissertation into what it has become. His experience is very valuable to the instructional technology department and doctoral students alike. Dr. Moseley, thank you for being a member of my committee!

Dr. Monica Brockmeyer was a member of my committee and was responsible for writing the cognate section of my qualifying exam. She was instrumental in introducing me to computational thinking; a topic that I have come to fully embrace. Dr. Brockmeyer thank you for not only providing the charge for my study but reaching out from the Computer Science department to offer your support!

Finally, I would like to thank my former advisor, Dr. Rita Richey for giving me the necessary foundation in instructional technology required for me to accomplish this goal.

I would like to extend a heart-felt thank you to Michele Norris. Michele's encouragement, quick wit and humor for almost ten years helped me to keep my sanity. The duck and grape joke will be with me always. Next, I would like to thank Khayyam Hashmi and the Computer Science department for permitting me to work with the computer literacy students. I wish Khayyam all the best in his studies and future endeavors. I would like to also thank Dr. Janice Green, Paul W. Johnson, Gursharon Shergill and Betsy Baumann. I am grateful for their patience with me at the end of this long and winding road during the most challenging times of my life.

I would like to thank my mom, Joan Mingo, who was there for me since day one of this journey and who would never let me quit, no matter how many times I told her that I wanted to set my dissertation ablaze. She also spent so many hours proofing numerous drafts and helping me out wherever she could. Mom, thank you for being there for me!

I would also like to thank my brother, Dr. Alfie Mingo. Although he is my younger brother, I look up to him for his drive, tenacity and being the shining example in our family. I would like to thank a number of other immediate family members: My dad, Charles Mingo for his support and my aunts, Pauline Kelly and Dr. Helen J. Powell for being such positive role models in my life.

Next, I would like to thank two mentors who I have known for most of my life. Barry (Bear) Mattock has been a big brother figure to me for over twenty years. His positive and motivational way of looking at life kept me encouraged and helped me keep things in perspective. Dolores Shepherd, my sorority sister and former teacher, has known me since my days at Ferris Middle School in Highland Park, Michigan and has pushed me academically as long as I have known her.

Finally, I would like to thank the following colleagues for their encouragement, time and support: Srilakshmidevi Akasapu, Shikha Arora, Bernice Brogan, Sara Ibrahim, Usha Kompalli, Sravana Muthavarapu, Mark Parker, Murthy Punyamurtula, James Roosa, Shabnam Saghir, James Tang and Janine Zurro.

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CHAPTER 1 INTRODUCTION

Instructors in various capacities continue to aspire to implement real-world learning opportunities in the classroom that actually reflect societal situations in which learning could be applied. Authentic learning provides engaging opportunities within learning environments to students by allowing them to participate in real-world problem-solving activities (Herrington & Oliver, 2000). Authentic learning also optimizes the relevancy of learning to students and encourages them to develop applicable competencies for various aspects of their lives (Gulikers, Bastiaens & Martens, 2005). Computational thinking is a fundamental skill commonly practiced within the field of computer science that could benefit other disciplines (Wing, 2006). Although a number of computational thinking initiatives have been implemented, a limited number of them are applicable to disciplines external to the sciences. In one study, authentic learning was used as an instructional strategy to teach computational thinking within a scientific discipline (Pulimood & Wolz, 2008). However, no initiatives have been implemented within the non-scientific disciplines that use concepts from authentic learning as an instructional strategy to teach computational thinking skills. This study attempted to both construct a tool that will integrate these skills using authentic learning strategies as the instructional venue and assess the motivation and knowledge acquired with using this tool to teach computational thinking skills to undergraduate computer literacy students.

Statement of the Problem

While the number of occupations that require computer literacy skills has dramatically increased over the last ten years, the number of students in the United States actually majoring in computer and information sciences, computer engineering or some computer technology-dependent field of study has struggled to keep up with industry demand. Enrollment declined significantly between 2002 where there was an average of 400 undergraduate majors per computer science department and 2007 where the average dropped to under 200 (Zweben, 2012). Since then, there have been modest increases in enrollment between 2008 and 2011 averaging about 10% per year bringing the average number of majors per computer science department up to about 280. The continued lack of interest and enrollment in computer science and other sciences and quantitative disciplines is also reflective in the number of Americans who possess the necessary technical skills to fully function in most professions (Jolly, Campbell & Perlman, 2004). Computer technology is no longer the novelty that it was two decades ago. Practically every occupation relies on computers in some form of computer usage whether it be programming, engineering, designing, research, analysis, information processing or data entry (Denning, 2007; Margolis, Estrella, Goode, Holme, & Nao, 2008; Wing, 2006). Unfortunately, society does not fully comprehend how exposure to the computational thinking problem-solving opportunities often realized in the classrooms of four-year computer science programs provides a significant advantage to those students who major in this field. The learning experience not only provides graduates the background and the foundation to function in practically any technology-based occupation but it also provides them the advantage of being able to obtain employment in many professions aside from computer science (Margolis et al., 2008; Wing, 2006).

In 2006, Jeanette Wing, head professor of computer science at Carnegie Mellon University, introduced a term called computational thinking (Wing, 2006). Computational thinking involves knowing how and when to apply a number of problem-solving techniques normally associated with computer science, including but not limited to reduction, transformation, simulation, recursion, abstraction, decomposition and heuristics (Wing, 2006). Computational thinking also boasts a number of benefits for various disciplines and professions

(Adams, 2008; Hambrusch, Hoffman, Korb, Haugan & Hosking, 2009; Priami, 2009; Topi, 2008; Wing, 2006). What people do not realize is that they commonly and unwittingly employ or experience some type of computational thinking skill or characteristic. A building equipped with backup generators that automatically turn on in case of a power outage is a computational thinking example of fail-over and redundancy. An Internet search engine such as Google or Yahoo uses heuristics to return a number of responses that may or may not be the answer but closely resembles the search item. Finally, algorithms are formulated to calculate fixed monthly mortgage payments and can be used to estimate payments if the mortgage was based on an adjustable rate.

According to Wing (2006), colleges and universities should support the practice of teaching computational thinking skills to students external to the computer science discipline. Furthermore, computational thinking was initially supported by the Cyber-Enabled Discovery and Innovation (CDI) initiative, which was sponsored by the National Science Foundation. This initiative encouraged research-based agendas that will develop educational opportunities in computational thinking for students across many scientifically based disciplines (National Science Foundation, 2007). As a result of this initiative, programs and classes were introduced that focus on computational thinking for disciplines that are primarily geared towards the sciences; however, few programs have focused on computational thinking opportunities for disciplines that are not based on the sciences.

Authentic learning is an instructional strategy that exposes the learner to real-world situations by using a variety of interactive and engaging learning activities (Lombardi, 2007; Reeves, Herrington & Oliver, 2002). “Authentic learning intentionally brings into play multiple disciplines, multiple perspectives, ways of working, habits of mind, and community” (Lombardi, 2007, p. 2). Authentic learning benefits learners by allowing them to learn realistic and applicable tasks in a safe environment (Radinsky, Bouillion, Hanson, Gomez, Vermeer, & Fishman, 1998; Resnick, 1987). It also benefits learners by allowing them to “engage in the type of multidisciplinary problem solving and critical thinking that researchers and experts use every day” (Windham, 2007, p. 3). Authentic learning allows learners to experience real-life situations that they normally would not experience in a traditional classroom setting. Knowledge acquired in an authentic learning environment is likely to be more retrievable than what is experienced in a traditional setting because of its interdependency between the situation where the learning could be applied and the learner’s cognition (Herrington & Oliver, 2000). When learning is separated from its context, learners lose the benefit by perceiving knowledge as an educational product having no meaningful purpose instead of being a tool that is applicable in various problem-solving circumstances (Herrington & Oliver, 2000).

Authentic learning practices have evolved over the years as technology has advanced. Currently, authentic learning is often implemented using some type of electronic or web-based learning environment. Prior to the influence of advanced technology, authentic learning activities were conducted using activities such as reading literature, listening to music, watching videos, looking at pictures or constructing something by hand (Brown, Collins, & Duguid, 1989; Cognition and Technology Group at Vanderbilt, 1990; Collins, Brown, & Newman, 1987; Gordon, 1998; Lello, 1980; Windham, 2007). A major benefit that technology brings to authentic learning is simulation. Simulation has many capabilities such as fast-forwarding time-sensitive activities, safely and accurately displaying the outcome of a specific action based on decisions made by the learner, repeating scenarios as necessary by the click of a button and allowing multiple learners to cohabit the same learning environment (Lombardi, 2007). Additionally, technology makes it easier to record learner activities, which helps to automate assessments and can *pause* an activity allowing the learner to resume where the last activity concluded at a later time. Finally, web-based environments support the integration of various types of software including word processors, spreadsheets, presentations and email that could jointly function in an authentic learning environment.

The overall feedback for authentic learning and computational thinking initiatives as separate entities was positive within the context that they were applied (Cortina, 2007; Edwards, Nash, Sacre, Courtney, & Abbey, 2008; Garde, Heid, Haag, Bauch, Weires, & Leven, 2007; Hambrusch et al., 2009). The challenge becomes integrating the two entities where authentic learning is used as the instructional strategy to teach computational thinking.

Purpose of the Study

The purpose of this study was to determine if a prototype of a tool that uses authentic learning strategies to develop skills in computational thinking can be used to increase the motivation and knowledge acquisition of undergraduate computer literacy students. Although computer literacy is not a declared profession as what is preferred in an authentic learning environment, there is hardly a profession in existence that does not heavily depend upon its substance. This study had a threefold approach. First, there was a lengthy and stringent process involving the design and the development of the tool. Next, subject matter experts in the field of information technology reviewed the tool and corresponding assessment instruments. Finally, an assessment was conducted to measure the acquired knowledge and motivation from using this tool against another instructional intervention. This study involved the following eight steps:

1. Problems and examples taken from computer science and computer literacy books were used to assist with designing computational thinking techniques that would be integrated

within the authentic learning tool.

2. Using the computational thinking problems that were created from the computer science and computer literacy instructional materials, a prototype of an authentic learning tool was developed that provided students with real-world campus-life scenarios in computer literacy that were structured into computational thinking methods and problem-solving opportunities.
3. The information obtained from the same computer science and computer literacy books were also used to develop the pretest and posttest.
4. Informal expert reviews with experts in the field of information technology were conducted to evaluate the tool, the pretest and the posttest. Their feedback was used to make improvements to the materials where feasible.
5. A sample of computer literacy students was given the pretest to measure their existing computational thinking skills.
6. After being split into an experimental and control group, students were issued either the authentic learning tool or another instructional intervention.
7. The sample of computer literacy students was given the posttest to measure acquired computational thinking skills.
8. The study concluded with giving the students a motivation assessment for the instructional interventions that were assigned to them.

Research Questions Investigated

This study was guided by the following two research questions:

1. What are the effects of using an authentic learning tool to teach computational thinking on the knowledge acquisition of undergraduate computer literacy students?

2. What are the effects of using an authentic learning tool to teach computational thinking on the motivation of undergraduate computer literacy students?

Variables

The authentic learning tool served as the independent variable in this study while motivation and knowledge acquisition served as the dependent variables.

Definition of Terms

The terms that are used in this research are as follows:

Authentic learning environment. An authentic learning environment is an actual, life like, virtual or technologically based environment that allows students to perform complex and realistic tasks that they would find relevant to the subject being studied within the environment, their future professions or to their everyday lives (Herrington & Oliver, 2000; Gulikers, Bastiaens, et al., 2005).

Situated learning. Situated learning is a learning strategy that “investigates learning as an essentially social phenomenon that takes place at the juncture of everyday interactions” (Henning, 1999, p. 143). The objective of situated learning is to examine how learning relates to the social situation where it occurs (Lave & Wenger, 1991). The position assumed by situated learning is that “learning is an integral and inseparable aspect of social practice” (p. 31). In situated learning, the focus migrates from the types of cognitive processes or activities that take place within the minds of individuals to the types of social engagements and co-participation activities that provide opportunities for learning to increase (Lave & Wenger, 1991).

Computational thinking. Computational thinking is comprised of a set of skills focusing on problem-solving capabilities normally applied by computer scientists (Wing, 2006). There are a number of skills supported by computational thinking involving applying reduction, embedding, transformation or simulation techniques to simplify problems. Computational thinking also involves thinking recursively, using heuristic reasoning to discover a solution and using abstraction and decomposition when attacking large complex tasks or designing large complex systems. Finally, computational thinking involves thinking in terms of prevention, protection, and recovery from worst-case scenarios by using redundancy, damage containment, and error correction (Wing, 2006).

Motivation. Motivation is the intention of achieving a goal that leads to goal-directed behavior (The Columbia Encyclopedia, 2008). It is the stimulation of peoples' desires to be interested and involved in their surroundings and the desire for people to do their best (Keller, 1987).

ARCS model of motivational design. ARCS is an acronym that stands for Attention, Relevance, Confidence and Satisfaction, where each member of the acronym represents a category within the model (Keller, 1987). Each category has three related sub-categories that are paired with questions used to guide instructors in designing motivational instruction along with types of strategies to apply. The motivational design process has four activities: define, design, develop and pilot, that are each paired with three sub-activities and corresponding process questions. The members of the ARCS acronym are used to determine levels of motivation by addressing the following four questions: does the instruction hold the learner's attention; is the instruction relevant to the learner; does the learner have confidence that the instruction can be applied; and is the learner satisfied with what has been learned (Keller, 1987).

Simulation. Simulation is a methodology that resembles learning in the real world by replicating a phenomenon within some type of apparatus and simplifying it by adding, removing or altering functionality within the apparatus (Alessi & Trollip, 2001).

Web-based learning. Web-based learning is a subset of e-learning that delivers instruction on a computer by way of the Internet or intranet (Clark & Mayer, 2008). It contains the following features: content relative to the learning objective; instructional methods to facilitate learning; media elements including words, pictures, sound and video; synchronous or asynchronous learning; and the ability to build new knowledge and skills that relate to the learning goals or organizational performance of the individual (Clark & Mayer, 2008).

Summary

This section began with an introduction of authentic learning and computational thinking and the benefits that both provide. It described the imbalance of technological skills held and obtained by Americans to the number of occupations that require these skills and how that gap continues to widen where the number of occupations are outpacing the number of people qualified to fulfill them. The push for teaching computational thinking in classrooms for all students regardless of educational levels can assist in closing that gap. This section concluded with discussing the purpose of the study, the steps I took to complete the study, the variables used and the research questions that were addressed as part of this study. I begin the next section with a discussion on constructivism as the theoretical foundation of this study followed by a detailed discussion on authentic learning, which is the primary focus of the study and conclude with a brief overview of computational thinking and a sample of associated studies that have been conducted.

CHAPTER 2 REVIEW OF THE LITERATURE

The two primary sections described within this literature review pertain to authentic learning and computational thinking. The first section begins with defining authentic learning and constructivism as its theoretical foundation. It continues with describing design practices of authentic learning environments and discusses some of the concerns mentioned in the literature with using authentic learning as an instructional strategy. It also expounds on authentic learning studies by reviewing applications of authentic learning, technological approaches that were used, theories that were applied, students' perceptions of the studies conducted and students' knowledge outcomes. The second section discusses the importance of computational thinking and continues with a summary on learning strategies, computer applications and courses used to teach computational thinking skills. It concludes with a brief discussion on authentic learning, computational thinking and technology.

Authentic learning

In this section I begin with a review of how authentic learning is defined throughout the literature. I then briefly discuss constructivism which is the theoretical backbone for authentic learning. My review of authentic learning included the following: (a) design strategies used, (b) concerns, (c) applications, (d) technological trends, (e) theories used, (f) characteristics, and (g) outcomes of student interactions.

Defining authentic learning. Authentic learning is an instructional strategy that "focuses on real-world, complex problems and their solutions, using role-play exercises, problem-based activities, case studies and participation in virtual communities of practice" (Lombardi, 2007, p. 2). It is simply defined as the ordinary practices of the culture (Brown et al., 1989) and as the mapping between structured learning activities and some meaningful context for that activity

(Radinsky et al., 1998). Brophy and Allman (1991) defined authentic learning as a method for applying procedural or strategic knowledge as tools to accomplish life applications that justify the reason for including them. In an authentic learning situation, learning revolves around authentic tasks including real-world problems and simulations closely associated with the field of study (Nicaise, Gibney, & Crane, 2000). As described by Cronin (1993), “the power of the authentic learning movement has been in the simplicity of its central idea: students' experiences in school should more closely resemble the experiences they encounter in real life” (p. 7).

Theoretical support for authentic learning. Constructivism is a learning perspective that states that each person constructs reality, individually and socially, by interpreting perceptual experiences of the external world (Jonassen, 1991; Jonassen, 1999). The principle of constructivism states that, “all knowledge is constructed by individuals on the basis of what appears to be adaptive, viable or satisfying” (Gruender, 1996, p. 24). Constructivists posit that knowledge cannot be transmitted from one person to another. Instead the learner is involved with constructing or interpreting reality based upon what the learner perceives (Jonassen, 1999). Constructivists are also partial to learning in ill-structured domains rather than structured domains. Within structured domains, there are predefined correct solutions that the learner must work to solve but assumes no ownership of the problem (Jonassen, 1999). Within ill-structured domains, problems do not have specific goals or boundaries, guidance on what rules and principles should be applied for a solution, or general rules or principles to assist with determining an outcome. In addition, problems could contain none or many solutions, contain various ways of evaluating solutions, and require learners to support their solutions (Jonassen, 1999).

Constructivist learning environments are ill-structured domains used to support and promote the experience of meaning making and knowledge construction during learning. According to Huang (2002) constructivist learning environments should "provide real-world, case-based environments for meaningful and authentic knowledge" (p. 34). There are several guidelines describing the composition of a constructivist learning environment that focus on the role of the teacher, the student and the learning environment. In the teacher's role, the teacher should be expected to function as a coach or a guide for the learner (Honebein, 1996; Jonassen, 1999). In addition, the teacher should maintain the authentic context of the learning task by embedding learning in realistic and relevant contexts (Honebein, 1996). Jonassen (1999) adds that the teacher should model the desired performance of the activity to the learner and scaffold learning to support performance beyond what the learner is able to accomplish alone.

Honebein (1996) provides a set of guidelines, based on publications by Cunningham, Duffy and Nuth (1993) and Knuth and Cunningham (1993) that focus primarily on the role of learners:

- Learners should be allowed to assume responsibility for constructing their own knowledge by determining the topics to be learned, the methods for learning them and the problem-solving strategies.
- Learners must be able to engage in activities that will enable them to examine various solutions to problems for testing and enriching their understanding.
- Learners must play a lead role in identifying issues, directions, goals and even objectives.
- Learners should be encouraged to be socially interactive with other students and teachers.
- Learners should be expected to experiment with various types of media.
- Learners should be expected to explain their problem-solving processes on how they came to the conclusion that was reached.

Jonassen (1999) provides guidelines for a constructivist learning environment that focus more on the learning environment. The three integrated components of the learning environment include the problem context, the authentic problem representation or simulation, and the problem manipulation space. Next, a constructivist learning environment should have cognitive knowledge-constructing tools that will assist the learner with knowledge scaffolding. A constructivist learning environment should also support conversation among learners and contain collaboration tools that will support the learning community (Jonassen, 1999).

Designing authentic learning environments. Over the years various authors have derived similar guidelines as to how an authentic learning environment should be designed. Reeves, Herrington and Oliver (2002) assembled and summarized an extensive list of design guidelines that are commonly found throughout the literature and are briefly revisited here.

Real-world relevance. Real-world relevance is the primary design requirement for an authentic learning environment where activities must resemble tasks as much as possible that are performed by professionals in practice (Reeves et al., 2002). For a teacher to be able to guide a student to a level of expertise in a topic or field, the environment must support the teacher in engaging the student in realistic and complex authentic activity (Young, 1993). Newmann and Welhage (1993) discuss the importance of connectedness in an authentic learning environment stating that students should address real-world problems, and use personal experiences as a context for applying knowledge. The Cognition and Technology Group at Vanderbilt (1990) describes two levels of authenticity supporting the real-world design requirement which involve using objects and data in the learning environment that are directly related to the topic and involving the actual tasks that the students are asked to perform pertaining to the topic. These tasks could be contrived to fit the classroom provided that the activities do not lose their authentic characteristics. Tasks in an authentic learning environment may not be completely authentic but should be relative to the context in which it is applied (Cronin, 1993). It may not be feasible for learners to be exposed to a full range of conditions such as those found in a workplace. Learners could face challenges with safety; there could be insufficient opportunities to make corrections when an error occurs; plus the experience itself could prove to be expensive when something is mishandled (Resnick, 1987). By bridging apprenticeships that use simulated real-world work environments and specially designed social interactions, learners are given the opportunities to observe and practice in traditional ways (Resnick, 1987).

Ill-defined tasks. Authentic learning environments should be designed to be ill-defined, requiring students to define the tasks needed to complete the activity (Reeves et al., 2002). Given a task in an authentic learning environment, students should be able to find their own issues plus find the appropriate information required to address the issues (Cognition and Technology Group at Vanderbilt, 1990). Conditions of an authentic learning environment should also be ill-structured while problems presented in the environment should be ill-formulated and have unknown solutions (Lebow & Wager, 1994).

Flexible time on tasks. Serious intellectual activity cannot be limited to set blocks of classroom periods scheduled over a set number of days (Means & Olson, 1994). Therefore, authentic learning environments should be designed using complex tasks that students can investigate over an extended period of time (Reeves et al., 2002). Activities should be durable enough to allow learners the opportunity to engage in active and generative problem solving that involve personal values and beliefs (Lebow & Wager, 1994). This will encourage learners to be accountable for the activities and to engage in long-term purposeful learning.

Various perspectives and resources. Authentic activities should be designed in ways that allow students to examine tasks from different perspectives using various resources (Reeves et al., 2002). Authentic activities can be situated in one of two ways: either by allowing students to cover multiple topics using several distinct and separate resources, or by applying the macro-context approach which involves using one resource and digressing on the information obtained from that resource to cover multiple topics and perspectives (Young, 1993). Authentic activities should also be designed so various perspectives of a problem are addressed by students (Bransford, Vye, Kinzer, & Risko, 1990). This will allow students to produce multiple solutions that can be compared and contrasted to solutions from other students (Bransford, Vye et al., 1990).

Collaboration. Authentic learning environments should be designed with activities that support collaboration between students (Reeves et al., 2002). Petraglia (1998) considers collaboration to be a powerful tool to motivate learners and a crucial skill to have in the workforce. In a collaborative setting, students are allowed to (a) have considerable interaction about ideas of a topic, (b) articulate ideas to others that are not scripted or controlled, (c) have dialogue that build on ideas which help to promote improved understanding of a topic, (d) share their knowledge and skills while observing the learning processes and activities of others, and (e) address the various viewpoints of other learners (Newmann & Welhage, 1993; Petraglia, 1998). Similar to any real-life situation involving teams with experts in various complex domains, no one person contains all of the knowledge or can solve a problem alone (Young, 1993). Therefore, in order for students to succeed in solving real-world problems, students should have some exposure in working collaboratively on a team (Gordon, 1998).

Open to integration. Authentic learning environments should be designed so they can be integrated and applied across subject areas and domains (Reeves et al., 2002). These environments would avoid inert learning situations that provide students with relevant knowledge but renders them incapable of using it in other problem-solving contexts (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990). Rather than being subjected to arbitrary facts, these environments would also support students with transferring information learned in the classrooms to knowledge that can be applied in various situations (Bransford, Sherwood et al., 1990).

Integrated with assessment. Authentic learning environments should be designed to have activities seamlessly integrated with assessment (Reeves et al., 2002). Gulikers, Bastiaens and Kirschner (2004) refers to this as an authentic assessment, which is defined as "an assessment requiring students to use the same competencies, or combinations of knowledge, skills, and attitudes, that they need to apply in the criterion situation in professional life" (p. 69). The benefits of authentic assessment is that the locus of control rests with the student giving the student authority to determine the topic, time allocated to work on the assignment, control on the pace of the assignment, and control of the conditions under which the assignment is produced (Meyer, 1992). Young (1995) proposes three ways of supporting assessments in authentic learning environments: (a) assessments should emphasize the learning process as well as the product being learned; (b) assessments should support the complex, unpredictable and spontaneously chaotic characteristics of real learning opportunities; and (c) rather than answering routine multiple choice questions and being expected to be able to recall factual knowledge, technologies should be implemented to expose learners to rich, problem-solving, situated learning environments that parallel the real world.

Polished products. Authentic activities should be designed to create polished products that will not only allow students to obtain a grade but will also allow students to apply the products for what they were actually created for (Reeves et al., 2002; Means & Olsen, 1994). Within an authentic learning environment, students should be able to take products that they create, exhibit them publicly to subject matter experts and benchmark them against real life standards of quality (Gordon, 1998). Three models were developed in support of this design requirement. Radinsky et al. (1998) defined the simulation and the participation models. The simulation model posits that classroom activity should be created as similar to communities of practice outside of school as possible. The participation model is based on the assumption that the authenticity of an activity depends on the extent to which learners engage in the authentic practices as part of a community. Barab, Squire and Dueber (2000) developed the co-evolutionary model that boasts having greater benefits than the other two models. The co-evolutionary model limits the risk of facilitating the development of inert and impractical knowledge by having teachers learn in the environment in which the learning is to be applied, limiting physical space and time constraints, and assisting teachers in engaging in the types of practices or use the technologies that are desired for the students to learn.

Competition and diversity. Finally, authentic learning environments should be designed to allow competing solutions and diversity of outcome (Reeves et al., 2002). Debate and discourse is encouraged in an authentic learning environment because discourse enables students to build and validate hypotheses while debate provides students with opportunities to view knowledge and information from various perspectives (Nicaise et al., 2000).

Concerns with authentic learning environments. There are some concerns with designing or using authentic learning environments. One debated topic involves the resources required in relation to developing these environments. Linn, Baker and Dunbar (1991) caution that when designing authentic assessments, the level of detail required in developing efficient data collection designs and scoring procedures may prove to be expensive. On the other hand, Cronin (1993) believes that developing original, creative and fun authentic learning solutions can be accomplished without taking significant time, energy and resources to implement.

Another concern initially expressed by Petraglia (1998) and reiterated by various authors (Barab et al., 2000; Gulikers et al., 2005; Herrington, Oliver & Reeves, 2002) is the challenge with Preauthentication. Preauthentication is defined as "the educational practice whereby "authentic" learning technologies, environments, or pedagogies are devised prior to, and independent of, a learner and a specific learning context" (p. 198). In preauthentication, students are "presented with environments and specific tasks predetermined to correspond to tasks as they exist in the real world" (p. 11). The problem is that if a student does not perceive the learning as authentic, it will not be. There must be some effort to persuade the students that the learning is meaningful to them or the purpose of using an authentic learning environment is lost. In order to ensure that meaningfulness is attained, students should have ownership of their learning, the learning should be part of a bigger picture and students must be encouraged to generate multiple perspectives within a learning task (Petraglia, 1998).

There are some other precautions to consider when creating authentic assessments. The first item is to ensure that a student's performance is directly examined based on meaningful, intellectual tasks and problems that provide worthwhile experiences (Linn et al., 1991; Wiggens, 1990). Next, Wiggens (1990) states that students should be challenged to create well-rounded responses rather than be provided with correct responses to questions without reasoning. Linn et al. (1991) agree but raise concern with students memorizing solutions to standard features in an assessment without understanding or developing the expected problem-solving skills. Wiggens, (1990) also believes that it is safe to assume that criteria are standardized when authentic products are rated. However, there could actually be challenges in reducing biases against minorities such as finding tasks appropriate for various cultures, fairly scoring students' responses, and finding time and money to review topics to address various cultures (Linn et al., 1991). Next is the issue of generalizability. In an authentic assessment, it is important to consider how accurately the results of authentic assessments reflect actual student achievement (Linn et al., 1991). Also, Reeves and Okey (1996) believe that the knowledge and skills acquired by students in an authentic assessment cannot always be generalized to other contexts nor does an authentic assessment allow for accurate comparisons between students. Finally, gaps in coverage in an authentic assessment can result in reducing the importance of the information, misleading high scores, and a distorted view of the instruction (Linn et al., 1991).

Applications of authentic learning environments. The context in which authentic learning environments have been applied occurs in various educational settings for various reasons. In the field of nursing, authentic learning environments have been used to build competency skills, improve techniques in diagnosing illnesses, and teach proper care for patients and for the elderly (Edwards et al., 2008; Reilly & Spratt, 2006; Woolley & Jarvis, 2006). The field of law is also taking advantage of using authentic learning for more real life settings as opposed to the traditional textbook approach (Barton, McKellar & Maharg, 2007; Martens, Bastiaens & Kirschner, 2007). In the field of medicine, authentic learning environments are being used to construct medical cases for medical students (Garde et al., 2007). Finally, in the sciences authentic learning environments are being used to teach bioprocess engineering to chemical and agricultural engineering students (Sessink, van der Schaaf, Beeftink, Hartog & Tramper, 2006).

Technological trends. The current trend in developing authentic learning environments is to use technologies that can give students the most realistic experience in the topic that they are studying. The most common technologies used in the literature included web-based technologies, multimedia environments and fully functional simulations. Web-based technologies were used in the Learning Materials, Quality Aged Care and the Constructivist e-Learning Environment studies (Edwards et al., 2008; Martens et al., 2007; Sessink et al., 2006).

Multimedia environments that are not hosted on a web-based environment were also common in a number of studies. CAMPUS, a computer-based training course, is an application that is installable from a CD-Rom (Garde et al., 2007). Buiten Dienst, VitalSim, the Preservice Learning Environment and Ardcallough are all multimedia environments used to teach students in general education, nursing, K-12 education and law respectively (Barton et al., 2007; Gulikers, et al., 2005; Herrington & Oliver, 2000; Reilly & Spratt, 2006). These multimedia environments that are physically hosted on computers use a number of electronic media and techniques such as audio, video, pictures and interactivity techniques including the ability to send and receive email, request and response scenarios and problem-solving opportunities.

The one fully functional authentic learning environment, Clinical Practice Suite, is a simulation where students physically learned in an environment that resembles a real-life hospital setting (Woolley & Jarvis, 2006). The setting contains wards used to represent various clinical scenarios, it operates using closed circuit television, videos, microphones for communication to staff overseeing the students and it contains a comprehensive library of digital learning materials.

Theories applied in authentic learning environments. A common trait in many of the authentic learning environments was that each environment was based on a constructivist approach or was based on the design requirements commonly found in authentic learning. A summary of the constructivist characteristics that were applied in some of the studies is provided in Table 1.

Table 1

Constructivist Characteristics Used in Authentic Learning Environments

Author	Environment	Characteristic
(Martens et al., 2007)	Constructivist e-Learning Environment: 10-point constructivist educational design model	Learner control over content and sequence Learner control over learning strategy Top down organization Content in context Discovery Zone of proximal development Authentic activity Articulation and discussion Meta-cognitive strategies Intrinsic motivation
(Woolley & Jarvis, 2006)	Clinical Practice Suite: constructivist learning environment (Jonassen, 1991)	Modeling Coaching Scaffolding Articulation Reflection Exploration
(Barton et al., 2007)	Ardcallough: General traits of constructivism	Authentic problem-solving opportunities Open or ill-structured problems The ability to construct knowledge Embedding the problem in the context of social negotiation

Authentic learning characteristics. Earlier studies by Gulikers et al., (2005) and Herrington and Oliver (2000) both used characteristics based on the work completed by Herrington and Oliver (2000), which then used the term “situated learning environments” to describe what is known today as authentic learning environments. The characteristics in a situated learning environment include authentic context, authentic activity, multiple perspectives, expert performances, collaboration, reflection, articulation, coaching and scaffolding, and authentic assessment. These characteristics slightly differ from the current list of characteristics that is now used to describe authentic learning environments (Reeves, Herrington & Oliver, 2002). Recent studies used elements taken from the more recently defined characteristics of authentic learning environments. The authentic learning characteristics used in the Quality Aged Care environment involved facilitating the application of aged care theory to practice through authentic learning situations that simulate practice, encourage the development of professional competencies and generic capabilities, and promote flexibility in teaching and learning for both nursing students and staff (Edwards et al., 2008). In addition to being based on four constructivist learning traits, Ardcallough also uses a learning model called transactional learning that is used to develop task authenticity and is based off of legal transactions commonly found in law (Barton et al., 2007). The transactional learning characteristics, which are also subsets of the authentic learning characteristics, include active learning, real life legal transactions, reflection, collaborative learning, holistic learning, professional role-play, and task authenticity. The Learning Materials guidelines consisted of authentic learning characteristics such as student activation, authentic contexts and tasks, modularly designed materials, personalized support and the use of motivating materials (Sessink et al., 2006). Finally, in addition to having ties to Bloom's Taxonomy, the CAMPUS authentic environment is based on a set of principles called practice fields that mirror many of the characteristics found in authentic learning environments (Garde et al., 2007). Practice fields principles include active engagement in domain-related practices, ownership of the dilemma and development of a resolution, reflection of actions and decisions, engagement in ill-defined dilemmas, motivating context, a collaborative and social working environment, coaching and problem-solving support, and a learning environment that supports real world complex thinking and tasks (Barab & Duffy, 2000).

Student interactions. CAMPUS is a computer-based training (CBT) application that constructs medical cases for medical students in training. Out of 218 participants that participated in the CAMPUS study, 80.7% of participants reportedly liked learning with CAMPUS, 72% stated that learning with CAMPUS is effective and 73.5% said that learning with CAMPUS was motivating for further learning (Garde et al., 2007).

Quality Aged Care is a web-based application used to teach nursing school students how to work effectively with older people, which addresses the concern of the rapid increase of the elderly in the world. In the study conducted for Quality Aged Care a relatively small sample size of 42 was used. Most of the survey ratings scored between 4 and 5 on a scale of 1 to 5 with 5 being the highest score (Edwards et al., 2008). Nineteen questions were included in this survey that focused on usability, likability, interactivity, navigability and relativity.

Buiten Dienst is an electronic virtual learning environment where students are given the role of junior advisor of a consultancy agency. The job of the junior advisor is to address the problem of a high sick-rate in a bus company. In the qualitative portion of the Buiten Dienst study, a test involving six variables resulted in no significant difference between a comparison of the authentic and non-authentic environment used to address the same learning problem (Gulikers, Bastiaens, et al., 2005). The six variables that were tested included perceived authenticity, motivation, innovation, support, extent of confusion, and explorative behavior.

The Constructivist e-Learning Environment (CEE) is a web-based e-learning environment used by post-graduate law students whose purpose is to examine problems with the principles used by educational developers of the CEE and determine whether tasks designed in a CEE are perceived as being authentic, interesting or challenging. The CEE study reports that the students scored the study lower than the developers of the environment (Martens et al., 2007). Results taken from eleven variables showed that the environment was not perceived as authentic to the students nor did the students appreciate role-play as much as the developers had expected.

The VitalSim environment is a high-fidelity simulation-based learning product used to teach undergraduate nursing students how to diagnose illnesses and care for patients (Reilly & Spratt, 2006). VitalSim reported an overall favorable rating in a qualitative study stating that the simulation encouraged thinking, motivated learning and was realistic. It also increased students' confidence and provided a better experience than a classroom setting (Reilly & Spratt, 2006).

The Preservice Learning Environment is a multimedia-based situated learning instructional design model that assists pre-service teachers with developing assessment strategies for mathematics classrooms (Herrington & Oliver, 2000). The study conducted for the Preservice Learning Environment used qualitative analysis techniques to measure how well the environment and the outcome of the environment match the expectations of an authentic learning environment. The results showed that the majority of students realized the importance in collaboration, hearing multiple perspectives, integrated assessment, significant time on task and the creation of polished products. There was some apprehension while working on the ill-defined tasks although overall students seem to respond well to the assignment (Herrington & Oliver, 2000).

Ardcallough is a simulation environment primarily used in a one-year course for the attainment of the Diploma in Legal Practice (Barton et al., 2007). Its purpose is to teach graduate students who desire to become legal solicitors or advocates in Scotland. In the Ardcallough study, although the training was criticized for being too short, students positively assessed the environment stating that it can produce transactional learning, enrich the overall learning experience and provide a useful and fair assessment of learning (Barton et al., 2007).

Learning Materials (LM) is a web-based learning environment used to teach bioprocess engineering to undergraduate students (Sessink et al., 2006). For this study, limited qualitative or quantitative data were provided although the researchers reported positive results. Students rated the usefulness of the materials at a 3.9 on a 1 to 5 scale. The students also described the environment as both challenging and fun, quickly learned from their initial designs and would continuously look to improve them, and were self-motivated enough to optimize their designs in order to compete with other students (Sessink et al., 2006).

The number of quantitative studies that actually document how well authentic learning environments improve knowledge acquisition is limited. In the quantitative portion of the Buiten Dienst study, the multiple-choice comprehensive exam resulted in no significant difference between a comparison of the authentic and non-authentic environment used to accomplish the same learning goal (Gulikers et al., 2005).

Computational Thinking

Researchers have implemented computational thinking strategies in various forms since the creation of the term in 2006 and have even introduced computational thinking like solutions prior to then. The purpose of this section is to review how researchers have accomplished this using teaching strategies, technology-based solutions and curriculum strategies. Some examples include research that was not labeled computational thinking but were based on similar characteristics of the skill.

Computational thinking teaching strategies. The Computational Thinking Language (CTL) is a teaching strategy that includes a vocabulary, a notation, and techniques in revisiting, advancing and integrating computational concepts (Lu & Fletcher, 2009). The objective of the

CTL is to introduce a common language that can be used to annotate and describe computation and abstraction, suggest information and execution, and provide notation around which semantic understanding of computational processes can be understood. A series of examples were provided that displayed ways in which computational thinking could be integrated into primary and secondary curricula.

The Renaissance Computing teaching strategy gives students the opportunities to apply computational thinking skills to various disciplines, allows training outside of computer science, provides interdisciplinary problem-solving and collaborative learning skills, and can assist instructors with developing meaningful and engaging authentic applications for non-computer science majors (Soh et al., 2009). This strategy is used to prepare students for the challenges presented by any one computational domain by exposing the students to multiple domains where computational thinking plays a predominant role. The authors concluded with discussing plans for teacher training workshops and pilot classes to be implemented over the next school year.

Problem-solving models were used as a teaching strategy designed to promote inquiry-based education in a multidisciplinary setting (Pulimood & Wolz, 2008). These models were implemented as teaching strategies that included the promotion of collaborative problem solving in a traditional computer science content focused course, a multidisciplinary course with highly personalized learning goals, and trans-disciplinary collaboration between distinct courses with on-demand content shared across disciplines. These models were also applied within an authentic learning approach where students were responsible for solving real-life problems in collaboration with their peers. Students were participative in the traditional computer science course in concocting real-world projects that both met a real need and were multidisciplinary. In the multidisciplinary courses, 90% of students achieved a grade of 85 while 87% of students viewed the class as valuable. In the trans-disciplinary courses, however, students complained about the lack of participation from the students in the partnered course plus students did not appreciate the expertise from students that were not from their disciplines.

Technology-based solutions. Some researchers have attempted to implement computational thinking strategies by using some type of computer technology-based solution. Three of the solutions that have been implemented include installed computer application and web-based solutions. Escape Machine is a computer application based on a puzzle game built using a hub-and-strut construction kit called Posey that is used to provide a platform for play to teach a powerful and common abstraction technique called a state machine (Weller, Do & Gross, 2008). The purpose of Escape Machine is to teach concepts in computational thinking, using objects-to-think-computationally-with, to K-12 students using tools that are both economically feasible and commonly used in classrooms. In a pilot study conducted with university students, the students found the application fun, intriguing, engaging and enjoyed playing the game within a collaborative setting (Weller et al., 2008).

BLASTed was implemented as an educational website to introduce biology, computer science and mathematics students to its parent tool called the Basic Local Alignment Search Tool (BLAST) (Adams, Matheson & Pruim, 2008). BLASTed introduces important issues in computational thinking to biology students by providing the relevant background information on genetics and algorithms. As a result of developing BLASTed the researchers pointed out the importance of teamwork among faculty members when developing interdisciplinary materials, recognized that biology is no longer a math-free zone, and emphasized the time and hard work that is required to implement effective interdisciplinary teaching (Adams, et al., 2008).

Bowling Green State University (BGSU) is one example where computational thinking techniques were considered prior to the term computational thinking coming about. Researchers at BGSU proposed using a computer application called TERA to implement an interdisciplinary approach called visual analysis, which is used to teach visual literacy to computer science and art students (Eber & Wolfe, 2000). Visual analysis is a process used to discover visual cues in an image and identify the algorithms associated with the cues. As a result of using this tool, students were able to better understand how their choices of images impacted the perception of their work plus they were more capable of describing their work using formal analysis.

Curriculum solutions. Other researchers in the field have attempted to implement computational thinking solutions as either courses or majors within college curricula. Researchers at Franklin and Marshall College implemented computational science as a major within the college of liberal arts (Adams, 2008). The idea behind this approach was to create opportunities for extending the field of computer science while simultaneously embracing the concept of interdisciplinary study that is a trademark of the liberal arts. The major was designed with two specific tracks that a student would take: a general requirements track that contained the fundamental computer science courses and the student's chosen track which could be one of any seven disciplines that the program supports such as bioinformatics or computational physics (Adams, 2008).

Carnegie Mellon developed a course that focuses on understanding the power of computing rather than programming by using a flowchart and simulation tool called Raptor (Cortina, 2007). The course was designed with ten specific computational topics where students used the Raptor tool for algorithm assignments to examine how computations work and to experiment with various algorithms to study the process of computation. This study resulted in a 200% increase in registration over three courses. In addition, although the grades were slightly lower in the computational course in comparison to the programming course taught by the same professor, students found the computational course more interesting and expressed that it should remain as part of the program (Cortina, 2007).

Faculty members from Purdue University developed a course on computational thinking for science majors. This course uses a problem-driven approach with a focus on scientific discovery through computational methods, which are grounded in computer science principles (Hambrusch et al., 2009). The course was developed based on five principles: (a) lay the groundwork for computational thinking; (b) present relative examples in a language familiar to the students; (c) teach in a problem-driven and meaningful way; (d) ensure that the programming language focuses on computational thinking and not on programming; and (e) make effective use of visualization. The results of an entry and exit survey taken before and after the course displayed an increase in the students' desire to take another computer science course and pursue a career that requires programming skills (Hambrusch et al., 2009).

As previously mentioned, some educators realized the importance of teaching computational thinking skills to students that are not computer science majors before the term computational thinking was publicized. In 2005, educators from Georgia Technological University published how it successfully implemented two alternative introductory computing courses to be taken first that focused on data structures and algorithms that were developed for computer science students, engineering and liberal arts students, management and architecture students, and a subsequent course that focused on object orientation (Tew, McCracken & Guzdial, 2005). The results of a pretest and posttest study showed a significant increase in learning where an average of 62% of the students answered the introductory multiple-choice questions correctly while an average of 65% of the students answered the advanced multiple-choice questions correctly (Tew et al., 2005). Educators from Trinity University used a simple programming language called Scheme within a laboratory science course and a computer science topics course to teach liberal arts students the structure of algorithms and abstraction techniques (Konstam & Howland, 1999). A pilot study conducted for this research showed that students' apprehension towards computers and programming reduced dramatically by the end of the course.

Authentic Learning, Computational Thinking and Technology

This section describes why technology is important in authentic learning and why authentic learning is a suitable strategy to use to teach computational thinking. Means and Olson (1994) state that technology used in authentic learning help teachers view complex assignments as feasible and capable of being produced plus provide access to content areas and inquiries. The benefit is that these opportunities allow teachers to offer students experiences that would likely be inaccessible until later in an academic career and can extend and enhance what students are able to produce. Technology also portrays school tasks as authentic by making schoolwork appear real and important and allow teachers the opportunities to become learners again. Technology can be applied to expose learners to rich, problem-solving, situated learning environments that represent the real world (Young, 1995). According to the National Institute of Literacy, web enthusiasts believe that the latest in technology, such as PDA's, interactive web 2.0 platforms and the convergence of media, not only creates opportunities for a new audience but provides much needed authentic learning activities as well (Silver-Pacuilla & Reder, 2008).

In an authentic learning environment, technology can be used to support both the learner and the learning tasks. Technology supports the learner by connecting the learner with other learners, tutors and teachers; providing access to resources; providing organizing means for learning and support materials; and functioning as a coach to the learner by pointing out problem areas and helping the learner complete the assigned tasks (Herrington, Reeves & Oliver, 2006; Petraglia, 1998). Technology supports the learning tasks by providing access to rich, real-world resources, enabling communications regarding research and inquiry, and providing tools to build the products that represent solutions to tasks (Herrington, Reeves, et al., 2006). Bastiaens and Martens (2000) assert that learning in schools and universities is converging with work that occurs in a professional environment. With the continued advancements in technology, the differences in learning between educational institutions and companies continue to shrink. Technology provides an environment where students can practice real cases composed of authentic activities, allowing them to explore real problems, view problems from various perspectives, and attempt to generate responses to the problems (Bastiaens & Martens, 2000).

Researchers and practitioners in the fields of both computer science and education have stated their support for computational thinking and persistently urge broadening its base. Although many of them have provided numerous benefits of computational thinking and support the relevancy of teaching this skill across multiple disciplines (Guzdial, 2008; Nahapetian, 2011; Qualls & Sherrell, 2010; Topi, 2008; Wing, 2006), there are a corresponding number of challenges educators face with teaching this skill set in the classroom. The primary challenge in computational thinking involves finding ways to show students the relevancy of the topic (Good, Romero, du Boulay, Reid, Howland & Robertson, 2008). Guzdial (2008) also discussed the importance of teaching computation to students that makes sense to them for their respective disciplines. The main characteristic of authentic learning that could address this challenge is that it is based on relevancy and real-world learning activities (Cognition and Technology Group at Vanderbilt, 1990; Newmann & Welhage, 1993; Reeves et al., 2002; Young, 1993).

In addition to relevancy, another challenge involves motivating students to participate in computational thinking activities (Good et al., 2008). One way to motivate students is to show them relevancy in what they are learning. Although motivation is not greatly emphasized as an expectation of authentic learning, a number of the studies conducted tested motivation as a variable with positive results when using authentic learning (Garde et al., 2007; Reilly & Spratt, 2006). Finding tools that will make computational thinking accessible is an additional challenge (Guzdial, 2008). In an authentic learning environment, technological advances in computer applications, web-based technologies and simulations can be extended to various disciplines and can be made accessible to a wide audience (Barton et al., 2007; Edwards et al., 2008; Gulikers, Bastiaens et al., 2005; Herrington & Oliver, 2000; Martens et al., 2007; Reilly & Spratt, 2006; Sessink et al., 2006).

Summary

This literature review began with a discussion on constructivism, the theoretical foundation for authentic learning. The importance of authentic learning is clearly stated as a key characteristic of constructivist learning. I continued the discussion by defining authentic learning in detail, its characteristics, and challenges, and reviewing some of the authentic learning environments in the literature that have been successfully implemented. There were both positive and not so positive outcomes with the authentic learning environments; however, there was never any indication by any author that the practice of authentic learning should be abandoned. Next, I summarized the importance of computational thinking as stated by experts in the field of computer science along with a review of some of the computational thinking initiatives that have been published in the literature. The researchers’ reviews agree that computational thinking is a skill that is seriously lacking in society and is important for everyone regardless of their discipline. In addition, although there may be some challenges with teaching computational thinking, it can be done and the research required to support the practice is desperately needed.

Chapter three describes the methodology section of this study. The chapter will being by describing in detail how I designed and developed the authentic learning tool. This will be followed by a description of the methods I took to conduct expert reviews with information technology professionals. The chapter will conclude by describing the procedures that I applied to conduct a study on the effectiveness of using the authentic learning tool to teach computational thinking to undergraduate computer literacy students from Wayne State University, Detroit, Michigan.

CHAPTER 3 METHODOLOGY

This is a design and development research study for tool development and use. Design and development research is defined as "the systematic study of design, development and evaluation processes with the aim of establishing an empirical basis for the creation of instructional products and tools and new or enhanced models that govern their development" (Richey & Klein, 2007, p. 1). This study focused on the effectiveness and usability of a prototype of an authentic learning tool that was created to help computer literacy students acquire knowledge and develop a motivation for computational thinking. The research design was a double-blind true control group pretest-posttest study and motivation assessment (Fitz-Gibbon & Morris, 1987; Stolberg, 2006).

There were two research questions investigated as part of this study:

1. What are the effects of using an authentic learning tool to teach computational thinking on the knowledge acquisition of undergraduate computer literacy students?
2. What are the effects of using an authentic learning tool to teach computational thinking on the motivation of undergraduate computer literacy students?

The methodology section describes the following in detail: (a) the design, development and assessment procedures for the experimental group instructional intervention; (b) the selection of the control group instructional intervention; (c) the research participants; (d) the instrumentation applied; (e) the research procedures; and (f) the data analysis procedures. The Wayne State University Instructional Review Board (IRB) was consulted to review the proposal for performing this study with the students along with all accompanying documentation, letters and instruments.

Instructional Interventions

Two instructional interventions were used in this study; a tool called COTHAULE (pronounced kō′ – thôl) that was provided to an experimental group and a set of online learning materials that was provided to a control group. The following sections describe how COTHAULE was designed, developed and tested and how the online learning materials were selected.

COTHAULE instructional intervention. The authentic learning tool being described is called COTHAULE which is an acronym that stands for Computational Thinking Authentic Learning Environment. I completed the entire design, development and self-assessment process for the COTHAULE tool in twenty-four months between June 2010 and June 2012. I followed specific steps to analyze and design COTHAULE and to compile the learning materials incorporated within the tool. The intellection behind COTHAULE was to take every-day experiences that could pertain to life in a college campus environment and merge them with computational thinking concepts and the learning objectives of a common computer literacy course. Although, the literature commonly proponed that authentic learning environments are designed to contain a professional real-life experience (Gulikers et al., 2004; Gulikers et al., 2005; Herrington & Oliver, 2000; Newmann & Welhage, 1993; Reeves et al., 2002), the campus-life experience was selected to refrain from isolating students' interest by selecting one profession over another. For example, selecting psychology as the real-life experience could have disinterested students who participated in the study who are not psychology majors.

COTHAULE design procedures. There were three primary steps I used during the design phase of COTHAULE. The case study development step was used to create the learning materials that would reside within the COTHAULE application. The storyboarding step was used to design the layout of the screens in COTHAULE (Lee & Owens, 2004). The database schema design step was used to design the database that the COTHAULE website would connect to in order to transmit the user information and learning materials.

COTHAULE case study development. I reviewed college level computer literacy books to obtain examples and problems that could be repurposed as computational thinking problems. The computer literacy book (Morrison & Wells, 2010) covered such topics as managing the computer, software fundamentals, understanding the operating system and fundamentals of Microsoft Office products. Specific to the three most common Microsoft Office products; Word, Excel and PowerPoint, the book contained guidelines on topics such as creating, sorting and searching tables, creating functions to perform calculations and generating graphs. The extracted information was consolidated to create case studies that were interwoven with computational thinking concepts. The case studies were based upon common problems faced by college students such as obtaining financial aid, purchasing a computer, generating extra income, living in resident housing and facing challenging class assignments.

I also consulted computer science books as needed to assist in the development of the computational thinking concepts. Two computer science books from Levitin (2007) and Wang (2007) and a presentation called SQL Basics that was used by the control group (US Environmental Protection Agency, 2005) were reviewed to derive the computational thinking learning content. SQL is an acronym that stands for Standard Query Language. The Levitin (2007) book was used to obtain information on algorithms, the Wang (2007) book was used to obtain information on basic object-oriented concepts and the SQL Basics (2008) presentation contained information on creating basic SQL statements. The Levitin (2007) book provided examples of various types of sorting, searching, swapping, tree traversal, and recursion algorithms, knapsack problems, graphs, arrays, stacks, queues and basic algorithm creation. The Wang (2007) book was consulted for object-oriented class creation and definition, object creation and understanding basic object-oriented concepts such as encapsulation, inheritance and polymorphism. The SQL Basics presentation described how to perform basic steps on inserting, updating and selecting data from tables.

Each case study contained seven scenarios that when read in sequence, flowed like a conversation taking place between two students. The conversations were based on real-life activities commonly experienced by college students. Each scenario was succeeded by one of two types of computational thinking problem-solving activities. The first type of activity required the end-user to respond by solving the problem and either selecting from one of four multiple choice answers or filling in a blank. For the second type of activity, the problem solving was similar to the first type of activity but also requires the end-user to complete a real-life task using one or more of the artifacts studied in computer literacy. For example, this could involve opening a Word document and challenging the end-user to write an equation that would calculate the average of a set of numbers in a table. The end-user would then take the learning experience from this activity and answer a corresponding computational thinking problem that relates to algorithms. It could also involve having the end-user open an Excel document to perform a complex data filtering activity to determine the contents of the table after the filter is applied. Then, based on the learning experience, the end-user would then answer a corresponding computational thinking problem that involves performing a searching algorithm in a table. A copy of all five case studies is provided in Appendix A while a copy of some of the authentic learning tasks are provided in Appendix B.

COTHAULE storyboarding. A storyboard is a graphical mockup of what the computer-based application or website would look like and how information flows from screen to screen (Lee & Owens, 2004). For this study, I used an Excel spreadsheet to create the storyboards for COTHAULE. This is a common process used by website developers where borders, shading and characters are used within Excel to draw out the proposed website screens. The importance of the storyboard process was to help me think through the layout of the screens prior to spending significant amount of time developing them. The storyboards I created for this study provides the layout of the screens and how each screen interacts with other screens within COTHAULE. It specifically shows where the following would be placed on the website: (a) the case study tabs; (b) the video screen; (c) the problem description; (d) the question for the end user to solve; (e) the link to the authentic learning activity; (f) the answer section; and (g) the website pagination. There are two storyboards shown in Appendix C displaying how the website would interface to the end-user if the question was a multiple choice problem and how it would interface to the end-user for a fill-in-the-blank question.

COTHAULE database schema. The Webhostinghub website hosting service contained the MySQL database administration software components along with all tools required to host the website. I used the MySQL Workbench software to create the database schema which is the logical design of the database that COTHAULE interfaces to. The schema contains the layout of eight tables that are divided into two sections: the user activity section and the learning activity section. Each table layout contains (a) the name of the fields within the table, (b) the field types, (c) and the field lengths. The database is used to store limited user information, manage the learning materials within COTHAULE and process information entered into COTHAULE by the end user. A brief description of each table is as follows:

1. The userregtbl table is used to capture the end-user's information when registering to use

the website. This is a prerequisite to use COTHAULE.

2. The userlogintbl table is used to capture how often the end-user logs into the COTHAULE website and whether or not the end-user was successful. To prevent hackers from running scripts to flood the database with random login requests, the database was designed to lock the end-user after six attempts. The end-user would have to reset the password on the user administration screen within COTHAULE before trying to log in again.
3. The userscoretbl table is used to determine whether the end-user answered the question correctly the first time and track whether the system is returning the correct answer.
4. The useractivitytbl table is used to track how many times an end-user attempted each question.
5. The showprobtbl table is used to hold all of the problem descriptions stored within COTHAULE and display the problem description on the website for each scenario.
6. The showanstbl table is used to hold all of the answers stored within COTHAULE and display the appropriate answer on the website for each scenario.
7. The solveprobtbl table is used to hold all of the options for the end-user to select from or the specific fill-in problem for the end-user to complete.
8. The showflvcntl table is used to display the video clip on the website for each scenario.

Appropriate keys and indexing were used in each table to maintain relationships to other tables. A copy of the COTHAULE Database Schema can be reviewed in Appendix D.

COTHAULE development. After designing the COTHAULE tool, I applied a number of software products to develop the tool. The development process took place between September 2010 and November 2011. The primary objective behind the development of this tool was to make it accessible on the Internet and fully independent for the students to use. In an optimal solution, teacher intervention would not be required for students to operate the tool and all applicable learning artifacts would reside within the tool (Honebein, 1996; Jonassen, 1999). For example, to adhere to the learning objective of becoming proficient in Microsoft Excel, the tool would incorporate authentic learning experiences involving the use of Microsoft Excel within the tool itself. The actual steps I took to develop COTHAULE are as follows:

1. A WAMP server was configured to host the test environment for the application. WAMP stands for Windows, Apache Server, MySQL and PHP which were the major components required to build and run an interactive Flash application. The test environment was used to complete all of the development and testing for COTHAULE prior to it being placed on the Internet.
2. MySQL was used to develop the physical database based on the database design schema created using MySQL Workbench during the design phase of the tool. The database is comprised of the same eight tables that were designed in the database schema design process.
3. The Adobe Flash software was used to develop the application frame and corresponding components that comprise the general makeup of COTHAULE. ActionScript 3, the scripting code for Adobe Flash, was used as the source code to control how the tool functions. Source code development involved writing code that controlled (a) how the animation movies operated; (b) how the data appeared in each of the textboxes; (c) how the buttons functioned when they were clicked; and (d) how the data were passed between the user, the COTHAULE website and the database. When the development is complete, the source code is compiled into a Shockwave Flash (SWF) file that is hosted

in an HTML container which makes it viewable from the Internet.

4. The Dreamweaver website design software was used to create the HTML container that would host the tool. The container was developed using HTML and contains an object identifier that references the SWF file produced using the Adobe Flash software.
5. Dreamweaver was also used as the scripting tool to create PHP scripts. PHP, which stands for PHP Hypertext Protocol, is a server side scripting language that is used to control the data passed back and forth between the Flash application and the database. PHP is also used to apply error logic between the Flash application and the database to handle invalid, missing or duplicate data. Based on an error input by the user, the code would respond with the appropriate error message. For example, if the user enters a user identifier and not a password, the system would return the appropriate error message to the user.
6. 3-Dimensional graphics that were compatible with the 3DS Max Animation software were purchased from two software vendors; AXYZ Design and TurboSquid. The graphics selected were those that could be used in campus settings such as furniture for a dorm room, a school office, a library or a cafeteria. The graphics selected also included human avatars which are graphical representations of people. For this study, the avatars selected looked and were dressed like students in a college campus setting. The avatars are purchased in T-Pose where the arms are extended horizontally so the outline of the body displays the shape of a T.
7. The 3DS Max Animation software was used to animate the graphics that were purchased and convert those graphics to an Alice readable format called Adobe Swatch Exchange (ASE). Animating the graphics involved adding bendability to the limbs (elbows, knees,

shoulders, etc.) of the avatars so they could move and bend emulating the limbs of human beings. This software was also used to convert the graphics to ASE format which is recognizable using the Alice software.

8. The Alice software was used to create the movie scenarios that are found within each case study. Alice is an open source software package developed by engineers from Carnegie Mellon that is used as a teaching tool to teach students object-oriented programming techniques while creating 3-diminsional animated movies. The furniture and avatars are all imported into Alice in the ASE format and put in place to create an Alice scene. Then Alice code is entered to have the avatars interact with each other and actually utilize the furniture and settings within the scenes.
9. The Natural Reader software was used to add voices to the avatars in the Alice movies. This software allows a user to type in a sentence and converts the sentence to a Movie Pictures Expert Group (MPEG) audio file. These MPEG files were imported into the Alice movies and used to provide voices to the characters in the movies. The voices were matched up to the gender of the avatar. At the appropriate times, the Alice code would play the MPEG file so it would appear as if a character was actually talking.
10. Although the user can record movies using the Alice software, the software is not conducive to recording movies with multiple audio files. When multiple sound files are embedded within an Alice movie, the quality diminishes significantly when recorded. The ZD Soft Screen Recorder software was used instead to record the completed animation movie created in Alice to a movie file. From the desktop, the Alice clip was run with the sound included and recorded using the screen recorder software.
11. The Adobe Media Encoder software was used to convert the movie clip that was

produced using the ZD Soft Screen Recorder software into a Video for Flash (FLV) compatible file. The FLV file compatibility allows the video to be played within the Flash application and other Adobe products. The video clips were hosted on YouTube.

12. Other documents produced using Microsoft Office products such as Word, Excel, PowerPoint and Access were stored within the Webhostinghub library and made accessible by placing links on the webpage of the tool. This allowed the user the ability to download the documents whenever required by the given scenario.
13. Finally, using the Webhostinghub website hosting service, COTHAULE was hosted on an external website located at https://www.cothaule.com. It also uses an encryption protocol of 128 bits in order to secure the website from hackers and vulnerability attacks.

A sample screenshot of the COTHAULE prototype is shown in Figure 1 while more screenshots are available for viewing in Appendix E.

Figure 1. Screenshot of the COTHAULE prototype.

COTHAULE testing procedures. I conducted two types of tests to ensure

COTHAULE's functionality and usability. Functionality testing was done to ensure that COTHAULE functioned, operated and performed as expected while usability testing was done to measure how well it met the expectations of the instructional design guidelines described in Lee and Owens (2004).

Functionality Testing. I developed the COTHAULE Test Case Spreadsheet as an instrument to track functionality tests performed on the tool. The spreadsheet contained 138 specific tests that examined the tool for errors, error handling techniques, technical anomalies, functionality, performance and consistency. The spreadsheet captured (a) the test case name, (b) the date the test was executed, (c) a description of the test, (d) the data used for the test, (e) the expected results, (f) the actual results, and (g) the status showing whether the test passed or failed. A sample of the test case spreadsheet is provided in Appendix F.

The COTHAULE Test Case Spreadsheet with 105 test cases. It was updated during testing to include 33 additional ones bringing the total number of test cases to 138. The rationale for the expansion was due to additional findings within COTHAULE as it was being tested that warranted new cases to include. Cyclical rounds of testing were conducted until a single round resulted in a passing percentage of 98%. The result of each test was tracked in the spreadsheet receiving either a pass or fail rating. After each round of testing concluded, corrections were made to COTHAULE for those tests that failed.

The test case spreadsheet was designed between September 2011 and November 2011. The test cases were executed between November 2011 and May 2012. Eight full test runs of the tool were conducted before the tool was considered functionally satisfactory. During each cycle, all test cases were regression tested to ensure that any corrections made to the tool did not cause other previously corrected items to fail. The full testing timetable along with test results is shown in Table 2:

Table 2

Test Case Test Results

Test Date	Tests Executed	Tests Passed	Percentage Passed
11/26/2011	105	61	58.6
12/21/2011	119	87	74.0
12/29/2011	121	99	82.6
1/15/2012	137	113	82.5
3/3/2012	137	115	83.9
3/18/2012	137	130	94.9
4/29/2012	138	134	97.1
5/12/2012	138	137	99.3

There were three changes made to the code that resulted in regression test errors. I faced most of my problems attempting to develop the tool to properly navigate between screens and scenarios using the menus and the next and previous page buttons. Due to the object-oriented nature of Actionscript 3, the code used to develop the tool, there were challenges with adding and removing objects on the stage or what is commonly known as the screen, at the proper time. For example, there is a specific time based on an action within the website that the problem frame should be placed on the screen and a specific time when it should be removed. When this activity was not handled properly within the code, the tool would raise a runtime error and stop functioning.

Usability testing. I developed the COTHAULE Self-Assessment Survey in Microsoft Excel to rate its usability and serve as a guide for me to ensure that specific expectations were met. The instrument was a four-point Likert scale that consisted of 33 questions used to rate how well I thought COTHAULE was designed and developed based primarily on the guidelines described in Lee and Owens (2004). The thirty questions were grouped into eleven categories. Those categories included look and feel, theme, interface, navigation, graphical design, interaction, animation, audio treatments, database design, performance and security. A copy of the questions is available in Appendix G. The four points used in the scale were excellent, good, fair and poor. The instrument also contained a comments section with each question that allowed me to document additional issues and findings with the tool as needed. After the tool was deemed functional by passing at least 90% of the test in the Test Case Spreadsheet, the COTHAULE Self-Assessment Survey was applied. To determine usability, cyclical rounds of testing were conducted until a single round resulted in an overall rating of at least 4.5. After each round was completed, modifications were made to COTHAULE for those items that received a score lower than 4. Some modifications made to COTHAULE based on changes that stemmed from findings from the self-assessment survey required some test cases to be retested.

The Self-Assessment Survey was designed between May 2012 and June 2012. There was some overlap with this survey and the Self-Assessment Test Case Spreadsheet to see how close the results of the two tests aligned with each other. Five full iterations of the Self-Assessment Survey were required before the tool was considered to be in a satisfactory state. A summary of the testing results are provided in Table 3:

Table 3

Summary Results of Self-Assessment Survey

Test Date	Excellent (4)	Good (3)	Fair (2)	Poor (1)	Mean	Median	Mode
5/5/2012	10 (30.3%)	12 (36.4%)	6 (18.2%)	5 (15.2%)	70.5%	3	3
5/28/2012	16 (48.5%)	11 (33.3%)	4 (12.1%)	2 (6.1%)	81.1%	3	4
6/9/2012	24 (72.7%)	6 (18.2%)	3 (9.1%)	0 (0%)	90.1%	4	4
6/17/2012	32 (97.0%)	1 (3.0%)	0 (0%)	0 (0%)	99.2%	4	4
6/30/2012	31 (93.9%)	2 (6.1%)	0 (0%)	0 (0%)	98.5%	4	4

Most of the challenges experienced while testing the tool were resolved between rounds of functional and operational testing. As stated previously, the more persistent challenges occurred while navigating between scenarios within the tool using the menus and next and previous buttons. Other challenges were observed with the voices used in the character animation and the clarity of the animations themselves. In some instances, I attempted to improve the diction of the Alice movies by substituting complex words with simpler words or by making sentences shorter and thus more understandable. In addition, I had to switch video formatting tools because some of the videos came out distorted. Finally, I eventually resulted to switching computers because the videos that were created on computers with slower CPUs were jumpy and hard to follow.

Expert reviews. I requested a small group of experts to perform an informal review of the COTHAULE tool. The experts were all experienced Information Technology Management employees from an automotive financial services corporation located in Farmington Hills, MI. An expert review is “an intrinsic evaluation of the instruction, meaning that the instruction is evaluated in terms of intrinsic merits such as content accuracy or technical quality” (Tessmer, 1993, p. 47). The SMEs are employees that have “acquired current and thorough knowledge about the instructional topic” (Tessmer, 1993, p. 51). In order to gain the most from this study, a total of six experts were involved that are actively engaged with the development and research aspects of their profession. Two experts reviewed the pretest and posttest while three reviewed the COTHAULE tool. One expert was involved in reviewing both the COTHAULE tool and the pretest. Each expert that reviewed the COTHAULE tool had at least fifteen years of experience in Java Development, SQL development, and numerous other applied programming languages while two of the three experts had Master’s Degrees in an Information Technology field. I attempted to limit the number of testers in agreement with the statement by Thiagarajan that “too many experts of the same type might spoil the evaluation with contradictory and counterproductive criticisms and that one or two experts of the same type may be adequate” (as cited in Tessmer, 1993, p. 55).

The experts were provided access to the COTHAULE learning tool, reviewed it for approximately two weeks and provided verbal feedback to me on their findings. The first thing they assessed was the stability of the website. The experts attempted various debugging techniques, such as inserting invalid data or clicking scenes out of sequence, to see if the website would crash. They also checked to see if the verbiage for each of the problems on each webpage was visible and legible. The buttons and links on each webpage were tested to ensure that they were functional. Finally, the experts checked to see if they could answer the problems within the website. A summary of their findings and how each finding was addressed is provided in Table 4.

Table 4

COTHAULE Expert Review Feedback

#	Finding	Solution
1	Add a logoff button to the application.	A logoff button was added to the frame so it would appear on each page. The button would log the user off, disconnect the session and return the user to the login screen.
2	If the password should be at least ten characters, then put a label on the screen with that statement. This will prevent the user from entering less than 10 characters and getting an error message.	A message was added to the registration screen under the password stating that the password should contain at least 10 characters.
3	For the fill-in-the-blank questions, add a header that will show the user where to enter the answer.	A header was added above the user response box that shows the user where to enter the answer.
4	The text in the textbox options on the multiple-choice screen are being cut off. Please expand the textbox.	The textboxes were expanded as suggested. It was validated by taking the answer with the largest amount of content and displaying it in the textbox to see if it would fit.
5	The plus (+) signs are missing in the problems on the screen.	The plus (+) sign must be converted to an ASCII safe format in order to be displayed on the

		Internet. To actually write a plus sign, it has to be encoded as '%2B'. This correction was made.
6	There was a screen error when scenarios were skipped. Some of the old data was still on the screen then the website crashed.	This was a coding error that was corrected and retested until it worked properly.
7	The hijab that the woman avatar is wearing in scenario 4 is showing too much hair in the front of her head. If the hijab is not going to be shown worn properly, then it should not be shown at all.	This feedback was provided specifically by a Muslim woman. The hijab was removed as suggested.
8	Some of the problems are too long. Can you shorten them?	Where possible, some of the problems were shortened and reviewed again by the expert for approval.
9	The mouths are not moving on the characters when they are speaking.	The characters were modified to have mouths that actually moved. Because of the limitations in Alice, the mouths would open when the characters were speaking and close after the characters stopped speaking.
10	The password reset function did not work.	This was a coding error that was corrected
11	The video clip for Case Study 1 scenario 6 was a repeat of scenario 5.	This was a typing error that was corrected.
12	Some of the verbiage in the problem description appeared to be run together.	All database content was examined to ensure that spacing was properly inserted between words.
13	The page backward button on the bottom did not work on scenario 3.	This was a coding error that was corrected.
14	I could not get the fill-in-the-blank to work no matter what.	The characters are case sensitive. So the input from the end user was converted to all capital letters and the answers in the database were converted to all capital letters when compared.

Online Learning Materials Instructional Intervention

The objective here was to find an instructional intervention that contained similar learning content as the materials used within the COTHAULE website. I selected an online Java programming language manual called Java Notes (Eck, 2011) and a PowerPoint presentation on SQL Basics (US Environmental Protection Agency, 2005) as the control group learning materials. The two entries are referred to as the Online Learning Materials throughout this study. The Java Notes website is located at http://math.hws.edu/javanotes/. The Java Notes website is governed by the Creative Commons organization in terms of its use. The guidelines for use of the website are placed as a link on the Java Notes home page and can be found at http://creativecommons.org/licenses/by-nc-sa/3.0/. The SQL Basics website is located at http://www.epa.gov/ttn/airs/airsaqs/training/SQL Basics.pdf.

There were challenges with finding a comparable set of control group learning materials. First, the materials had to be readily available online. If this was not possible, I would have had to manually copy and distribute learning materials to the students. This would have been very expensive and difficult to accomplish considering the number of students involved in addition to concerns with copyright laws. The next challenge was finding learning materials that were comparable to the learning materials in COTHAULE. A single set of materials did not have everything required to compare with COTHAULE so I had to use two separate sets of materials. For example, a number of functions used in Microsoft Excel to sum, traverse and manipulate spreadsheets could mirror both the Java and SQL programming languages; however, there was no single online document that incorporated both languages. The final challenge was finding learning materials that used similar nomenclature that was used in COTHAULE. For example, a computational thinking concept called pipelining was referred to as parallel processing in the

Online Learning Materials although the concept behind the two terms is generally the same. In order to maintain fairness between both groups, questions asked in the pretest and posttest where the user would have to select a definition that was not common between the learning materials was avoided. Instead, the focus was on the common concept between the two definitions and how problem solving would occur based on that concept. For example, instead of giving a definition where the user was expected to select pipelining as the answer, the user was asked to solve a problem where the task involved calculating production time by running two processes in parallel instead of sequentially.

Setting

Wayne State University is located in Detroit, Michigan. It is home to approximately 29,000 graduate and undergraduate, full-time and part-time students from various countries. At the start of the 2012 academic year, there were approximately 19,300 undergraduate students. At the start of this study, 1350 students had registered for the Introduction to Computer Science class, which uses the class course identifier CSC1000. This class is commonly referred to as the computer literacy class and will be referred to as such throughout this study. The entire study took place on the Internet allowing students to complete the study at their leisure. Students either worked on the materials from within one of the Wayne State University computer labs or by using their own computers at the location of their choice.

Participants

This section begins by describing the targeted population of computer literacy students and the criteria established for participant consideration. It was followed by a description of the participant sample and how the sample of students that were enrolled in the fall 2012 computer literacy course was obtained. It continues with a discussion on the treatment which describes the study designs. The two designs that were implemented include a double-blind true control group pretest-posttest design and a double-blind motivation assessment (Fitz-Gibbon & Morris, 1987; Stolberg, 2006). It concludes with a brief discussion on the risks with implementing these types of designs.

Population. The general population of undergraduate students taking computer literacy at four-year institutions in the United States is statistically not obtainable. The experimentally accessible population includes the 1350 students that were enrolled in the fall 2012 computer literacy course at Wayne State University. The selection criteria applied to obtain the participants were minimized to encourage participation in the study while maintaining its integrity. First, participants must be undergraduate students. To avoid placing any student at a disadvantage, graduate students were still able to participate but their test results were not included in the pretest and protest. Second, students must be willing to participate in the entire study. Commitment from each student involved taking a pretest, a posttest, web-based training and a motivation survey lasting for approximately four weeks. Full participation for the duration of time required for this study was crucial to its success.

Sample. All students enrolled in the computer literacy course were informed of the study by the head instructor of the course. The study contained both male and female students from various ethnic backgrounds, age ranges, programs and academic years within the university. Population validity is the ability to generalize the results of the study to those individuals who were not included as part of the study (Johnson & Christensen, 2008). Since this study was conducted exclusively to Wayne State University, the population validity with the computer literacy students in this study could be generalized to other Wayne State University undergraduate students but would not be generalizable to all undergraduate students in four-year public universities. All students who completed the entire study were compensated with three percentage points of extra credit towards their final grade. Students who did not want to participate in the study were able to receive the three percentage points by completing an alternative assignment identified by the instructor.

Treatment. The treatment applied in this study was a double-blind study containing a true control group, pretest-posttest design and motivation assessment for using either intervention (Fitz-Gibbon & Morris, 1987; Stolberg, 2006). All students who expressed interest in this study were separated into an experimental group and a control group based on the day that their classes met. The instructor assigned classes that met on Monday, Tuesday and Wednesday to the experimental group while classes that met on Thursday and Friday were assigned to the control group. The experimental group received access to the COTHAULE tool while the control group received access to the Online Learning Materials.

Risks. There were a number of risks that I faced while implementing this type of study design. The primary risk was that control of the study was assumed by the computer literacy course instructor. The number of students that the instructor had to manage was significant. Therefore, the instructor decided to control the distribution of the instruments limiting communication between me and the students. With this constraint, there was an additional risk of students failing to complete all instruments in the study or picking which parts of the study they want to complete. For example, students could complete the posttest without completing the pretest or students could complete the pretest without the demographics survey. Furthermore, there was the risk of contamination where members of the experimental group shared information with members of the control group. There was also the additional risk of contamination where members of either group could switch places with members of the other group. Finally, there was the risk of losing the students' interest. Since the study was schedule to take place over a three-week time span, some students may not be able to allocate that amount of time for the entire study.

Instrumentation

The four instruments applied in this study included a demographics survey, pretest, and posttest and motivation survey. The instruments were administered using the Survey Monkey online survey service. I developed the demographics survey, pretest and posttest while the Instructional Materials Motivation Survey (Keller, 2010) was used in its original form. Four information technology experts were asked to review the pretest and posttest in terms of their logic, correctness, difficulty and legibility. The reliability of the motivation survey was accepted as is**.** Each instrument is described in detail in the order that it was applied during the study.

Demographics survey. A ten-question on-line survey was provided to the computer literacy students to document and obtain participants for the study. The first question of the survey forced the student to accept consent of the study before the survey could be submitted. The second question captures the 6-digit Wayne State University student access identifier. This identifier was used as the means to compare individual results between the pretest and the posttest, which was required to assess the change in individual student understanding. The survey also captures general information such as age, ethnicity, academic year and familiarity with using a computer. A copy of the Demographics survey is provided in Appendix H.

Computational thinking pretest. The objective of the pretest was to measure students' initial knowledge and understanding of computational thinking prior to applying the experimental and control group treatments. The pretest was provided to participants from both experimental and control groups using the Survey Monkey online survey service. The first two questions of the pretest captured student consent to the study and the Wayne State University 6-digit student access identifier. I applied logic from a variety of resources including my own experiences to develop a test that focuses on computational thinking opportunities that are relative to a computer literacy course within a campus life setting in general (Levitin, 2007; Morrison & Wells, 2010; Wang, 2007). To remain consistent, the same books used to create the case studies in COTHAULE were used to develop the computational pretest and the posttest. The concepts that were used in the case studies were similar to what was used in the pretest and posttest with different questions and results. For example, the computational thinking concept called backtracking was used in a problem in one of the case studies. The same concept was used as a problem in both the pretest and posttest using different data and problem structures. There was no specific process used to select and create problems to solve with the exception that similar concepts should exists in the control group Online Learning Materials to ensure as fair a test as possible. The test was a 26-question multiple-choice test that challenged participants on topics such as using SQL to perform sorting and searching in an Excel spreadsheet, using pseudo code to represent complex Excel equations and understanding the logic behind manipulating tables in a Word document. A copy of the pretest is displayed in Appendix I.

The pretest was then reviewed by two experts in the field of information technology for accuracy and legibility. The first reviewer did not find any errors or problems with the pretest and even stated that it was a well-written test. He did, however, find four out of the 26 questions difficult for him to solve. The second reviewer attempted to solve each problem and suggested both changes and corrections. A summary of the findings with the problem numbers and resolutions is provided below in Table 5.

Table 5

Pretest Expert Review Findings

Prob. #	Finding	Resolution
5	Change the word syntactically to read logically.	The word syntactically was replaced with the word logically.
5	Change the less than sign (<) to greater than (>).	The less than sign (<) was replaced with the greater than sign (>).
9	This is confusing. Will students know what backtracking is?	The definition of backtracking is included with the definition to find all combinations of numbers that would equal an amount of 12.
13	None of the answers appear to match the outcome of the problem.	This is OK. The correct answer is 17.
14	The void call is missing for initTaxes()	The void call was mistakenly taken out but added back in for initTaxes().
18	None of the answers match the outcome of the problem.	This question did read correctly.
19	This problem is confusing.	Not sure how to simplify this problem.
19	Is the capacity the people?	Yes, capacity is explained as representing the people.
24	Option A seems to be the answer but it does not read correctly.	This question did read correctly.
24	I could not get the Excel function to work.	A right parenthesis (')') was missing when the reviewer attempted the equation. This was not an issue.
25	The problem reads "sum the credits" but the function has a multiplication (*) sign instead of a plus (+) sign.	The correction was made to replace the multiplication (*) sign with a plus (+) sign.

Computational thinking posttest. The objective of the posttest was to measure the participants' acquired knowledge and understanding of computational thinking after being exposed to the experimental and control group instructional interventions (Appendix J). The posttest was provided to participants from both experimental and control groups using the Survey Monkey online survey service. The first two questions of the posttest captured student consent to the study along with the Wayne State University 6-digit student access identifier. The methodology that was used to develop the pretest was also applied to the posttest. The posttest was a 26-question multiple-choice test mirroring the pretest that challenged the student on various computational thinking topics. Similar problems as those provided in the pretest using life like computational problems and computer literacy as the learning venue were also used in the posttest. Prior to having the posttest reviewed by two experts, I attempted to apply any corrections to the posttest that were recommended for the pretest. The first reviewer did not provide any feedback. The second reviewer had challenges with trying to solve three of the posttest problems and provided feedback for those. A summary of the findings with the problem numbers and resolutions is provided in Table 6.

Table 6

Posttest Expert Review Findings

Prob. #	Finding	Resolution
14	None of the questions matched the answer.	Replaced the answer that read 56 to read 65.
19	Replace variable ‘n’ with the variable ‘intensity’.	Correction was made.
20	This question was hard to answer.	This question was reworded to have the user count how many times the algorithm was executed.

Instructional materials motivational survey. The purpose of the Instructional Material Motivation Survey (IMMS) was to measure the students’ motivation for using either COTHAULE or the Online Learning materials. The IMMS is “designed to measure reactions to self-directed instructional materials" (Keller, 2010). Two versions of the IMMS, one for the experimental group and one for the control group, were provided by using the Survey Monkey Survey service. The first question on both survey captured consent for the study by forcing all participants to check the consent form before the survey could be submitted. In order to ensure transparency with the participants' feedback, the Wayne State University 6-digit student access identifier was not requested for the IMMS. This way, the participants could feel comfortable in documenting their perceptions of the learning materials regardless how well they appreciated the learning experience and how much of the learning exercises they were able to complete.

The ARCS Model, where ARCS is an acronym that stands for Attention, Relevance, Confidence and Satisfaction is the foundation of the IMMS (Keller, 1987). Each letter in the ARCS acronym is represented as one of the four scales in the IMMS. The Attention scale incorporates twelve questions of the IMMS, the Relevance and Confidence scales contain nine questions each and the Satisfaction scale contains six questions. The IMMS is designed as a Likert-style scale survey where the allowable range is between one and five points. The scale is Not True (1 point), Slightly True (2 points), Moderately True (3 points), Mostly True (4 points) and Very True (5 points). The responses from ten of the questions must be reversed because they are phrased negatively. This translates to having the responses from Very True and Slightly True awarded the points for Not True and Mostly True respectively. The reliability estimate for the IMMS was previously proven as satisfactory by the author during a previous test conducted with undergraduate students from a large southern university (Keller, 2010). The results of the Cronbach Alpha reliability estimates were Attention at 0.89, Relevance at 0.81, Confidence at 0.92, Satisfaction at 0.96 and a total scale estimate of 0.96. A copy of the email from Dr. Keller granting me permission to use the IMMS can be found in Appendix K while a copy of the IMMS questions can be found in Appendix L.

Procedures

I partnered with the instructor of the computer literacy course in the computer science department to recruit computer literacy students to participate in the study. The instructor administered the instruments to the participants using Wayne State University's blackboard system. Each instrument contained screenshots of the two-page authorized consent form that was required for the participants to select before the survey could be submitted. A copy of the authorized consent form is provided in Appendix M. The links to the online demographics survey and pretest were made available to the students on the Blackboard website during the first week. After a week had passed all participants were provided with either the experimental or control group materials based on the day that their classes were scheduled to meet. Participants in the experimental group received the link to the COTHAULE website while those in the control group received the links to the Online Learning Materials. After a week had lapsed, the instructor placed a link to the posttest on the Blackboard website. Finally, after an additional week had passed, participants were granted access to the link of the motivation survey that reflected the treatment that was received. A high level summary of the research procedures involved five primary steps:

1. An online questionnaire was provided to all computer literacy students enrolled in the computer literacy course to obtain the sample for the study.
2. An online pretest was given to participants to determine their existing understanding of computational thinking prior to using either instructional intervention.
3. The instructor separated the participants into experimental and control groups based on class meeting day. The experimental group who met on Monday, Tuesday and

Wednesday received access to the COTHAULE instructional intervention while the control group who met on Thursday and Friday received access to the Online Learning Materials instructional intervention.

4. An online posttest was given to all participants to determine their acquired knowledge for computational thinking after using either instructional intervention.
5. All participants were provided a link to a motivation survey to measure the motivation for using either learning intervention.

Analysis

The analysis of the pretest and posttest was conducted using a pair of independent two-tailed t-ratio statistical test to determine if either treatment had any effect on the participants in terms of knowledge acquisition and a pair of t-ratio correlated tests to determine if there was significance in learning within either group between taking the pretest and taking the posttest (Runyon, Coleman & Pittenger, 2000). The analysis of the motivational study was conducted using a MANOVA to determine whether COTHAULE had a more positive affect on the students than the online reading materials (Hair, Black, Babin, Anderson, & Tatham, 2006; Tabachnick & Fidell, 2001). The null hypotheses that were tested are:

1. H_0: $\mu_t = \mu_c$ – Two-tailed t-ratio statistical test shows that there is a significant difference in computational thinking knowledge between the experimental and control groups based on the results of the pretest.
2. H_0: $\mu_t = \mu_c$ – Two-tailed t-ratio statistical test shows that there is a significant difference in computational thinking knowledge acquisition between the experimental and control groups based on the results of the posttest.
3. H_0: $\mu_D = 0$ – The performance of the participants in the pretest and posttest by either

group is equivalent.

4. H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$ – A MANOVA statistical test shows that there is an overall significant difference in motivation between the experimental and control groups.

Research question one. What are the effects of using an authentic learning tool to teach computational thinking on the knowledge acquisition of undergraduate computer literacy students? Here, knowledge acquisition serves as the dependent variable while the instructional interventions serve as the independent variables. The knowledge acquisition is reflected in the pretest and posttest scores. Independent two-tailed t-ratio statistical tests were applied to determine whether there were any statistical differences between the experimental and control groups for both the pretest and posttest (Runyon, Coleman & Pittenger, 2000). A set of correlated t-ratio statistical tests were applied to determine if there were any statistical differences within each group from taking the pretest and taking the posttest. The four general hypotheses that were tested for this research question are as follows:

1. The results of the pretest would show that there are no significant differences in the participants' understanding of computational thinking for either the experimental group or the control group. This hypothesis was tested using an independent two-tailed t-ratio statistical test that should fail to reject the null hypothesis that the performance of the two groups is equivalent.
2. The results of the posttest would show there is significant difference in the participants' understanding of computational thinking for either the experimental group or the control group. This hypothesis was also tested using an independent two-tailed t-ratio statistical test that should reject the null hypothesis that the performance of the two groups is equivalent.

3. The results of the pretest and posttest for the experimental group would show that there was a statistical difference after taking the pretest and posttest. This hypothesis was tested using a t-ratio test for correlated groups that should reject the null hypothesis that the performance between the pretest and posttest for the experimental group is equivalent.
4. The results of the pretest and posttest for the control group would show that there was no statistical difference after taking the pretest and posttest. This hypothesis was tested using a t-ratio test for correlated groups that should fail to reject the null hypothesis that the performance between the pretest and posttest for the control group is equivalent.

Research question two. What are the effects of using an authentic learning tool to teach computational thinking on the motivation of undergraduate computer literacy students? In this case, motivation serves as the dependent variable while the instructional interventions serve as the independent variables. The general hypothesis for this question states that there is a significant difference in motivation for those that had access to COTHAULE in comparison to those that received the other treatment. This hypothesis was tested using a MANOVA to reject the null hypothesis that states that the motivation for using the two tools between the experimental and control groups was the same. Table 7 presents a breakdown of the relationship of the questions to the data that was collected and the data analysis techniques that were proposed.

Table 7

Summary of Data Analysis Techniques

Research Question	Data	Data Analysis Techniques
What are the effects of using an authentic learning tool to teach computational thinking on the knowledge acquisition of undergraduate computer literacy students?	Experimental and Control Group Pretest Results	Pretest: Two-tailed Independent t-ratio statistical test will determine if the pretest performance of the experimental and control groups is equivalent. $H_0 : \mu_t = \mu_c$ $H_1 : \mu_t \neq \mu_c$ $\alpha = 0.5$, $n = 200+$
	Experimental and Control Group Posttest Results	Posttest: Two-tailed Independent t-ratio statistical test will determine if the posttest performance of the experimental and control groups is equivalent. $H_0 : \mu_t = \mu_c$ $H_1 : \mu_t \neq \mu_c$ $\alpha = 0.05$, $n = 200+$
	Experimental Group Pretest & Posttest Results	Pretest & Posttest: T-ratio test for correlated groups shows that there is a significant difference in computational thinking knowledge acquisition between taking the pretest and taking the posttest. $H_0 : \mu_D = 0$ $H_1 : \mu_D \neq 0$ $\alpha = 0.05$, $n = 200+$
	Control Group Pretest & Posttest Results	Pretest & Posttest: T-ratio test for correlated groups shows that there is a significant difference in computational thinking knowledge acquisition between taking the pretest and taking the posttest. $H_0 : \mu_D = 0$ $H_1 : \mu_D \neq 0$ $\alpha = 0.05$, $n = 200+$
What are the effects of using an authentic learning tool to teach computational thinking on the motivation of undergraduate computer literacy students?	The Authentic Learning Tool for Computational Thinking Assessment (Part 2)	The MANOVA shows that there is a significant difference in motivation between the experimental and control groups based on the results of the survey. $H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4$ H_1 : Not H_0 $\alpha = 0.05$, $n = +300$

Summary

The methodology chapter began with the instructional intervention section that described in detail how I designed, developed and assessed the COTHAULE tool and how subject matter experts were involved in testing the tool. I completed a stringent series of steps to design and develop this tool. Two instruments were used by me to rate the outcome of COTHAULE: (a) a pass or fail test case spreadsheet used to assess the functionality and operability of the authentic learning tool; and (b) a Likert-type scale survey used to rate the design and usability of COTHAULE. Three experts in the field of information technology provided informal feedback on the tool. This section concluded with a brief discussion of the Online Learning Materials instructional intervention that was used by the control group.

The settings section followed providing insight on the undergraduate population of students at Wayne State University. The participation section discussed the computer literacy participants that were selected for the study. It described the treatment of the computer literacy students and how the sample of participants taking the computer literacy course during the fall semester of 2012 was obtained. The instruments section discussed the demographics survey, pretest, and posttest and motivation survey and how these instruments were developed, reviewed and applied. It concluded with an overview of the analysis and associated hypotheses that the study was based upon. Chapter four describes in detail the statistical results of the study and determines how well the tool was perceived in terms of motivation and knowledge acquisition by the sample of computer literacy students.

CHAPTER 4 RESULTS

The purpose of this study was to assess the acquisition of knowledge and motivation from using a prototype of an authentic learning tool called COTHAULE to teach concepts in computational thinking to undergraduate computer literacy students. This chapter discusses the results of the study using the computer literacy student participants from Wayne State University. The first section describes the strategy behind how I validated and cleansed the data prior to performing the statistical analysis. The second section continues with a description of the demographic makeup of the participants that were involved with the study. The participants' pretest results are discussed in the next section for both the experimental and control groups followed by a discussion on the participants' posttest results for both groups. The subsequent section illustrates the comparative results between the pretest and posttest for both groups. The final section discusses the results of the motivation survey for both groups.

Data Cleansing Process

Two significant challenges I faced while executing the study were (a) not being able to control the distribution of the instruments; and (b) the possibility of having the instruments available to all participants, regardless whether they completed previous instruments relative to the study or not. For example, there were instances where students completed the demographics study but did not complete the pretest and the posttest or completed only one of the two tests. There were also instances where students completed the pretest but did not complete the demographics survey or did not complete the posttest. The important initial step involved extracting complete sets of traceable and consistent data that could be used to support the study. Each complete set of traceable data had to include at minimum a pretest and corresponding posttest for each student and preferably a demographics survey entry. Instances for the demographics survey, pretest and posttest were tracked using the student Wayne State University 6-digit student access identifier. In order to ensure transparency with the participants' results, the motivation surveys for both the experimental and control groups did not require the 6-digit student access identifier.

The raw results from the demographics survey, pretest and posttest were extracted from the SurveyMonkey online survey service and loaded into SPSS tables. The SPSS tables were saved and named SM_DemogResults.sav, SM_PretestResults.sav and SM_PosttestResults.sav. Each table contained 652 rows, 580 rows and 478 rows respectively. The data were examined for inconsistencies. In instances where the student used the nine-digit student personal identifier, I worked with the instructor to obtain and update the data to reflect the corresponding 6-digit student access identifier. Each table was then examined for duplicates based on the student access identifier. The Identify Duplicate Cases feature in SPSS sorts duplicates to the top of the table and flags which entry was the original one. To remain fair and consistent, I removed the second entry of all duplicates. However, this feature does not recognize duplicates if some of the letters are capitalized, so I manually removed all duplicates that fell into that scenario based on the submission date of the survey. The demographics survey contained 29 duplicates, the pretest contained nine duplicates plus three entries with no student access identifier and the posttest contained seven duplicates, five entries with no student access identifier and four entries where the identifiers were indiscernible and thus discarded from the study. The SPSS tables were exported into Microsoft Excel comma separated values (CSV) files. The CSV tables were named SM_DemogResults.csv, SM_PretestResults.csv and SM_PosttestResults.csv to remain consistent with the naming of the SPSS tables. Each CSV file was loaded into a separate table within a MySQL database. The tables were named SM_DemogResults, SM_PretestResults and

SM_PosttestResults to remain consistent with the naming of the SPSS tables. Appendix N contains a table listing (a) the names of all tables generated in MySQL that were used to help derive the cleansed data, (b) a description of the data stored in each table, (c) the SQL script written to create the tables, and (d) the number of rows created in each table. A visual representation of the data analysis is provided in Figures 2 through 5.

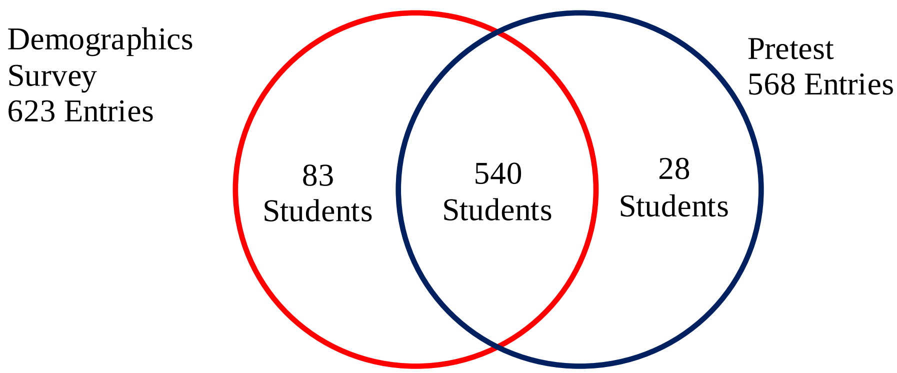


Figure 2. Venn diagram showing the logical relationships between the demographics survey and the pretest entries.

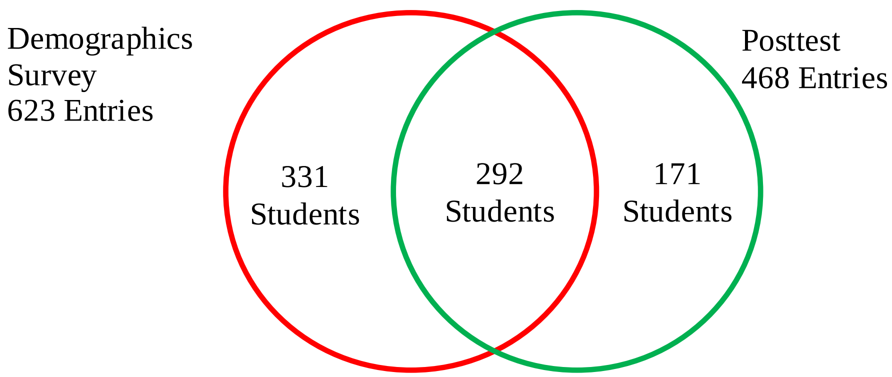


Figure 3. Venn diagram showing the logical relationships between the demographics survey and the posttest entries.

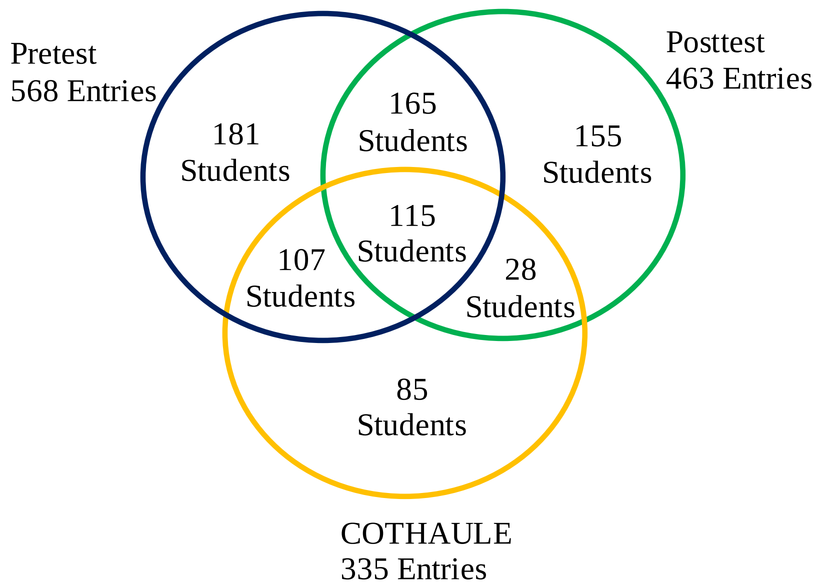


Figure 4. Venn diagram showing the logical relationships between the demographics survey, the pretest and the posttest entries.

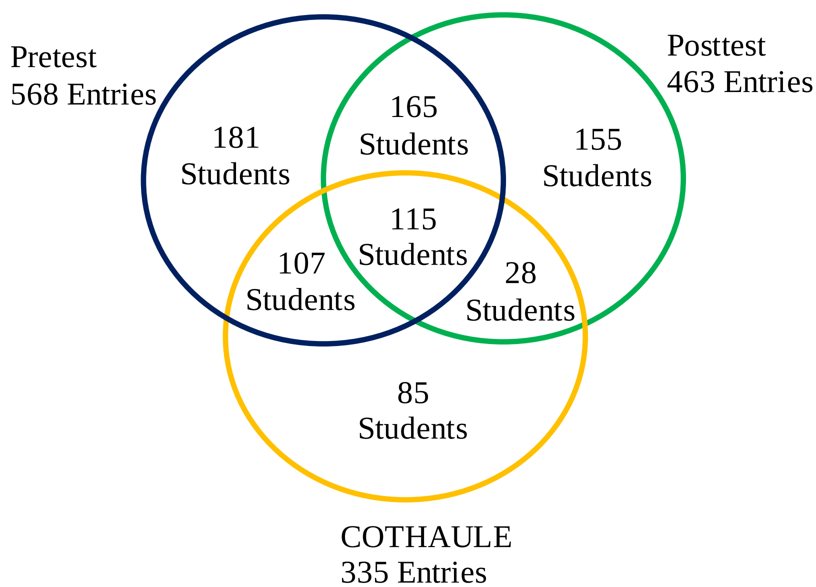


Figure 5. Venn diagram showing the logical relationships between the pretest, the posttest and COTHAULE participation entries.

After the data cleansing process was complete, the MySQL tables that contained the final cleansed data for the demographics survey, the pretest and the posttest were then imported into SPSS to perform the statistical analysis. The tables were named FinalDemogResults, FinalPretestResults and FinalPosttestResults containing 623 rows, 568 rows and 423 rows respectively.

Of the 1350 students who registered for the computer literacy course, 623 (48.66%) participants completed the demographics survey while 568 (42.07%) students completed the pretest yielding a 55-student difference between the two instruments. Based on this result, it would initially appear that 55 (8.82%) of the 623 students withdrew from the study. What is important to note is that of the 623 students that completed the demographics study, only 540 of the same students completed the pretest resulting in an 83-student difference while 28 students completed the pretest but did not complete the demographics survey. Taking this into consideration, there was a total of 651 unique entries between the pretest and demographics survey. This resulted in a true difference of 111 (17.05%) students who completed only one of the two instruments while 540 (82.95%) students completed both entries.

The posttest results displayed greater inconsistency in student participation. With only having 463 (34.3%) of the 1350 students complete the posttest and not the demographics survey, it would appear that 160 (25.68%) of 623 students withdrew from the study. By applying the same logic of matching the instruments based on the student 6-digit access identifier, it was determined that only 292 students completed the demographics survey and the posttest. However, 331 students completed the demographics survey but did not complete the posttest and for some unknown reason, 171 students completed the posttest but did not complete the demographics study. Taking this into consideration, there was a total of 794 unique entries between the posttest and demographics survey. This resulted in a true difference of 502 (63.22%) students who completed only one of the two instruments while 292 (36.78%) students completed both entries.

The most important step to ensure consistency in the results of the learning outcome is to validate that students completed both the pretest and the posttest. There were 280 students that completed both tests. This would translate into a survey completion percentage of 49.30% for the pretest and 60.48% for the posttest. On the other hand, a dismal 288 (50.70%) students completed the pretest and not the posttest, while 183 (39.52%) students completed the posttest but not the pretest. Of the 280 students that completed both tests, 269 of the same students completed the demographics survey. I decided to include the 11 students who did not complete the demographics survey as part of the research group recognizing that their demographical information will not be accounted for. The 280 students were identified as the sample in which the knowledge acquisition results would be based upon.

The COTHAULE website experienced a significant amount of activity during the study that was inconsistent with the number of students that completed the pretest or the posttest. This raised the question whether students that only wanted to work on the website and not complete the entire study were allowed to do so or if students received access to the website that were not supposed to. There were 335 people that registered on the COTHAULE website during the study. Out of the 280 students that completed both the pretest and posttest, 115 (41.07%) of the same students worked on the COTHAULE website while 165 (58.93%) worked on the control group learning materials or nothing at all.

Demographics Summary

Participants for this study were students enrolled in the computer literacy course during the fall 2012 semester. The data for the entire study were captured between September 2012 and October 2012. A sample size of 269 (19%) participants out of 1350 students completed the demographics survey that represents the cleansed data. Of the 269 participants, there were two graduate student entries that were discarded from the results leaving 267 participants. Out of the 267 participants, 177 (66.3%) were female while 90 (33.7%) were male.

The majority of participants were in the age range of 18 – 24. This category accounted for 86.5% of participants splitting the percentage with 56.9% as female and 29.6% as male. The second highest category of participants between ages 25 – 31 accounted for only 8.6% of the total population having 5.6% female and 3.0% male. Based on the researchable data, no one over the age of 52 completed the study. Further details of the results can be found in Table 8.

Table 8

Participant Age Range by Gender

Age	Female		Male		Total	
Range	n	%	n	%	n	%
18 – 24	152	56.9	79	29.6	231	86.5
25 – 31	15	5.6	8	3.0	23	8.6
32 – 38	4	1.5	1	0.4	5	1.9
39 – 45	4	1.5	1	0.4	5	1.9
46 – 52	2	0.7	1	0.4	3	1.1
Totals	177	66.3	90	33.7	267	100.0

Finally, for both genders, White was the ethnic group most represented having 46.1% of the total population and a percentage split of 28.8% for female and 17.0% for male as shown in Table 9. The second highest ethnic group represented was Black at 29.9% with a split of 24.7% female and 5.2% male. The lowest ethnic groups represented were Native American or Alaskan Native and Native Hawaiian or Other Pacific Islander having a total number represented of two participants. A total of five (1.9%) students chose not to answer. Of the five participants, three

(1.1%) were female while two (0.8%) were male.

Table 9

Participant Ethnicity by Gender

	Female		Male		Total	
Ethnicity	n	%	n	%	n	%
White	77	28.8	46	17.2	123	46.1
Black or African American	66	24.7	14	5.2	80	29.9
Asian	19	7.1	12	4.5	31	11.6
Native American or Alaskan Native	0	0.0	0	0.0	0	0.0
Native Hawaiian or Other Pacific Islander	0	0.0	1	0.4	1	0.4
Spanish, Hispanic or Latino	3	1.1	3	1.1	6	2.2
Other Ethnicity	9	3.3	12	4.5	21	7.9
Chose Not To Answer	3	1.1	2	0.8	5	1.9
Total	177	66.3	90	33.7	267	100.0

There was an adequate representation of participants across all years of college. The majority of participants were in their second year of college (Female = 23.2%, Male = 13.5%) while taking the computer literacy class. The participants' year of college based on gender is shown in Table 10.

Table 10

Participant Year of College by Gender

	Female		Male		Total	
Year of College	n	%	n	%	n	%
Freshman	39	14.6	22	8.2	61	22.8
Sophomore	62	23.2	36	13.5	98	36.7
Junior	55	20.6	18	6.7	73	27.3
Senior	21	7.9	14	5.2	35	13.1
Total	177	66.3	90	33.7	267	100.0

The majority of participants for both males and females selected liberal arts and sciences as their academic program at 31.1% while the second most popular was nursing for females at 10.5% and medicine for males at 6.4%. The program with no representation from either gender was Library and Information Science while the second lowest was Law for females at 0.4% and both Fine, Performing and Communication Arts and Social Work for males at 0.4%. Overall, the academic program interests were widely spread across all programs. Table 11 provides a breakdown of the academic program interest by gender.

Table 11

Participant Academic Program Interest by Gender

	Female		Male		Total	
Academic Program	n	%	n	%	n	%
Business Administration	13	4.9	9	3.4	24	8.2
Education	10	3.7	4	1.5	14	5.2
Engineering	3	1.1	5	1.9	8	3.0
Fine, Performing and Communication Arts	4	1.5	1	0.4	5	1.9
Law	1	0.4	3	1.1	4	1.5
Liberal Arts and Sciences	55	20.6	28	10.5	83	31.1
Library & Information Science	0	0.0	0	0.0	0	0.0
Medicine	19	7.1	17	6.4	36	13.5
Nursing	28	10.5	7	2.6	35	13.1
Pharmacy & Health Sciences	25	9.4	12	4.5	37	13.9
Social Work	13	4.9	1	0.4	14	5.2
Unknown	6	2.2	3	1.1	9	3.4
Totals	177	66.3	90	33.7	267	100.0

Wayne State University offers over 100 specific majors for undergraduate students. An ideal scenario for analyzing the major selection data would have been able to have the capability to filter majors by academic program; however the survey tool did not have this provision. Therefore, participants were asked to type in their major in a textbox within the survey. The participants' major of interest was encoded and categorized based on its interpretation. If the question was unanswered, the non-answer was interpreted as being undeclared. Also, in some cases, the major of interest did not reflect what the participant selected as the academic program of interested. The leading major was psychology for females at 26 (9.74%) and biological science for males at 13 (4.87%). There was a small but noticeable interest in computer science with three (1.12%) females and seven (2.62%) males. A summary of the participants' majors of interested by gender is described in Table 12.

Table 12

Participant Academic Major by Gender

		Female		Male		Total	
College/School	Major	n	%	n	%	n	%
Business Administration	Accounting	2	0.75	2	0.75	4	1.50
	Business Administration (General)	2	0.75	1	0.37	3	1.12
	Finance	2	0.75	2	0.75	4	1.50
	Global Supply Chain Management	1	0.37	0	0.00	1	0.37
	Information Systems Management	0	0.00	1	0.37	1	0.37
	Management	3	1.12	3	1.12	6	2.25
	Marketing	3	1.12	0	0.00	3	1.12
College of Fine, Performing & Communication Arts	Fashion Design & Merchandising	1	0.37	1	0.37	2	0.75
	Communications	4	1.50	2	0.75	6	2.25
	Music Education	0	0.00	1	0.37	1	0.37
	Theatre	1	0.37	0	0.00	1	0.37
College of Liberal Arts & Science	Anthropology	1	0.37	0	0.00	1	0.37
	Biological Sciences	13	4.87	13	4.87	26	9.74
	Chemistry	3	1.12	0	0.00	3	1.12
	Criminal Justice	4	1.50	8	3.00	12	4.50
	Dietetics	1	0.37	0	0.00	1	0.37
	Economics	1	0.37	0	0.00	1	0.37
	International Studies	0	0.00	1	0.37	1	0.37
	Liberal Arts	0	0.00	1	0.37	1	0.37
	Labor Studies	0	0.00	1	0.37	1	0.37
	Mathematics	2	0.75	1	0.37	3	1.12
	Nutrition and Food	2	0.75	0	0.00	2	0.75

	Science						
	Political Science	2	0.75	2	0.75	4	1.50
	Psychology	26	9.74	8	3.00	34	12.73
	Sociology	0	0.00	1	0.37	1	0.37
	Spanish	1	0.37	0	0.00	1	0.37
	Speech Pathology	1	0.37	0	0.00	1	0.37
	Urban Planning	1	0.37	1	0.37	2	0.75
Dentistry	Dentistry	2	0.75	0	0.00	2	0.75
Engineering	Computer Science	3	1.12	7	2.62	10	3.75
	Mechanical Engineering	0	0.00	2	0.75	2	0.75
Education	Teacher Education	6	2.25	0	0.00	6	2.25
	Kinesiology, Health & Sport Studies	3	1.12	6	2.25	9	3.37
Pharmacy & Health Sciences	Clinical Laboratory Science	1	0.37	1	0.37	2	0.75
	Mortuary Science	2	0.75	2	0.75	4	1.50
	Occupational Therapy	1	0.37	0	0.00	1	0.37
	Pharmacy	8	3.00	4	1.50	12	4.49
	Physical Therapy	3	1.12	2	0.75	5	1.87
	Physician Assistant	2	0.75	0	0.00	2	0.75
Nursing	Nursing	26	9.74	6	2.25	32	11.99
Medicine	Biochemistry and Molecular Biology	2	0.75	3	0.75	5	1.87
	Pathology	4	1.50	0	0.00	4	1.50
	Physiology	1	0.37	0	0.00	1	0.37
	Pre-Medical	5	1.87	2	0.75	7	2.62
	Radiology	2	0.75	1	0.37	3	1.12
	Ultrasound Training	1	0.37	0	0.00	1	0.37
NA	Undeclared	16	5.99	4	1.50	20	7.49
Social Work	Social Work	12	4.49	0	0.00	12	4.49
Total	Total	177	66.29	90	33.71	267	100.0

The participants stated practically no discomfort with computer use. An overwhelming 99.2% of participants were comfortable with using a computer while a mere 0.8% reported otherwise. The details are listed in Table 13.

Table 13

Participant Computer Comfort by Gender

Gender	Female n	Female %	Male n	Male %	Total n	Total %
Comfortable with Computer	176	65.9	89	33.3	265	99.2
Not Comfortable with Computer	1	0.4	1	0.4	2	0.8
Total	177	66.3	90	33.7	267	100

Similar to the computer comfort results, most participants (90.3%) were comfortable with playing a computer game. Only 9.7% reported otherwise which provided assurance for me that there would be minimal challenges with using the instructional interventions in this study. The details are shown in Table 14.

Table 14

Participant Comfort with Computer Game by Gender

Gender	Female n	Female %	Male n	Male %	Total n	Total %
Comfortable with Gaming	157	58.8	84	31.5	241	90.3
Not Comfortable with Gaming	20	7.5	6	2.2	26	9.7
Total	177	66.3	90	33.7	267	100

Pretest – Posttest t-Test Introduction

Various *t*-ratio statistical tests were conducted to determine if there was significant difference within and between the experimental and control groups' understanding of computational thinking before and after being exposed to the instructional interventions. Independent t-ratio statistical tests measured whether either instructional intervention significantly improved learning more than the other intervention. T-ratio tests for correlated groups measured whether the instructional interventions resulted in a significant increase in learning within either group. Additional questions were posed to determine how participants from both groups rated the difficulty of the pretest and posttest before and after being exposed to the instructional interventions. Of the 26 questions on both tests only 11% of the participants answered question seven correctly; therefore, this question was discarded from the results.

Pretest Independent t-Test Results

An independent two-tailed *t*-ratio test with a significance of $\alpha = 0.05$ was conducted to compare the experimental and control groups and determine if the two groups are equivalent prior to the use of either instructional intervention. Appendix O provides a summary of the raw data test results from the pretest based on the topic of the question. The null hypothesis assumes that the performance of the pretest is equivalent and is formally stated as follows:

1. H_0: $\mu_1 = \mu_2$. The performance of the experimental and control groups is equivalent before using either instructional intervention.
2. H_1: $\mu_1 \neq \mu_2$. The performance of the experimental and control groups is not equivalent before using either instructional intervention.

As shown in Table 15, the control group (n=163) is slightly larger in size than the experimental group (n = 115) by 30%. Sawilowsky and Blair (1992) as cited in Erceg-Hurn and Mirosevich (2008) confirm robustness in the *t*-ratio test provided that the variances and sample sizes are equal, greater than 25 and a two-tailed test is being applied. The data captured in this study and corresponding *t*-ratio test satisfies three of these assertions leaving the unequal sample sizes as a potential issue. The result of Levene's Test for Equality of Variances was reviewed to prove homogeneity of variance. The mean of the control group ($\overline{X} = 7.31$) is slightly higher than the experimental group ($\overline{X} = 7.27$) which shows that the control group had a slight advantage in understanding computational thinking over the experimental group at the start of the study. In addition, the standard deviation of the control group ($SD = 2.943$) was slightly larger than the experimental group (*SD* = 2.451). This shows that there was a greater difference in scores in relation to the mean for the control group due to a sufficient subset of scores that was responsible for generating the larger mean result.

Table 15

Pretest t-Ratio Test Group Results

	n	$\overline{X}$	*SD*	$\sigma_{\overline{X}}$
Experimental	115	7.27	2.451	.229
Control	163	7.31	2.943	.231

Note: $\sigma_{\overline{X}}$ = Standard deviation of the mean.

The result of Levene's Test for Equality of Variances prove that equal variances can be assumed, F = 2.147, *p* = .144. Table 16 presents the Independent Samples *t*-ratio test results for the pretest and posttest taken by both groups. The t-ratio test failed to prove that there was significant difference at the .05 level between the experimental and control groups, *t*(276) = -.129, *p* = .897, thus failing to rejecting the null hypothesis that the performance of the two groups is equivalent. Therefore, it is safe to assume that the understanding of computational thinking between the two groups is relatively the same prior to being exposed to either instructional intervention.

Table 16

Pretest Independent Samples t-Ratio Test Results for Equality of Means

Equal variances	t	υ	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% CI
assumed	-.129	276	.897	-.043	.335	[-.703, .616]
not assumed	-.133	268.439	.894	-.043	.335	[-.682, .596]

Note: CI = confidence interval.

One question was posed at the end of the pretest that asked how the participants rated the difficulty of the test. From the experimental group, 61 (21.9%) strongly agree that the test was too difficult while 77 (27.7%) participants of the control group felt the same as shown in Table 17. Only one participant from the experimental group strongly disagreed that the test was too difficult.

Table 17

Pretest Difficulty Rating

	Experimental Group		Control Group		Totals	
Rating	n	%	n	%	n	%
Strongly Agree	61	21.9	77	27.7	138	49.6
Agree	31	11.2	58	20.9	89	32.0
Neutral	18	6.5	23	8.3	41	14.7
Disagree	4	1.4	5	1.8	9	3.2
Strongly Disagree	1	0.4	0	0.0	1	0.4
Totals	115	41.4	163	58.6	278	100.0

Posttest Independent t-Test Results

A similar test was repeated for the posttest results to determine if the performance of one group significantly differed from the other group after using the instructional interventions. Appendix P provides a summary of the raw data test results from the posttest based on the question topic. The test should validate the second hypothesis that states that the posttest proves significant difference in the participants' comprehension of computational thinking between the experimental and the control groups after exposure to the instructional interventions. The null hypothesis will assume that the performance of the posttest is equivalent and is formally stated as follows:

1. H_0: $\mu_1 = \mu_2$. The performance of the experimental and control groups is equivalent after using the instructional interventions.
2. H_1: $\mu_1 \neq \mu_2$. The performance of the experimental and control group is not equivalent

after using the instructional interventions.

Table 18, shows that the mean for the control group ($\overline{X}$ = 8.07) is slightly higher than that of the experimental group ($\overline{X}$ = 8.06); however, the difference between the posttest means is slightly smaller than the difference between the pretest means. The standard deviations for the two groups is actually closer in the posttest than in the pretest with the experimental group (*SD* = 2.869) being slightly higher than the control group (*SD* = 2.621).

Table 18

Posttest T-Ratio Test Group Results

	n	$\overline{X}$	*SD*	$\sigma_{\overline{X}}$
E-Group	115	8.06	2.869	0.268
C-Group	163	8.07	2.621	0.205

Note: $\sigma_{\overline{X}}$ = Standard deviation of the mean.

Table 19 presents the Independent Samples t-ratio test results for the posttest taken by the experimental and control groups. Levene's Test for Equality of Variances was reviewed to prove that equal variances can be assumed, F= 2.644, *p* = 0.105. The posttest t-ratio test results did not indicate statistically significant difference at the .05 level between the experimental and control groups after using the instructional interventions, *t*(276) = -.038, *p* = .969. Therefore, the test failed to reject the null hypothesis that the control group performed better than the experimental group after using the groups' respective instructional interventions. This actually proves that the performance on the posttest between the two groups is still practically the same which signified that neither intervention contributed to an increase in learning more than the other intervention.

Table 19

Posttest Independent Samples T-Ratio Test Results for Equality of Means

Equal variances	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% CI
assumed	-.038	276	.969	-.013	.332	[-.666, .641]
not assumed	-.038	231.333	.970	-.013	.337	[-.677, .652]

Note: CI = Confidence Interval

A question similar to the pretest was posed at the end of the posttest that asked how the participants rated the difficulty of the test. The opinion of the experimental group did not change much where 60 (21.6%) strongly agreed that the test was too difficult while there was some noticeable improvement with the control group where only 60 (21.6%) down from 77 (27.7%) of participants felt the same as shown in Table 20. What was interesting was that the number of participants that strongly agreed that the test was too easy increased to two (0.7%) for the experimental group and six (2.2%) for the control group. Although small, it was a noticeable improvement considering that only one participant from the experimental group strongly agreed that the pretest was too easy.

Table 20

Posttest Difficulty Rating

	Experimental Group		Control Group		Totals	
Scale Rating	n	%	n	%	n	%
Strongly Agree	60	21.6	60	21.6	120	43.2
Agree	30	10.8	59	21.2	89	32.0
Neutral	16	5.8	29	10.4	45	16.2
Disagree	7	2.5	9	3.2	16	5.8
Strongly Disagree	2	0.7	6	2.2	8	2.9
Totals	115	41.4	163	58.6	278	100.0

Pretest – Posttest Correlated Groups

The t-ratio test for correlated groups was conducted to determine if either instructional intervention had a significant learning impact for either group. For this test, a comparison of each students pretest and posttest results for both the experimental and control groups was conducted. The null hypothesis will assume that the performance of the pretest and posttest is equivalent and is formally stated as follows:

1. H_0: $\mu_D = 0$: The performance of the participants in the pretest and posttest by either group is equivalent.
2. H_1: $\mu_D \neq 0$: The performance of the participants in the pretest and posttest by either group is not equivalent.

Table 21 presents the paired sample correlations between both the experimental and control groups. As shown, there is little evidence of correlation for either group between the two tests. It cannot be determined whether the participants that scored high on the pretest also scored high on the posttest or whether the participants that scored low on the pretest also scored low on the posttest for either group. This means that enough participants that did relatively well on the pretest likely did poor on the posttest.

Table 21

Experimental & Control Group Paired Sample Correlations

	Group	n	Correlation	*SD*
Pretest & Posttest	Experimental	115	.071	.449
	Control	163	.088	.263

Table 22 presents the paired samples test results between the pretest and posttest for both the experimental and control groups. The tests were successful at revealing a statistically significant difference at the .05 level between the pretest and posttest for the experimental group, *t*(114) = -2.332, *p* = .021, and the control group, *t*(162) = -2.580, *p* = .011. This is sufficient to reject the null hypothesis that there is no difference in learning for either group between taking the pretest and the posttest. This proves that the use of both instructional interventions may have assisted with improving learning computational thinking for both groups; however, it does not mean that the scores for all participants consistently increased between the pretest and the posttest.

Table 22

Experimental & Control Group Paired Samples Test Results

	Group	t	df	Sig (2-tailed)
Pretest - Posttest	Experimental	-2.332	114	.021
	Control	-2.580	162	.011

Motivation Survey Results

Prior to proceeding with any tests, the data were thoroughly reviewed for completeness. A total of 190 IMMS survey entries were submitted by the experimental group while the control group submitted 312 survey entries. Two incomplete entries in the experimental group and four incomplete entries in the control group were removed bringing the researchable survey entry totals to 188 and 308 respectively.

The descriptive statistics for the group and pooled means are shown in Table 23 and a copy of the summary data for each question is provided in Appendix Q. The group means represents the sum of the overall average for each item in the subscale while the pooled means represent the average Likert-scale score for items in the subscale. The group mean scores for the control group are consistently higher than the experimental group with the largest difference of 3.05 reflected in the Confidence scale. The standard deviation for the Confidence scale also has the greatest difference between groups at .136. Subsequent testing will determine if the control group scores are statistically different from the experimental group.

Table 23

IMMS ARCS Subscale Group and Pooled Scores

IMMS Subscale		*Experimental (n=188)*		*Control (n=308)*		*Total (N=496)*	
		$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*
Attention	Group	32.08	8.148	33.89	8.469	33.21	8.387
	Pooled	2.673	.679	2.824	.705	2.767	.699
Relevance	Group	24.49	5.242	26.36	5.628	25.66	5.554
	Pooled	2.721	.582	2.928	.625	2.851	.617
Confidence	Group	23.40	5.956	26.45	7.180	25.29	6.896
	Pooled	2.600	.661	2.938	.797	2.810	.766
Satisfaction	Group	14.34	4.864	15.95	5.167	15.34	5.110
	Pooled	2.390	.810	2.658	.861	2.556	.851

Reliability testing for each subscale in the IMMS survey was based on the Cronbach Alpha results and proven to be satisfactory in Keller (2010). The data from both IMMS surveys used in this study were merged to validate that satisfactory correlations also existed which would determine whether the participants understood the questions within the survey. The Cronbach Alpha results along with the summary of the mean, variance and standard deviations for each IMMS subscale are listed below in Table 24.

Table 24

IMMS Composite Cronbach Alpha Results

IMMS Subscale	Cron. α	Var.
Attention	.813	.105
Relevance	.678	.173
Confidence	.800	.058
Satisfaction	.791	.104
Total	.919	.111

The data reveal that the Cronbach Alpha score for the Relevance subscale is questionable but close to the recommended minimum score of .70 (Hair et al, 2006) while the scores of the remaining subscales are significant. The Relevance subscale also had the largest standard deviation revealing that it had the greatest variation of responses from the mean. To further analyze the Relevance score, the Item Total Statistics feature in SPSS was reviewed to determine which items in the scale, if deleted, would result in an increase in the Cronbach Alpha score. The statistics revealed that question 26, the single question that was stated in the negative within the Relevance subscale, was the culprit to the calculation of the low score. If this question was removed from the results, the Cronbach Alpha score for the Relevance subscale would increase to 0.782. In order to determine if the anomaly was more prevalent in the experimental or control group, the Cronbach Alpha, mean and variance was produced for both groups as shown in Table 25. In situations where the Cronbach Alpha is suboptimal or poor, it is recommended to discard the incompliant questions to attempt to improve the score (Ho, 2006). As shown, the results showing the low Cronbach Alpha score for Relevance are consistent between the two groups both just under the .70 recommendation (Experimental .66 & Control .69). The conclusion could be made that either there was a misunderstanding of the question or that I could have been better stated the question. The variance for the Relevance subscale was also the largest variance in both groups for all four subscales which could also support the assumption that the question was not clear to the participants. Since, there were no significant inconsistencies with the Cronbach Alpha between the two groups and the scores were not poor in either group, the Relevance score will be accepted as is.

Table 25

IMMS Experimental and Control Group Cronbach Alpha Results

IMMS Subscale	Experimental Group (n=188)		Control Group (n=308)	
	Cron. α	Var.	Cron. α	Var.
Attention	.807	.151	.815	.089
Relevance	.660	.270	.682	.138
Confidence	.713	.077	.825	.061
Satisfaction	.780	.118	.791	.101
Total	.905	.157	.922	.098

The IMMS survey contains four dependent variables each represented as an ARCS subscale. The immediate choices for examining the survey for statistical significance would be to apply either a series of ANOVAs, t-ratio tests or the MANOVA. If correlation exists between the dependent variables and to avoid an experimentwide Type I error rate which could occur if the dependent variables are assessed separately, the MANOVA would be the most appropriate technique (Hair et al, 2006). The Pearson's R was applied to review the strength of each set linear associations between any two dependent variables within the IMMS subscales. The variables based on the composite scores for each subscale produced the correlation matrix table of the Pearson's R as shown in Table 26.

Table 26

IMMS ARCS Subscale Pearson's R Results

	Attention	Relevance	Confidence	Satisfaction
Attention	1	.690**	.570**	.719**
Relevance	.690**	1	.568**	.752**
Confidence	.570**	.568**	1	.585**
Satisfaction	.719**	.752**	.585**	1

Note: ** Correlation is significant at the 0.01 level (2-tailed).

Manova evaluation of assumptions. The multivariate analysis of variance (MANOVA) was used to determine statistical significance in motivation for learning computational thinking with either COTHAULE or the Online Learning Materials. Authors have consistently supported a general set of assumptions that should be validated when applying the MANOVA (Hair et al, 2006; Tabachnick & Fidell, 2001). The statistical documentation generated to validate these assumptions is available in Appendix R.

Independence. The support for independent observations would ensure that participants of the experimental group had limited interaction with the control group. Although there could have been some interaction between participants from either group, the study was completed within a single time frame, within individual and controlled settings and via an online survey service.

Unequal Sample Sizes, Missing Data and Power. The concern for missing data was previously addressed. Tabachnick and Fidell (2001), describe a set of strategies applied to account for unequal sample sizes. Having a research type of an experimental design, the decision was made to test all hypotheses with SPSS using the sum of squares type three (SSTYPE(3)) or what is also referred to as the unique method. The decision was made to keep all complete cases and not reduce the size of the larger group because it reflects the true outcome of the study.

Linearity. The data were graphically checked for linearity by reviewing the scatter plots. The majority of data were relatively linear with minor acceptances with the relationship between the attention and confidence dependent variables.

Absence of Outliers. Descriptive statistics were reviewed to test for outliers in the data. Z-scores for each ARCS tallied score were produced to see if any scores exceeded the normal distribution boundary of 3.29. The Relevance variable z-score produced a maximum score of $z = 3.48$ which was reflected by a single entry within the data. This entry produced a maximum Relevance score total of 45 and was methodically removed as an outlier. The reproduced z-score improved the maximum score reducing it to z = 3.16.

Multivariate Normality. The multivariate normal assumption was validated by testing dependent variables for univariate normalcy (Hair et al, 2006). Histograms were reviewed in addition to tests for skewness and kurtosis to check for normality. Skewness and kurtosis values for all four dependent variables were between -1 and 1 which supports the assumption that the variables are univariate normal. As long as there is at least a sample size of 20 entries in a group, even with unequal groups being compared as in this study, the assumption of multivariate normality should hold (Tabachnick & Fidell, 2001). Plus, the number of cases for each group is much larger than the four dependent variables used in this sample also supporting the assumption of multivariate normality.

Homogeneity of Variance-Covariance Matrices. The test for equality of variance matrices is better supported by equivalent group sizes. In this situation, the large group size divided by the smaller group size yields a result of 1.64 which is greater than the maximum recommend size of 1.5 (Hair et al, 2006). The results of Box's M Test for homogeneity of covariance matrices yields a significance value, Box's M, $F(10, 734302.519) = 1.378$, $p = .183$, which failed to reject the null hypothesis that the covariance matrices are unequal. Therefore, the initial assumption of homogeneity of covariance matrices is accepted. Additional tests were conducted to confirm equality of variance by applying Levene's Test Equality of Variance dependent variable on each dependent variable. Levene's test reveals that the test was not significant at the 0.05 level for all dependent variables except the Confidence variable (Levene's = 4.622, $p = 0.032$). A retest of the same set using random sampling of the control group to equate the number of cases in the experimental group yielded a similar result for the Confidence variable (Levene's = 5.024, $p = 0.026$). So for the Confidence variable, it appears that the expectation of equal variance is not met. Fortunately, the Robust Tests for Equality of Means yielded significant results for all four dependent variables. Therefore, this test rejects the null hypothesis that the equality of variance has been met allowing the test to proceed with the MANOVA.

Absence of Multicollinearity and Singularity. The linear regression was analyzed for each subscale in relation to the other three subscales by checking for a variance inflation factor (VIF) value that was greater than 3.0 and a tolerance factor over 10 (Ho, 2006). All factors were within the expected range thereby addressing the concern for multicollearity.

MANOVA statistical results. All four multivariate test results, Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all show significance of $p < .001$. Therefore, the null hypothesis that the experimental and control groups rated motivation equally on both instructional interventions is rejected, Pillai $F(4, 490) = 6.642$, $p < .001$. The between-subjects effects results show significance in motivation for all four IMMS subscales at the .001 level given the percentages shown in Table 27.

Table 27

IMMS Subscale Mean Percentages

IMMS Subscale	EG	CG
Attention	32.08	33.83
Relevance	24.50	26.30
Confidence	23.40	26.40
Satisfaction	14.34	15.91

IMMS written feedback. Finally, a summary of the open-ended feedback provided within the IMMS can be reviewed in Appendix S. Unfortunately, there was not a lot of valuable feedback between the two groups but there were some consistent patterns in the feedback worth noting.

For the experimental group, some participants thought that COTHAULE was too hard, confusing and not well designed while some actually thought it was boring and repetitive. For some reason, some participants did not see the instructions or stated that the instructions were not clear and that they did not know how to operate the website. Some participants also mentioned that the talking characters were “creepy”. There was some positive feedback where some participants thought that the website was interesting. They liked the graphics, they thought that the videos were a good learning tool and they could see how the materials in the website related to them.

For the control group some participants thought that the Online Learning Materials were well organized. On the other hand, some participants thought that the control group instructional intervention was too long and boring. Some participants did not care for the intervention and it did not help at all with the exam. In addition, some participants clearly stated that they only completed the assignment to obtain the extra credit. One person from the control group mentioned appreciation of witnessing the experimental group instructional intervention and that it was good to see that someone was focusing on STEM for minorities.

What is interesting is that overall, the positive and negative feedback between the two groups was pretty much the same. However from a statistical perspective, the control group’s instructional intervention was rated significantly more motivating than the experimental group’s intervention.

Summary

T-ratio statistical tests were conducted to determine the knowledge acquisition from using two instructional interventions on an experimental and control group of undergraduate computer literacy students. The independent t-ratio test revealed that both groups tested relatively the same prior to using either intervention but did not show any difference in learning after using the interventions. However, both groups were able to show a significant improvement in learning after using the instructional intervention that was assigned to them. The concern is that the learning correlation between each student was not satisfactory which translates that a significant number of students could have done worse when taking the test the second time. The outcome of the IMMS revealed that there was a significant difference in motivation between the experimental and control group where the control group was more motivated by its instructional intervention than the experimental group. Additional comments provided in the survey revealed little as to why there was a significant difference in motivation.

CHAPTER 5 DISCUSSION

This section begins by recapping the purpose of this study, the research questions that were addressed, the significance of this study and its limitations. It continues by discussing the research results of the knowledge acquisition and motivation assessments from using the two instructional interventions and highlighting the shortcomings of the COTHAULE website which was the instructional intervention used by the experimental group. The recommendations section offers suggestions for future research, lessons learned from completing the type of complex research design that was implemented in this study and improvements to the COTHAULE website.

Purpose

This was a double-blind true control group pretest-posttest and motivation study to validate the benefits of an instructional intervention. The purpose of this study was to build a prototype of an authentic learning tool that would teach concepts in computational thinking and statistically compare it to a set of online learning materials in terms of knowledge acquisition and motivation. I designed, developed and tested a website called COTHAULE whose purpose was to use everyday campus-related real-life learning experiences to teach concepts in computational thinking. I also designed and wrote the corresponding pretest and posttest to measure student learning and used the IMMS to measure student motivation. The website, pretest and posttest were reviewed by experts in the field of information technology prior to being given to the participants in the study. A sample of computer literacy students were divided into an experimental group who received access to the COTHAULE website and a control group who received access to the Online Learning Materials that teaches basics in Java and SQL programming. The two questions that were researched as part of this study were:

1. What are the effects of using an authentic learning tool to teach computational thinking on the knowledge acquisition of undergraduate computer literacy students?
2. What are the effects of using an authentic learning tool to teach computational thinking on the motivation of undergraduate computer literacy students?

Research Background

A series of t-ratio statistical tests were conducted to determine if either instructional intervention resulted in a learning advantage over the other intervention. A MANOVA test was conducted to determine if the use of either instructional intervention motivated the students more than the other intervention.

The purpose of the first t-ratio test for independent groups was to determine whether the understanding of computational thinking was equivalent between the two groups prior to the use of the instructional interventions. The null hypothesis is formally stated as follows:

1. H_0: $\mu_1 = \mu_2$. The performance of the experimental and control groups is equivalent before taking either instructional intervention.
2. H_1: $\mu_1 \neq \mu_2$. The performance of the experimental and control groups is not equivalent before taking either instructional intervention.

The purpose of the second t-ratio test for independent groups was to determine whether learning concepts in computational thinking by the experimental group improved significantly greater than the control group after using the instructional interventions. The null hypothesis is formally stated as follows:

1. H_0: $\mu_1 = \mu_2$. The performance of the experimental and control groups is equivalent after taking either instructional intervention.

2. H_1: $\mu_1 \neq \mu_2$. The performance of the experimental and control groups is not equivalent after taking either instructional intervention.

The purpose of the t-ratio test for correlated groups was to determine whether there was a significant difference in learning between the pretest and the posttest within the experimental and control groups. The null hypothesis for both groups is formally stated as follows:

1. H_0: $\mu_D = 0$. The performance of the participants from both groups is equivalent.
2. H_1: $\mu_D \neq 0$. The performance of the participants from both groups is not equivalent.

The purpose of the MANOVA was to determine whether the results of the IMMS revealed a significant difference in motivation between the experimental and control groups. The null hypothesis is formally stated as follows:

1. H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$. The motivation for using either instructional instrument is equivalent between the two groups.
2. H_1: Not H_0. The motivation for using either instructional instrument is not equivalent between the two groups.

Research Results

Although the mean score of the control group was slightly higher than the experimental group, the independent t-ratio test results for the pretest failed to reject the null hypothesis that there was a significant difference between the experimental and control group. After administering the instructional interventions the mean score of the posttest for the control group was very close to the score of the experimental group but still slightly higher. However, the independent t-ratio test results for the posttest also failed to reject the null hypothesis that there was a significant difference between the experimental and control groups. This signifies that neither instructional intervention gave one group a learning advantage over the other one.

The t-ratio test for correlated groups for both experimental and control groups was successful in rejecting the null hypothesis that the performance of the pretest was equivalent to the posttest. This means that there was a significant increase in learning for both groups regardless of the learning intervention. The results also revealed that there was little correlation between the scores of the pretest and posttest for both groups. This raises the concern that there was likely a small relationship between how well some students did on the pretest versus how well they did on the posttest.

The results of the IMMS reveal that the mean scores for all four of the IMMS ARCS subscales were higher for the control group who used the Online Learning Materials than the experimental group who used the COTHAULE website. In addition, the statistics reveal that those that used the Online Learning Materials were significantly more motivated than those that used the COTHAULE website. Interestingly enough, the written feedback in the motivation survey did not reveal that much difference in appreciation for the instructional interventions by either group.

There were a number of possible reasons as to why the results of the COTHAULE website did not meet expectations. When designing and building a substantial project such as COTHAULE, it becomes easy to lose focus on ensuring that the end product thoroughly matches what is expected from the established guidelines. Although measurements were taken to ensure that the product was properly designed and operated as it should and without error , assessments should have occurred throughout the design and development phase to ensure that it maintained all or at least most of the guidelines expected of an authentic learning environment Herrington and Oliver (2000).

Revisit of authentic learning guidelines. As a post mortem to the study the

COTHAULE product was revisited and compared to the expectations of Herrington and Oliver (2000).

Real-world tasks. In COTHAULE, students were expected to perform tasks that involved using instruments and processes that both students and professionals use on a daily basis to learn or work. This includes performing complex tasks using Microsoft Office products, tasks often completed by those in the information technology field and even research related tasks by students.

Ill-defined tasks. Not all tasks were ill defined in COTHAULE. In some instances in trying to ensure that the student would understand what is expected of them, I was too specific in defining the tasks. For example, instead of telling the student to find a way to perform a complex sort procedure or enter a complex equation to perform activities on a table, I guided the student to some extent on how to complete the task which diminished the opportunity for exploration. In addition, although most of the questions contained problem-solving activities some of the questions did not require the completion of an authentic learning task to answer the question.

Flexible time on tasks. The COTHAULE website provided opportunities for students to work on tasks at their convenience both inside and outside of the classroom.

Various perspectives and resources. There were minimal opportunities to exploit or integrate features within the resources that were used in this version of COTHAULE. An integration task could have involved the use of both Microsoft Word and Excel or some combination of the Microsoft toolset. For example, a task could have involved building a graph using tables in Excel and exporting the graph into Word. Also, to exploit the features within a given resource a situation could have involved completing multiple tasks within one of the resources to accomplish a goal. For example, a task within Excel could have involved, sorting and, filtering data and writing an equation for that same data to produce a result. Another example could have involved performing integrated tasks across multiple worksheet tabs in Excel. The expectation for completing these types of complex tasks at this level may have been too challenging for the students to comprehend.

Collaboration. Although not emphasized or enforced, COTHAULE would allow for students to collaborate on tasks if so desired.

Open to integration. The computer literacy and computational thinking learning opportunities experienced within this website could be applied in various venues. The understanding of how sorting tables and searching for information within tables in both Word and Excel is conducted and how this relates to computational thinking exceeds the boundaries of what is taught in the computer literacy course.

Integrated with assessment. Instead of having students complete an assessment that was separated from the environment, students were able to answer questions within each scenario after completing each task. Most scenarios involved having students complete a task that they were able to access via a link within a scenario. Afterwards the students would answer a question addressing the task they just completed within the same environment.

Polished products. This version of the website did not contain a method to create a polished product nor assess the user based on a comprehensive task that would produce a polished product. In retrospect, this could have been accomplished in some form by scaffolding and building upon the tasks as the students completed each case study. The outcome of completing the task in the seventh scenario in each case study would be a polished product.

Competing and diversity. Although the environment allows students to complete tasks and compare their solutions with each other, this was not a feature that was emphasized in

COTHAULE. This is another area of improvement that should be revisited in a future version.

Limitations of the Study

There were four specific sets of limitations that may have had some impact to my study. Those limitations are (a) generalizability to the population, (b) researcher control of the study, and (c) the use of student incentives.

Generalizability. There were three shortcomings noted that could contribute to the generalizability of the study (Johnson & Christensen, 2008). First, to limit the size of this study, the focus was specific to one course within the university that could benefit from its outcome. Second, all of the students that participated in this study were from the same university. Third, the one-month timeframe allocated for study was relatively short, which may have reduced the students' chances to fully comprehend the benefits of the research topic.

Researcher control. The second limitation concerned researcher control over the study. As previously mentioned, the computer literacy course instructor managed the distribution of all instruments to the students using the Wayne State University Blackboard site. This appeared to be a palatable idea at the time but as the study progressed, the issues came to light. The links were made available for all students at their set times determined by the instructor; however, there was no infallible way to determine who completed which instrument at which time. Researcher control of the distribution of any research materials is extremely important and should only be relinquished to a third party with a personal stake in the study. Having someone involved that has a stake in the study improves the chance that the third party would ensure that the participants correctly complete all facets of the study in the order that is expected. Allowing a third party to distribute the learning materials with no oversight could place the integrity of the study at risk and could result in a number of other unforeseen issues. First, there was no way to validate the message being conveyed to the participants with the research materials. If there are specific instructions that should be passed to the participants with the instruments, unless evidence is provided by the person issuing the test, there is no way to confirm whether this is done. I attempted to address this concern by writing a script for the instructor containing the links and instructions for using each link however, students still chose what parts of the study they wanted to complete. Second, although not the case in this study, there was no way to validate whether the pretest was removed from the Blackboard site prior to the posttest being placed on the site. Of course, this could skew the results of either test. In my situation, the submission date for the instruments in the Survey Monkey service assured me that the instruments were being made available in the expected sequence. Finally, there was no way to determine if the pretest or the posttest was available during the same time that the research materials were available. If available, the materials could have been used to help answer questions on either test.

Students incentive. Using extra credit as an incentive for completing the research adds its own set of challenges and limitations. The students were rewarded three percentage points for completing the study. First, the question becomes whether three percentage points was sufficient considering the amount of time that the study required. Perhaps the incentive should have been a larger amount with strict expectations on commitment to the study or perhaps a small financial incentive should have been included. This was discussed as an option, however sometimes the use of money can also bring its own set of challenges when time to distribute it. Also, without the proper monitoring, there is the chance that the extra credit points were rewarded to all students whether they completed the entire study or not. In addition, if the alternative study was not as challenging as the primary study but offered the same amount of extra credit points, some students may have gravitate to the easier opportunity. Finally, there was no way to determine if a student callously participated in the study just to obtain the extra credit points or actually gave an honest effort. There were references in the written feedback that students were only participating in the study to obtain the extra credit.

Recommendations

The outcome of this study produced a number of recommendations for future research, complex research design strategies and improvements to the COTHAULE tool. Future research should embark upon the following topics: (a) researching various instructional strategies to teach computational thinking to students that are not majoring in the sciences; (b) developing courses to teach basics in computational thinking to all students at Wayne State University; and (c) developing other authentic learning environments to teach computational thinking using subjects other than computer literacy. Recommendations for complex research design strategies will discuss challenges faced during this study and lessons learned to consider when attempting a double blind true control group study. Finally, the gaps in the COTHAULE tool and recommendations for improving the tool for future use will be discussed.

Future research. Various instructional strategies have been applied across institutions to teach concepts in computational thinking to college students particularly in the sciences. Real-life learning was commonly used as a strategy that was successful in gaining student interest and understanding in computational thinking within the sciences (Adams, 2008; Priami, 2009). Other strategies have included problem-solving models, project-based collaboration activities and gaming (Pulimood & Wolz, 2008; Soh et al., 2009; Weller et al., 2008). Quite a few of these strategies were implemented using some type of computer-based technology (Adams, 2008; Cortina, 2007; Weller et al., 2008). These learning opportunities should be explored and expanded to other disciplines. This could involve implementing instructional strategies such as problem-based, inquiry-based or collaborative-based learning to teach computational thinking to students majoring in business, psychology or social work; all of which were popular majors of interest selected by students in this study.

More researchers and institutions are recommending computational thinking classes as required course for students new to the school or students majoring in various disciplines (Adams, 2008; Cortina, 2007; Guzdial, 2008; Hambrusch et al., 2009; Nahapetian, 2011; Qualls & Sherrell, 2010). Wayne State University has a CSC1100 course called Problem Solving and Programming that teaches problem solving with algorithms which aligns with a number of concepts in a computational thinking course. Perhaps the university should consider CSC1100 as a required course similar to what is currently expected for the computer literacy course.

Finally, as mentioned, real-life learning was a common approach used to teach computational thinking although in not all situations was the research directly associated with or measured against what is expected in an authentic learning environment (Pulimood & Woltz, 2008; Soh et al., 2009). It would be interesting and worthwhile to see research conducted where real-life solutions to teach computational thinking were documented and created that aligns with the guidelines of Herrington and Oliver (2000). This will give students the opportunity to apply computational thinking strategies to topics that are meaningful to them while broadening the perspectives of researchers in both computer science and instructional technology.

Considerations for complex research design. The purpose is to reflect on the challenges experienced with implementing a double-blind true control group study. As illustrated in the study, there were a significant number of risks for this type of research design and thus should be avoided if at all possible. If a researcher would like to implement this style of research design, there are some lessons learned that can be adopted from this study. First, this research design had a rigid dependency on those who took the pretest and those who took the posttest. If a participant fails to complete both tests or if the tests cannot be matched based on the identifier that was used, then the scores must be discarded from the results. With such a high possible failure rate, it was important for me to collect a large volume of responses. This way, since a number of samples were discarded, I still had a sample large enough to conduct the study. In this study, I started with 652 demographic survey entries and concluded with only 278 reliable cases that were analyzable. Also, it was important to have some type of systematic way to match each pair of tests (a pretest and a posttest) to a participant and conduct comparable analysis on their results. I used the SQL package within the MySQL program to conduct the validation. Other solutions that could be considered include tools such as Microsoft Access or Excel.

With this type of study design, the researcher would have to develop a strategy to implement a unique and reliable identifier that would link the instruments to the participants. In this study, the participants were asked to use their Wayne State University 6-digit student access identifier as the identifier across some of the instruments. This identifier has a specific format, two letters followed by four numbers, which made it easy for me to determine if the identifier was correct. Instead of using this identifier, a number of students mistakenly used their personal student identifier which is the school version of a nine-digit social security number. Some students used the wrong identifier in the pretest and used the correct one in the posttest or vice versa. Also, some students used the wrong identifier both times. Other students did not use an identifier at all or entered unusable information (i.e. all zeros, nicknames, etc.) into the identifier field. Regardless of the problem, this technique is vulnerable to human error or even human mischief especially if there were students that did want to cooperate with the study. The lessons learned is to be clear what the identifier is and provide an example of what the identifier looks like. Students should be cautioned as to what not to put in the field and warned that entering anything but what is expected will negate their submission and opportunity for extra credit. The final lesson learned is to have the instructor post the students names and corresponding identifier on the Blackboard site notifying the participants of what identifier they are expected to use. If they state that they participated in the test and the identifier is unrecognizable, then the students should not receive the extra credit.

A demographics survey was issued to help collect general information from the participants. Fortunately, the focus of the study was not based on any demographical measurement. If it was, I would have had to discard the instance of the pretest and posttest where the demographic survey was missing. In this case, since there was no rigid dependency on the results of the demographics, the pretest and posttest results were preserved for those who did not complete the demographics survey. However the lack of having this information does not give a full picture of the sample size who participated in the study.

Another lesson learned is that a message should be posted with each active instrument stating that completion of that instrument was a prerequisite for completing the next one. In my study, the demographics survey should have contained a message that completing this survey was a prerequisite for completing the pretest. Subsequently the pretest should contain a similar message regarding the posttest. Not completing any prerequisite instruments would result in the student being denied the extra credit.

The best way to control a study of this design and magnitude is it to have it distributed to the participant body by email. This way, the response from each survey instrument could be easily traced to the participant. The Survey Monkey online survey services allow for a confidential mass distribution of links to be sent to a set of emails and tracks when the survey is returned. Therefore, if the participant fails to respond, the participant could be sent a reminder or ultimately disqualified from the study.

There is no way to validate the integrity of the results in a double-blind pretest, posttest study. Although the results from both pretest and posttest were equally bad, there is no way to corroborate that collaboration on the tests did not occur. The only lesson learned for this issue is to not conduct this type of study on research where the results from either the pretest or posttest are crucial to the success of the study.

In the motivation survey, I allowed for comments on every question with no guidance. Some of the responses were cryptic, did not relate to the question, did not give specifics or contained illegible data in them. For example, one student did not like the design but gave no specifics on what he or she did not like about the design. Instead, I should have added a section at the end of the survey that would allow the reviewer to add additional comments. The comments could be tailored to request general feedback on design, ease of use, how well the survey related to the user or any other specific questions worth asking. In addition, although this may reduce students' transparency, I should have requested the Wayne State University student identifier on the motivation survey that would have allowed me the capability to separate the students who completed the pretest and posttest from those who did not.

Improvements to COTHAULE. The COTHAULE website is a prototype; a very primitive example of what can be offered in terms of using web-based learning for a topic such as computational thinking. There are a number of changes that I would recommend to make to the COTHAULE tool. First, an administrative support system should be added to COTHAULE to make it easy for other instructors to make updates to the instructional materials in the site as needed. Currently, any changes to the problem scenarios or the screens themselves have to be made directly within the database. For example, the user would have to log into the actual MySQL database and apply SQL scripting to add new problems to the website. A better mechanism would be for COTHAULE to have a graphical user interface (GUI) front on the website itself where the instructor would be able to type in the problem they want to expose to the students which would load the information to the database. An ideal solution would be for the website to be ported to content management software such as Joomla, Microsoft Sharepoint, Drupal or Adobe Contribute. If templates are created to support the frame that the website runs on, there will be fewer instances where the actual source code would ever have to be modified. Plus, these options give the instructor more freedom to add content and move content around within the website as needed. There may be a small learning curve requiring the instructor to learn a new software package.

Next, one complaint listed on the feedback from the experimental group was that the problems were too long. Perhaps the problems should be shorter or rewritten that they are shorter but accomplish the same thing. On the other hand, it was hard to tell if the longer problems were also too hard or just too long or both. In some instances, perhaps the questions were too advanced for some students but the challenge becomes how to make the website practical for the majority of the intended audience.

Next, the Alice software used to create the animation was selected because of ease of use but is not ideal for actual animation in this sense. Alice is a great learning tool that teaches object orientation by creating animation. Alice does have its share of challenges. The version of Alice that I used had a memory leak in its software, cannot handle multiple voice files within a single movie and has restrictions on memory usage and file sizes. Other software packages to consider would be either 3DS Max or Blender. However, these packages are used for true animation, are extremely time consuming to learn and may require professional assistance. There are a number of animation products listed on the Internet such as SWiSH, AnimationShop and Poser, which claim ease of use but may come with their own sets of limitations.

Another improvement that I would like to make is to provide students the opportunity to produce a polished product upon completing an entire case study. To fulfill all of the guidelines of an authentic learning environment, there has to be a way to produce a fully functional product and have it electronically evaluated. If this website is used in mass as it was during this study, there is no way that an instructor would be able to manually grade each product submitted by a student. The challenge becomes how to program a website to electronically rate the students' progress without requiring manual intervention. This will take significant time and may require a development team to accomplish this. For example, in the one case study where the two students had part-time jobs developing a website, perhaps the final assignment would be to have the students generate an entire website proposal to submit to their boss using the same tools applied during the case study. It is important to note that this type of modification would require a significant increase in students' time which would render this website infeasible as an extra credit assignment. The use of this website having these types of expectations would have to be imbedded as part of the course objectives. An easier way to fulfill this expectation is to have the tasks within each scenario build upon a product where the final scenario would result in a polished product. For example, the first scenario would have the student create a table in Excel with filters on specific rows; the second scenario would have the student systematically add data to the table and so forth. Each task would still be accompanied by a computational thinking problem to solve. The output of the final scenario would be the result of some meaningful end product.

Finally, I would like to modify all of the problems to require hands-on activities. There were some instances where ordinary multiple choice questions were posed after the video clip was played because I did not have a solution on how to support the message from the clip with a relative hands-on activity.

Significance of the Study

This study provides examples on how the field of educational technology can contribute to the expansion and growth of computational thinking, a topic primarily associated with the computer science discipline. Authentic learning is one such strategy that could be used to teach computational thinking within other disciplines such as business administration, economics and other areas of mathematics. Second, this study suggests additional research on ways that computational thinking can be taught to those that are not heavily involved in the sciences or technology-dependent fields such as computer science and computer engineering. Finally, this study provides additional evidence on how authentic learning can serve as a useful learning strategy that could further benefit the field of instructional technology.

This study also has significance in its potential benefits for those students who participated. Although the results were not too convincing, it could result in an increase in student interest in either instructional technology or computer science and possibly encourage both declared and undeclared students to consider majoring in either discipline. Next, it provided an opportunity for students to experience how a general subject such as computer literacy can be computationally beneficial in various aspects of their lives. Finally, it provided opportunities for students to apply computer literacy and computational computer literacy in an everyday real-life context which are hardly ever realized in the classroom.

Conclusion

The purpose of this study was to determine the motivation and knowledge acquisition of using an authentic learning tool called COTHAULE to teach computational thinking to computer literacy students. Although there was no significant difference in learning outcome between either instructional intervention used by the control and experimental groups plus there was less motivation for using the experimental group instrument, the research in this topic could be improved and should continue. Based on the feedback from students and my internal assessment of COTHAULE, improvements should include:

1. Shorter problems with less direction, leaving more open for interpretation and exploration.
2. The ability to complete a final product either by building upon a product within each scenario or by completing a separate one at the end of the last scenario in a case study.
3. Improvements in the overall color scheme, use of voice and animation and user friendliness.

APPENDIX A: COTHAULE CASE STUDIES

Case Study 1: Welcome to Wayne State University

It is the first week of the first semester of college at Wayne State University for the incoming freshman class. After changing one of her classes, Simone runs into Cady in the campus student union. Cady is one of her friends from high school. They begin to discuss relative topics such as tuition, student loans, scheduling classes, applying for financial aid and the annoying and expensive task of buying books.

Scenario 1	Stacks and Queues	Audio Clip
Simone	Hello Cady!	C1S1_Simone1
Cady	Hello Simone! How are you doing?	C1S1_Cady1
Simone	I'm doing OK. Getting ready for my first semester of college here at Wayne State University.	C1S1_Simone2
Cady	Yeah, me too. Lots of running around to get books, papers, pens. Speaking of which, I went to Barnes and Noble to purchase my books. When I was ready to pay, there were about 40 people ahead of me in line!	C1S1_Cady2
Simone	Next time go early to purchase your books or order them from the web.	C1S1_Simone3

In computer science, there are various types of data structures such as stacks and queues. A *data structure* is an entity that provides a way for a computer to store, process and organize data. In a *queue*, the logic applied is based on an acronym called FIFO, which stands for first-in-first-out. The act of waiting in a line (i.e. to buy tickets to an event, to pay for groceries, etc.) is an example of a queue. What this means is that the first item into the queue is the first item to be served while the last one in the queue is the last item to be served. In a *stack*, the logic applied is based on an acronym called LIFO, which stands for last-in-first-out. What this means is that the last item on the stack is the first to be served or used while the first item on the stack will be the last to be served or used. Here are four examples of stacks and queues. Which one of the four answers is different from the other three?

a. Airplane traffic at an airport
b. An assembly line of placing engines in cars
c. A truck fully loaded with furniture
d. A doctor's waiting list

Answers:

a. In airplane traffic, the first airplane in line would be the first airplane to take off while the last airplane in line would be last to take off. This is an example of a queue. Two of the other answers are similar to this one.
b. In an assembly line, the car at the front of the line would be the first to get the part added while the last car would be the last to get the part. This is an example of a queue. Two of the other answers are similar to this one.
c. Correct. In a truck loaded with furniture, the first piece of furniture loaded would go to the back of the truck. The last piece of furniture loaded would be closest to the door and the first piece unloaded from the truck. This is an example of a stack. The other answers are examples of queues.
d. On a doctor’s waiting list, the first names on the list would be the first to be serviced while the last names on the list would be the last to get a seat. This is an example of a queue. Two of the other examples are similar to this one.

Scenario 2	Graphs and Trees	Audio Clip
Simone	How many classes are you taking?	C1S2_Simone1
Cady	I am taking 4 classes this semester, which, for me, is a full load.	C1S2_Cady1
Simone	Yeah, I’m taking 5 classes myself. All of them meet on Monday. I tried to arrange my classes so that they are in close proximity to each other. I did not have much luck.	C1S2_Simone2
Cady	Why do you say that? Where are your classes located?	C1S2_Cady2
Simone	Well, my first class is at State Hall building, the second is in the Education building, the third is in the General Lectures building, the fourth is in the Business Administration building and the fifth is in Old Main!	C1S2_Simone3
Cady	Well, try to put a positive spin on it. Look at it as a good way of burning calories while you run across campus.	C1S2_Cady3

Click on the link below to open the website showing a map of Wayne State University. A map is an example of a *graph*. A graph is another type of data structure that contains a finite state of ordered pairs of edges that are placed between two nodes. In the university map, each building would qualify as a node while the path between them would qualify as an edge. A *tree* is another type of data structure that, like graphs, contains edges and nodes but is hierarchical in nature. In a family tree, a mother can bear many children but a child cannot be physically born to more than one mother. Each node can have zero to many children but can have at most one parent node. Which one of the four answers is different from the other three?

a. A computer file directory
b. Your Facebook friends
c. A corporate organization chart

d. A pyramid selling scheme

Answers:

a. A computer file directory has a hierarchical structure. A subfolder can only have one parent folder at a time while the parent folder can have many subfolders. This is an example of a tree. Two of the other answers are similar to this one.
b. Correct. Your friends on Facebook can be friends with each other and there is no hierarchical structure. This is an example of a graph.
c. On a corporate organization chart, an employee can report to only one boss but one boss can have many employees reporting to that boss. This is an example of a tree. There are two other options like this one.
d. In a pyramid selling scheme, the money from a group of people is sent to one lead person but they cannot share the money between each other. This is an example of a tree. There are two other options like this one.

Scenario 3	Conditional Statements	Audio Clip
Cady	Would you like to sit down?	C1S3_Cady1
Simone	Sure. Did you have any luck with getting financial aid?	C1S3_Simone1
Cady	A little. I got enough grants to cover about three of my classes, I was able to pay for the other one, but I needed loans to cover room and board.	C1S3_Cady2
Simone	That's good. At least you got something. I applied for financial aid but I did not get much. Looks as if I will be taking out a few student loans.	C1S3_Simone2
Cady	I know your grade point average was pretty good. Did you apply for any academic grants?	C1S3_Cady3
Simone	Yes, for a computer science grant but it is distributed based on income and high school GPA. I am still dependent on my parents. I graduated with a 3.4 GPA but my parents' income was pretty good.	C1S3_Simone3

For the computer science grant Simone applied for, an algorithm was used to determine the grant amount. The algorithm contains a programming construct called a *conditional statement.* A conditional statement checks the condition of the data before executing a step and is usually constructed using an *if-then-else* or *case-switch* clause. In this scenario, the algorithm checks the possible conditions of income and grade point average to determine the amount of the grant. The algorithm used to determine the grant amount is as follows:

```
Function GrantMoney(decimal, income, grant, gpa)
        if income < $50,000 and gpa  >= 3.0
```

```
                then grant = $20,000
        else if income < $50,000 and gpa < 3.0
                then grant = $12,000,
        else if income >= $50,000 and gpa >= 3.0
                then grant = $6,000
        else if income >= $50,000 and gpa < 3.0
                then grant = 0
End Function
```

Simone graduated with a 3.4 grade point average; however, her parents' income was $70,000. Based on her parents' income, her grade point average, and the algorithm used to determine the amount of the grant, how much would she qualify for in grant money?

Answer: $6000

Scenario 4	Searching	Audio Clip
Simone	Thomas Granite told me that he is in my Computer Literacy class.	C1S4_Simone1
Cady	Tell him I said what's up. I hear that there are over 800 students registered in Computer Literacy this semester.	C1S4_Cady1
Simone	Yes. It is a required course so I am not surprised too much. However, registration for WSU has increased quite a bit over the last 10 years.	C1S4_Simone2
Cady	True. In my Computer Literacy class alone, there are over 40 students! I was able to pull the names from Blackboard. I think that Troy Lancaster is in my class.	C1S4_Cady2
Simone	Tell him I said hi!	C1S4_Simone3

Click on the button to open the attached Word document to review the list of student names. In a *sequential search*, the search begins at one end of the list (top or bottom) and reads each element in the list one-by-one in sequential order until the item is found or the search reaches the end of the list. This algorithm is an example of a sequential search:

```
// SequentialSearch searches for a given value in a given array by sequential search
//Input: An Array A[0.. rowNumber – 1] and a search key studentLastName
//Output: The index of the first element of A that matches studentLastName or – 1 if there are no
matching elements
SequentialSearch (A[0.. numberOfStudents – 1], studentLastName)
        rowNumber = 0; (This is the index)
        while rowNumber < numberOfStudents and A[rowNumber] <> studentLastName
```

```
        rowNumber = rowNumber + 1
        if rowNumber < numberOfStudents
            return rowNumber
        else
            return notFound
    end while
End SequentialSearch
```

The variable rowNumber shown in the equation above is used to represent a pointer that will point to the items in the array of names. An *array* is a data element that is used to hold items that are alike (i.e. all integers, all names, all letters, all dog breed names, etc.). So an example of an array of integers could be {3, 5, 7, 8, 9}.The one important thing to remember about arrays is that the position of the array often starts at 0 instead of 1. So in the integer array example given, the number 7 is in the 2nd position of the array. Look for Troy Lancaster's name on the list of students which represents the array in this scenario. You will see that his name is the 8th name in the list. Although Troy's name is the 8th name, the pointer named rowNumber would be equal to 7 representing the 7th position in the array.
Sort the table in the Word document. Now what is the value of rowNumber when pointing to Troy Lancaster's name in the array?

Answer: 26

Scenario 5	Decomposition	Audio Clip
Cady	What I find interesting is that registration continues to rise at colleges everywhere while tuition rises as well.	C1S5_Cady1
Simone	That is surprising. Last year, tuition was $278 per credit hour. This year it is $305 per credit hour.	C1S5_Simone1
Cady	How much of an increase was that?	C1S5_Cady2
Simone	I think it was about 9%.	C1S5_Simone2

Click on the link to review the Wayne State University tuition and fee charts. The equation that will calculate the tuition increase percentage between two years is: 100 * (ABS[firstYear – secondYear] / firstYear) where ABS stands for absolute value. Applying this equation to calculate the tuition differences between last year and this year is: 100 * ([278 – 305] / 278). *Decomposition* is the process of breaking down an entity into smaller parts, which could possibly be used in other programs. Take a look at the incomplete decomposed algorithm that represents the equation above that is used to calculate the tuition percentage increase.

```
Function FindPercent
    var lastTuition, recentTuition, tuitionDifference int
```

```
    var tuitionDivide, percentIncrease decimal
    lastTuition = 278
    recentTuition = 305
    tuitionDifference = lastTuition – recentTuition
    tuitionDifference = ABS(tuitionDifference)
    tuitionDivide = tuitionDifference/________________
    percentIncrease = 100 * tuitionDivide
End
```

Note the line that reads tuitionDivide = tuitionDifference / ___________. Which variable is missing that would complete this equation?

Answer: lastTuition

Scenario 6	Word Formulas	Audio Clip
Cady	I spent so much on books. Plus, I had to buy 15 of them. One class alone required 5 books.	C1S6_Cady1
Simone	I got away with only spending about $700 for the 14 books that I needed. How much did you have to spend?	C1S6_Simone1
Cady	I didn’t even keep track. Here is a list of my books with the costs, if you can stand to look.	C1S6_Cady2
Simone	No wonder! You spent full price on nearly all of your books!	C1S6_Simone2

Click on the Open button to open the attached Word document. The document contains a table listing the class number, class name, book title and the price of the book. Click in the book price column and the total row. You are going to enter a formula to add up the costs of the books.
1. Place your cursor into the Total Row and the BookPrice column.
2. Click on the Formula menu item located under the Table menu at the top of the Word document.
3. The default formula should say =SUM(ABOVE) in the Formula space. If it is not there, enter =SUM(ABOVE). Click on OK.
How much did Cady spend on books? Does the following algorithm correctly accomplish the same task of adding up the costs of the books?

```
Function SumBooks
    totalOfBooks = 0;
    moreBooks = True;
    while moreBooks = True Do
        read bookPrice[x];
        if bookPrice <> empty then
```

```
                    totalOfBooks = totalOfBooks –  bookPrice[x]
                    x = x + 1;
          else
                    moreBooks = False;
     end while
End SumBooks
```

a. The equation "While moreBooks = True Do" should be written as "While moreBooks = False Do"
b. The equation "x = x + 1" should be written as "x = x - 1"
c. The equation "moreBooks = False" should not be there
d. "totalOfBooks = totalOfBooks – bookPrice[x]" should be written as totalOfBooks = totalOfBooks + bookPrice[x]

Answers:

a. If the equation reads "While moreBooks = False Do" the equation would never execute.
b. The equation x = x + 1 causes the equation to read from the beginning to the end of the list which is the correct way to read the list.
c. "moreBooks = False" is needed because if moreBooks is never set, the equation would be in an infinite loop.
d. Correct. The equation "totalOfBooks = totalOfBooks – bookPrice[x]" should be written as totalOfBooks = totalOfBooks + bookPrice[x]

Scenario 7	Sorting	Audio Clip
Cady	I tried to find as many used books as I could. How did you get your books for so much less?	C1S7_Cady1
Simone	I purchased some as e-books and some using the Amazon book swap program. Saved a bundle!	C1S7_Simone1
Cady	Really? Do you think you can help me get some money back?	C1S7_Cady2
Simone	I can try. Let’s go take a look online and do a comparison. We can start with the most expensive books and work from there.	C1S7_Simone2
Cady.	OK. Thanks a lot!	C1S7_Cady3

Click on the Open button to open the attached Word document. This document contains a table listing the class number, class name, book title and the price of the book. As you see, the list is not sorted in any type of order. Sort the list by Class Number in ascending order and Book Cost in ascending order.

Now, let’s look at one type of algorithm that does sorting. A bubble sort is one type of sorting algorithm where the algorithm sorts the list by swapping sets of items in a list. The algorithm

checks each item and the following item in a list. If the first item is greater than the following item, the algorithm swaps the two items. Then it moves down one item (the previous following item becomes the first) and compares it to the next item. It repetitively goes through the list until the items are all sorted. For example, take the following numbers:
{45, 21, 8, 77, 99, 34, 11}
The first pass through the numbers will produce the following results:

- First swap 21 and 45: {21, 45, 8, 77, 99, 34, 11}
- Second swap 8 and 45: {21, 8, 45, 77, 99, 34, 11}
- Third swap 99 and 34: {21, 8, 45, 77, 34, 99, 11}
- Fourth swap 99 and 11: {21, 8, 45, 77, 34, 11, 99}

Now the algorithm will restart at the beginning of the now semi-sorted list.
The second pass through the set of numbers will produce the following results:

- First swap 21 and 8: {8, 21, 45, 77, 34, 11, 99}
- Second swap 77 and 34: {8, 21, 45, 34, 77, 11, 99}

…and so forth.
Look at the books purchased for the ECO2010 class. The book prices for those books are {143.62, 124.34, 68.20, 130.01, 117.56}. After completing only *the first pass* through the list in the Word document using the bubble sort algorithm, what would be the outcome of the list of book prices for the ECO2010 class? Remember, only complete one pass of the algorithm.

a. {68.20, 124.34, 130.01, 117.56. 143.62}
b. {124.34, 68.20, 130.01, 117.56, 143.62}
c. {124.34, 68.20, 117.56, 130.01, 143.62}
d. {68.20, 117.56, 124.34, 130.01, 143.62}

Answers:

a. The book price of 68.20 would not have sorted up to the first position after the first pass.
b. Correct. After the first pass, the book prices 68.20 and 117.56 would be in the second and fourth positions respectively.
c. The book price 117.56 would not have sorted up to the third position after the first pass.
d. It would take three passes of the selection sort to completely sort the list.

Case Study 2: I need a computer!

Autumn and Marley are two students having a discussion in the campus café about purchasing their own computers. They have both decided that their busy schedules make it difficult for them to try to visit the computer lab every time they need to use a computer. They are trying to figure out if they can afford to buy a computer and what type of computer to buy; a MAC or a PC. They are also discussing component needs with their computers and what software they will need for their classes.

Scenario 1	Functions	Audio Clip
Autumn	Hey Marley! How is it going?	C2S1_Autumn1
Marley	Hey Autumn. Hectic! Going to the computer lab in a few minutes. I really need my own computer. I hate going to the lab to do homework.	C2S1_Marley1
Autumn	Me too. I'm thinking about getting a computer. I saw an ad, for a fully-loaded PC for $900. I may be able to qualify for financing.	C2S1_Autumn2
Marley	I really want a MAC. I saw one offer where students can get a thirteen hundred dollar MAC laptop at 0% interest over the life of the loan as long as the minimum balance is paid on time.	C2S1_Marley2
Autumn	I also wanted a MAC but too expensive for me.	C2S1_Autumn3
Marley	Be sure to check the interest on that PC. By the time you pay the interest for the PC, there may not be that much difference in price!	C2S1_Marley3

The students mentioned that the MAC laptop costs $1500 while the PC costs $950. The MAC can be financed at 0% over a three-year period while the PC would charge 18% in interest for the same amount of time. Autumn should find out which computer would eventually cost the least over the amount of the loan. One common equation used to determine the total cost of an item with interest is "Simple Interest = Principle * Rate * Time (in years)". Based on the results of the calculation for the PC, is there much difference in costs between it and the MAC?
Functions are a well-defined piece of code that are called from a calling function and returns a value to the calling function after performing a calculation or set of tasks. The calling function passes a set of input variables to the called function. Then the called function generates the answer based on the input variables and returns an answer to the calling function. In this scenario, the calling function is:

SI = SICalc(Principle, Rate, Time)

Once the called function runs, it passes the answer back to SI, the calling function which in this scenario is expecting a decimal value. Take the principle, rate and time numbers provided for the PC and plug them into the calling function above. Which function will return the correct information?

a. Function SICalc(Rate, Principle):Decimal
   SI = Principle * Rate
   Return SI
   End
b. Function SICalc(Principle, Rate, Time):Decimal
   Principle = Rate * Time

Return Principle
End

c. Function SICalc(Principle, Rate, Time):Decimal
SI = Principle * Rate * Time
Return SI
End

d. Function SICalc(Principle, Rate, Time):Decimal
SI = Principle + Rate + Time
Return SI
End

Answers:

a. In this option, the variable named Time is not passed to the function.
b. In this option, the function has Principle being calculated using Rate and Time where instead Principle should be a variable passed to the function.
c. This is the correct answer.
d. In this case, the function sums the variables Principle, Rate and Time instead of multiplying them.

Scenario 2	Arrays and Lists	Audio Clip
Marley	One cool thing about the MAC is that it comes with iTunes already installed. If I have my own MAC, I can sync my iPod whenever I want instead of having to visit the lab.	C2S2_Marley1
Autumn	I also have to sync my iPod with either the schools computer or my mom's computer at home. If you get a MAC, maybe I can borrow yours.	C2S2_Autumn1
Marley	Yeah, sure. I'll allow you to do so for a small fee…	C2S2_Marley2
Autumn	*laughter* OK. If you say so.	C2S2_Autumn2

An *array* is a container that can hold a series of elements that are of the same type. These elements are placed in adjacent memory locations that can each be referenced by an index or a pointer that points to the position in the array. For example, here is an array containing five integers, [5, 21, 7, 4, 18]. Here is another array containing four colors, [red, blue, green, yellow]. In an array, the first position actually starts at 0 and increments from there. So, in the array of integers, the index's 1st position points to the number 21, not 5. In the array of colors, the 3rd position points to yellow, not green. Arrays and indexes are commonly assigned names by the programmer. If the name given to the array is *intArray* and the index is labeled *x*, the way to reference a number in the array becomes intArray[x]. So using the previous array of integers, intArray[0] is equal to 5.

Click the link to open the Excel spreadsheet. Listed in the spreadsheet are the titles of 12 songs. This list represents an array of song titles. If the index *x* is set to play songs 7, 2, 4, 8 in that order, what is the name of the third song that gets played?

Answer: Domino

Scenario 3	Select Statements	Audio Clip
Autumn	The problem with getting a computer is having to buy all of the other stuff such as software and other components; printer, scanner. Well, some of these I want, maybe not necessarily need.	C2S3_Autumn1
Marley	What are you thinking about buying?	C2S3_Marley1
Autumn	Here is a list that I have started based on discussions with my brother. Some items are required for my classes; some maybe not so much.	C2S3_Autumn2
Marley	Wow! This is a lot of stuff. You may want to start with the software you NEED for class this semester and work from there.	C2S3_Marley2

Click on the Open button to open the Excel document called SoftwareList. The spreadsheet has four columns labeled: Item Name, Price, Type and Need. Turn the Auto Filter feature on in the Excel document. Filter the document by selecting various items in the dropdown lists. What happens to the spreadsheet when you do this? Now filter the dropdown list by setting Type = *Software* and Need = *Class*. Note the results of the Excel document.
Which of the four possible answers correctly reflects the actions of the Excel formula?

a. Select all from SoftwareList
   Where (Type = "Software") and (Need = "Class")
b. Select all from SoftwareList
   Where (Type = "Software") or (Need = "Class")
c. Select all from SoftwareList
   Where Need = ("Class" and Type) = "Software"
d. Select all from SoftwareList
   Where Need = "Class" and "Software"

Answers:

a. Correct. The two where conditions should be joined with an *and* statement and the parentheses are in the correct place.
b. With the *or* statement, you will get more items than you probably want. This is equivalent to filtering using either Type or Need.

c. There is no way for Need to be equal to “Class” and Type. This program may throw an error if used in an application.
d. The filter called “Type” is missing from the where clause.

Scenario 4	Searching	Audio Clip
Marley	You do have a number of items to buy. Try to purchase the software in packages. Also, I am sure some of the other components you can get at a cheaper price.	C2S4_Marley1
Autumn	Yeah, I know. But packages can be expensive as well.	C2S4_Autumn1
Marley	True, but I am sure there are software rental programs and student discounts that can also help bring down costs. What is the most expensive item you were looking at buying?	C2S4_Marley2
Autumn	Well, Acrobat Pro is about $200 bucks by itself, plus a scanner costs $350! That’s a lot of money!	C2S4_Autumn2
Marley	Those are the retail prices. Check out the student discounts and then decide.	C2S4_Marley3

Marley asked what is the most expensive item that Autumn wants to purchase. Here is an example of simple search algorithm called *MaxItem* where its purpose is to find the largest item in a given array. The search executes the following steps:

1. Sets the variable *maxCost* as the first item in the array (position 0) as the default largest item
2. Reads through the rest of the list while there are still costs to be read
3. As an item is found that is larger than maxCost, it replaces the existing maxCost value. Also, the variable *loc* that points to the larger item is set to equal to the value of j which is the index used to point in the array
4. Returns the value of maxCost after the entire list has been traversed.

```
    MaxItem(costs[0..n – 1])
        maxCost = costs [0]
        j = 1;
        while costs[j] <> null do
                if costs [j] > maxCost
                        maxCost = costs [j]
                        loc = j;
                j = j + 1
        end while
        return maxCost
End MaxItem
```

Click the Open button to open the attached spreadsheet showing the costs for the items that Autumn wants to purchase. Say that the costs alone (excluding the header) are loaded into an array. Using the algorithm shown, when the largest item is found, what is the result of the variable loc?

Answer: 11

Scenario 5	The *For* Looping Statement	Audio Clip
Marley	Let's take a look at the components that you want to buy.	C2S5_Marley1
Autumn	The total of all components comes to $925.75. I can probably get a three-in-one printer, scanner and fax for a decent price.	C2S5_Autumn1
Marley	I hear that if you order from TechSoft, you can get a good discount on some items and a 10% discount on your entire order.	C2S5_Marley2
Autumn	Really! That would make for a great deal!	C2S5_Autumn2

Click the Open button to open the Excel spreadsheet. You will see the headers Item, Type, Price, Need and Discount. If the number of items in a list is known or fixed, a *For loop* can be used to perform operations on the items in that list. In this scenario, there are 16 items on Autumn's list. The equation that you will see contains a *For loop* that reads through the list to calculate the discounted cost of each component and tallies the cost of the discounted components. After the *For loop* finishes reading the list, the 25% additional discount is assessed to the discounted cost (to remain consistent, like the array, the for loop will also start at 0). To calculate the individual discount prices for each row using Excel try entering the following into the discount column and pressing enter: =IF(C2="Software",B2-(B2*E2), 0).
Note the missing piece of the equation below. Complete the part of the equation in the parentheses that is missing to calculate the DiscountCost which is 25% off of the TotalCost.

```
Function CalcDiscountCost
    For j=0 to 15
        If Type = Component Then
            DiscountPrice = Price – (Price * Discount)
            TotalCost = TotalCost + DiscountPrice
        End If
    Loop
    DiscountCost = TotalCost – (_______________)
End CalcDiscountCost
```

Answer: TotalCost*0.25

Scenario 6	Abstraction	Audio Clip
Autumn	I wonder if there is some data that shows which is the most preferred, MAC or PC.	C2S6_Autumn1
Marley	That is a never ending debate. I saw one Excel document containing a graph showing buyer's age in relationship to computer choice.	C2S6_Marley1
Autumn	Could you tell anything by looking at the graph?	C2S6_Autumn2
Marley	Yes. In my opinion, most people over 50 have no taste in computers!!	C2S6_Marley2

Click on the Open button to open the Excel document and look at the scatterplot representing the data in the Excel spreadsheet. Note the trend for the PC users and the MAC users. In this scenario, a code representing each person and each preference is associated with each dot on the graph. By not having the codes appear on the graph, it is easier to visualize trends more clearly since only the information that is necessary to project the trends are visible. If each dot were to display its x and y values, the graph would be cluttered. To see this, right click on one of the dots on the graph and select *Add Data Labels*. Excluding the irrelevant data is a process called *abstraction*.

Based on the graph, what can you discern from the data?

a. There is no general difference in the ages of those who prefer a MAC versus a PC
b. In general, people over 50 prefer MAC's
c. In general, people over 50 prefer PC's
d. There are more people that are computer neutral as there are people that prefer MAC's

Answers:

a. More people under 50 prefer PCs while people over 50 prefer MACs.
b. It appears that there are more people over 50 towards the left of the graph.
c. Correct. It is easy to see that most people over 50 prefer PCs over MACs.
d. There are not that many people that are computer neutral.

Scenario 7	Case Statements	Audio Clip
Autumn	I was thinking perhaps if I get a tablet, it will be a lot less expensive than a laptop.	C2S7_Autumn1
Marley	Maybe but I hear that tablet use is still pretty limited. You may want to talk with someone that has one.	C2S7_Marley1
Autumn	OK. I'll do that. I'll check the pricing for a laptop, a tablet and a desktop.	C2S7_Autumn2
Marley	Great! Well, I am off to the lab. Good luck on your purchase; whatever you decide to buy.	C2S7_Marley2

Autumn	Thanks, Marley! And thanks for all of your help!	C2S7_Autumn3
Marley	No problem!	C2S7_Marley3

Click on the Open button to open the attached Excel spreadsheet. Sort the table by computer type then by age. At the bottom of the spreadsheet, type in the missing calculations to determine:

a. The average age of those that prefer a laptop
b. The average age of those that prefer a tablet

Another popular type of conditional or branching statement is the *Case Statement*. When there is a need to complete multiple data checks before performing a condition, case statements can be more useful and clearer than if-then-else Statements. Review the case statement below that performs calculations to calculate the averages:

```
Function ComputerPreferenceAvg
        Case    category=”Laptop”
                laptopCount = laptopCount + 1
                laptopAge = laptopAge + Age
        end
        category=”Desktop”
                desktopCount = desktopCount + 1
                desktopAge = desktopAge + age
        end
        category=”Tablet”
                tabletCount = tabletCount + 1
                tabletAge = tabletAge + age
        end
        category=”No Preference”
                noPrefCount = noPrefCount + 1
                noPrefAge = noPrefAge + age
        end
        default
                Print “Bad Data”
        end
        avgLaptopAge = laptopAge / laptopCount
        avgDesktopAge = desktopAge / desktopCount
        avgTabletAge = ______________________________
        avgNoPrefAge = noPrefAge / noPrefCount
End Case
```

Note the blank space in the case statement. Type the missing part of the equation in the answer space below.

Answer: TabletAge/TabletCount

Case Study 3: Website Designers

Fernando and Kendrick were employed by the student relations department working on the WSU Athletics website. The school is fired up after the successful 2011 football season WSU had in which the team advanced all the way to the national championship game only to fall short of losing by only a few points. Expectations for the upcoming season are promising to be high. The students' first task is to redesign the merchandise page which is used to display athletic gear that can be purchased on-line. Fernando and Kendrick can only work up to 24 hours a week but will be paid a small bonus if they finish at least four hours ahead of schedule.

Scenario 1	Prefetching and Caching	Audio Clip
Kendrick	OK, we got our first assignment. The boss wants us to redesign the merchandise page for the Wayne State Athletics website in three weeks!	C3S1_Ken1
Fernando	We need to split the work up some way where it makes sense. We can work on some parts individually to try to finish early.	C3S1_Fern1
Kendrick	I agree. We definitely need a plan to tackle such a big project.	C3S1_Ken2
Fernando	We can start by copying some of the tasks from the Word document to an Excel spreadsheet. Then we can assign them to a category and split them between us based on category.	C3S1_Fern2
Kendrick	Sounds like a plan.	C3S1_Ken3

http://wayne.bncollege.com

Click on the link that will take you to the merchandise page of the WSU Warriors website. Fernando wants to copy and paste items from the Word document into an Excel spreadsheet. When he does this, the copied items are temporarily placed on a *Windows Clipboard*. A Windows Clipboard can hold approximately 25 items in virtual memory allowing those items to be used elsewhere in Word or in other applications. See if you can find the Clipboard function in Word. The use of the clipboard function is similar to a computational concept called *prefetching and caching*. This places an object or objects in memory or in storage for future reference which is usually done to help speed up performance and accessibility.
Which answer is *not* an example of prefetching and caching??

a. Loading a car with groceries
b. Dismantling your printer

c. Placing books in a backpack to take to school
d. Prepping a parts station at a vehicle assembly line

Answers:

a. This would be an example of prefetching and caching. The items are temporarily placed in the car to be transported to someone's home.
b. Correct. This is not an example of prefetching and caching.
c. This would be an example of prefetching and caching. The books are temporarily placed in a book bag to be transported to be used in a classroom.
d. This would be an example of prefetching and caching. The parts are temporarily placed in an assembly container to be eventually place on the vehicle.

Scenario 2	Knapsack Algorithm	Audio Clip
Fernando	Looks as if we have about five separate tasks for this first round of changes.	C3S2_Fern1
Kendrick	We should rank them based on expected level of difficulty and assign some work hours estimates to them.	C3S2_Ken1
Fernando	OK. On a scale of 1 to 5, I would say task 1 is about a 4, task 2 is a 2, task 3 is a 1, task 4 is the most difficult so give that a 5 and task 5 is about a 3.	C3S2_Fern2
Kendrick	Fair enough. I think we should allocate 17 hours to task 1, 10 hours to task 2, 5 hours to task 3, 18 hours to task 4, and 14 hours to task 5.	C3S2_Ken2
Fernando	Let's see what is possible to complete in 20 hours.	C3S2_Fern3

Fernando and Kendrick determined that they have five tasks to complete. They rated the tasks on a scale of 1 to 5 (5 being the most difficult) and estimated the number of hours required to complete each task. The *knapsack algorithm* can be applied here to determine the maximum number of items that can be placed in the knapsack without exceeding the given weight limit and having the least amount of waste. So in this case, they want to find the maximum number of hours they can spend to complete their tasks within the 20-hour limit in order to secure a bonus. The weight represents the difficulty rating for each task. Based on their discussion the input can be structured to appear as:

Task	1	2	3	4	5
Task Name	Page Design	Middleware	Database	Source Code	Graphics
Complexity	4	2	1	5	3
Hours	17	10	5	18	14

What would be the maximum number of hours with the highest amount of complexity that can be completed within the 20-hour limit?

Answer: 19 hours. Taking tasks 3 and 5 gives a total complexity of 4 with 19 hours' worth of work.

Scenario 3	Pipelining	Audio Clip
Fernando	Perhaps we can work on some of these in tandem to get done sooner. You take middleware development and I'll take the database tables.	C3S3_Fern1
Kendrick	OK. Based on our initial estimates, it should take me about 2 hours for each middleware instance. There are five instances so it will take a total of about 10 hours to complete. How long will it take you to finish each database table?	C3S3_Ken1
Fernando	It will take about one hour for each database table. Once I finish this table, you can start on the middleware and I can start the next database table.	C3S3_Fern2
Kendrick	Great! We should be able to improve on the delivery time and get all five sets done for both tasks quickly.	C3S3_Ken2

Pipelining is a process that looks for ways to run multiple processes in tandem based on availability. Say that each database table has a dependency on a middleware program. Fernando waits for Kendrick to finish all 5 middleware tasks before he starts working on the 5 database tables for every set of tasks that they have to complete. With five sets of tasks to complete, it will take a total of 15 hours to complete everything.
If Fernando overlaps the process and starts working on each database table as Kendrick finishes the middleware program for each table, how much time will the entire process take to complete?

a. 7 hours
b. 9 hours
c. 10 hours
d. 11 hours

Answers:

a. 11 hours is the correct answer. After Kendrick completes all 5 middleware programs taking a total of 10 hours, Fernando will only need one additional hour to complete his last database table.
b. 11 hours is the correct answer. After Kendrick completes all 5 middleware programs taking a total of 10 hours, Fernando will only need one additional hour to complete his last database table.

c. 11 hours is the correct answer. After Kendrick completes all 5 middleware programs taking a total of 10 hours, Fernando will only need one additional hour to complete his last database table.
d. Correct. 11 hours is the correct answer. After Kendrick completes all 5 middleware programs taking a total of 10 hours, Fernando will only need one additional hour to complete his last database table.

Scenario 4	Tree Traversals	Audio Clip
Fernando	Looks like my next task is to create a link for shirts and add some way to filter the shirts.	C3S4_Fern1
Kendrick	Well, we will have t-shirts, polo shirts, sweatshirts, shirts for men, shirts for women…	C3S4_Ken1
Fernando	Hmmm. Perhaps it makes sense for the user to first filter by gender then by shirt type?	C3S4_Fern2
Kendrick	Let's give it a try and see how it looks.	C3S4_Ken2

Link: https://www.cothaule.com/Worksheets/C3S4_Trees.docx

Fernando's assignment is to create a series of links for shirts. When the shirt link is clicked, the screen provides an option to select a gender. When the gender link is clicked, the screen provides you the option to click on a shirt type. When the shirt type link is clicked, it provides the shirt size. This concept is an example of a *tree*. In this scenario, each sub-tree could have many nodes. So there would be many shirt types, many sizes, etc. This is referred to as an *N-ary tree*.
If there are at most two options per node, this would make the tree a *binary* tree. There are three primary ways to traverse or trace through a binary tree. The tree traversals ways are called *pre-order, post-order and in-order* traversals.
For example, to traverse a non-empty binary tree in *pre-order* format use the concept of [root, left, right]:

1. First, go to the *root* of the tree
2. Second, traverse the *left* subtree
3. Third, traverse the *right* subtree of each of the left subtrees

Take a look at the attached PowerPoint document. You will see two trees on two separate slides. The order of traversing the first tree on slide one in pre-order format is:

[12, 8, 6, 2, 9, 5, 4, 10, 19, 17, 16, 20, 14, 21]

What is the correct order of traversing the second tree on slide two in pre-order format?

a. [Female, Shirts, Polo, T-Shirt, M, L, S, Male, Crew, Muscle, XL, XXL]

b. [Shirts, Female, Polo, T-Shirt, M, L, S, Crew, Male, Muscle, XL, XXL]
c. [Shirts, Female, Polo, M, T-Shirt, L, S, Male, Crew, Muscle, XL, XXL]
d. [Female, Polo, M, Shirts, T-Shirt, S, L, Male, Crew, XL, Muscle, XXL]

Answer: [Shirts, Female, Polo, M, T-Shirt, L, S, Male, Crew, Muscle, XL, XXL]

Scenario 5	Recursion	Audio Clip
Kendrick	After the user is done shopping, the shopping cart should automatically sum the selected items.	C3S5_Ken1
Fernando	What if the shopper changes his or her mind? Will the shopper have to start from the beginning?	C3S5_Fern1
Kendrick	Should not have to. The system should allow the user to add or delete items then recalculate the selected items.	C3S5_Ken2
Fernando	I'll run another test to see if it is working properly.	C3S5_Fern2

Link: https://www.cothaule.com/Worksheets/C3S5Shirts.docx

There are a number of ways to write algorithms to sum columns. The most common way is by using an iterative process such as what you have seen in the while…do and for…loop examples. Another more uncommon way is to use *recursion*. Recursion is a technique where an algorithm or function calls upon itself as part of the process to calculate the function. One common recursive function calculates the Fibonacci sequence. Visit the web to take a look at some of the recursive algorithms used to calculate the Fibonacci sequence.
Click the Open button to open the Excel Spreadsheet. As you can see, there are 10 numbers in the spreadsheet. Using the algorithm below, what is the result of TotalCost using the array x[0…9] which represents the set of numbers in the spreadsheet?

```
n = 0;
int TotalCost(int n, array x) {
        if (n = 4)
                return 0;
        else
                return x[n] + TotalCost(n + 1,  [x]);
}
```

Answer: 30. This can be determined by calculating the first 4 numbers in the array.

Scenario 6	Asynchronous and synchronous transmission	Audio Clip
Fernando	Perhaps we should also have the system email the customer after they submit their order.	C3S6_Fern1

Kendrick	OK. We need a place for the user to enter an email address.	C3S6_Ken1
Fernando	What if they don't want to put in an email address? Should it be required? After all, there are concerns with spam.	C3S6_Fern2
Kendrick	No. We should make it optional. After all, the user should be able to log into their Wayne website account and check the status of their order.	C3S6_Ken2

In an *asynchronous* transaction, communication flows one way from point *a* to point *b* and a return response is not required. Email is an example of one-way communication. In a *synchronous* transaction, the communication between the two entities is two-way communication, where data flows freely between the two points *a* and *b*. Video conferencing is an example of a synchronous transaction. Which answer is an example of asynchronous communication?

a. Internet Chat
b. Cell phone
c. Skype
d. Blog

Answers:

a. Internet chat is an example of synchronous communication
b. A cell phone is an example of synchronous communication
c. Skype is an example of synchronous communication
d. Correct. A blog is an example of asynchronous communication. The information is posted by one person and read by others without expecting a response.

Scenario 7	Security	Audio Clip
Kendrick	One important thing we have to do is make sure that our website is secured.	C3S7_Ken1
Fernando	Yeah. Good point. Last thing we want to do is get hacked or worse, have an information security breach.	C3S7_Fern1
Kendrick	Since we are collecting personal information, address, phone, email, credit card, we should at least make sure that our website uses 128-bit encryption or better.	C3S7_Ken2
Fernando	Let's start by obtaining an SSL certificate. This will allow the website to use https which will encrypt the data being passed.	C3S7_Fern2
Kendrick	OK. I'll go back to the office and ask the boss to order the certificate.	C3S7_Ken3
Fernando	Cool. I'll stay here and continue to work on my task.	C3S7_Fern3

Thousands of websites are launched each day, some with good intensions and some with bad intensions. The success of launching a good website is as good as its security. There are a number of things to take into consideration when securing a website for user authentication and validation. Which of the following four answers are *not* required to secure a website?

a. The password should be masked.
b. The password should require a minimum length using a combination of special characters, letters and numbers.
c. The user login should be the user's email address.
d. The data should be encrypted in transit.

Answers:

a. Password masking is required.
b. The password should require a certain length with special characters, letters and numbers.
c. Correct. This is not required. This actually gives a hacker a chance to gain more information about you than is necessary.
d. The data should be encrypted in transit.

Case Study 4: The Research Paper

Siona and Halimah are taking Dr. Krusher's Education History class. They each are taking the class at different times. The instructor gave an assignment that requires everyone to complete 100% of the work online in order to get students acclimated to using the Internet for research. She is expecting a 10-page paper on Types of Educational Training complete with online references. She promises to find and review every reference that the students list. The problem is Siona is not used to using the Internet for research. Halimah tries to help her get going.

Scenario 1	Heuristics	Audio Clip
Halimah	Hi Siona. How is it going?	C4S1_Hali1
Siona	This assignment is going to be tough. I don't use the computer that much. I surf the web a bit for the news. That's about it.	C4S1_Siona1
Halimah	I like to use the computer for gaming. I had one assignment where I used Internet references, but lost points because some of my articles were not peer reviewed.	C4S1_Hali2
Siona	I tried to Google a few topics for my project. It gave me 17 million hits. How on earth do you search through 17 million hits?	C4S2_Siona2

Link: http://www.google.com

Click on the Open button to open the Google search engine link. Start typing in a topic of your choice. Notice that the Google search engine starts to generate possible matches to your search

topic. Search engines use a strategy called *heuristics*. Heuristics is similar to a guessing game where the guesses are based on past experiences and data collected over time that would be considered relative to the search item. As people search for new items, those items may be associated with other items and if found to be true, a link is established between the items. Type the word *dog* into the Google search engine and notice how many items appear.
Below are three examples of situations that would involve the use of heuristics and one that would not. Select the item that would likely not use heuristics?

a. Anti-virus software
b. Stock market projections
c. Debugging a computer program
d. Expert evaluation on a specific topic

Answers:

a. Anti-virus software would use heuristics. It would look for variations of dangerous virus names that could be harmful to a computer
b. Stock market projections would use heuristics. It could project multiple outcomes based on what the economy might do or how specific business might perform
c. When debugging a program, a person would use heuristics. They may try various possibilities to see if the solution would correct the problem in the program
d. Correct. An expert evaluation would *not* likely use heuristics.

Scenario 2	Decomposition	Audio Clip
Halimah	Start by using the school library system first. Perhaps you can narrow the focus on what to search for.	C4S2_Hali1
Siona	How do you get to the school library system?	C4S2_Siona1
Halimah	Easy. Google Wayne State University library. It should give you a direct link to the school library system.	C4S2_Hali2
Siona	Sure does. Here it is.	C4S2_Siona2

Link: http://www.lib.wayne.edu/

Click on the link to open up the WSU online library webpage. Note the five tabs near the top of the page, Catalog, Article Databases, etc. Surely there are separate programs behind the scene to execute search items for each tab. Take an ATM machine for example. There are commonly four options on an ATM machine, Deposit, Withdrawal, Balance and Inquiry. Each option has its own separate program to complete the selected transaction. Imagine if all of the programs for either option are bundled into one long continuous program. Before the Withdrawal could happen in the ATM machine, the program had to maneuver through all of the code for the Deposit option. Similarly, before the search in the Online Journals option could execute, the program had to maneuver through all of the code for the Catalog and Article Databases options.

The process of breaking down an application such as an ATM machine or a library system into programs or modules that can be executed independently is called:

a. Transformation
b. Decomposition
c. Simulation
d. Recursion

Answer:

a. Transformation is the process of either rephrasing a piece of code using the same programming language or translating a piece of code into another programming language.
b. Correct. Decomposition is the process of breaking down an entity such as a program or a function into smaller parts, which could eventually be used in other entities.
c. Simulation is a methodology that resembles learning in the real world by replicating a phenomenon and simplifying it by adding, removing or altering functionality within the simulation.
d. Recursion is a technique where an algorithm or function calls itself as part of the process of calculating the function.

Scenario 3	Searching a System	Audio Clip
Halimah	Let’s try a few searches to get used to how this works. I’m not too familiar with the system myself.	C4S3_Hali1
Siona	OK. Clicking on Catalog Search.	C4S3_Siona1
Halimah	What are you going to search for?	C4S3_Hali2
Siona	I’ll start with seeing what is available for training first.	C4S3_Siona2
Halimah	Wow! You definitely need to narrow the search. You got 19000 hits!	C4S3_Hali3

Complete the same tasks as Siona and search for *training*. Note the number of hits this created. Click on the Catalog tab at the top of the webpage. Under the textbox that has [keyword search] in it, select the Advanced Search link. Scroll down to the keyword search section. In the search area, complete the following steps:

1. Change the first dropdown showing Any Field to author
2. Enter the word “smith” in the textfield next to the first dropdown
3. Change the second dropdown showing AnyField to subject
4. Enter the word “train” in the textfield next to the second dropdown
5. Change the Search and Sort dropdown to “Sorted by Title”

Standard query language (SQL) is a programming language used to read and manipulate tables. Note the following SQL statement:

Select * from Catalog
where (filter1 = author) and (textfield1 = “smith”)
and (filter2 = ____________) and (textfield2 = “train”)
order By Title

Complete the missing portion of the SQL statement below which reflects the steps that you just executed.

Answer: subject

Scenario 4	Wild Card Searches	Audio Clip
Halimah	Click on Advanced Search. As you see, you have many more options that will help narrow your search.	C4S4_Hali1
Siona	This looks intimidating.	C4S4_Siona1
Halimah	Come on! It’s NOT intimidating. Let’s try a few searches to get going. Are there other search items that you want to include?	C4S4_Hali2
Siona	Well, let’s start with all subjects that have anything to do with training at corporations.	C4S4_Siona2

Click on Catalog, then Advanced Search. If you scroll down a little further on the website, you will see some search examples that show how to enter Wild Card selections in the database. This same functionality is available using the *like* operator in a table selection statement. The *like* operator is usually combined with the wildcard word and a wildcard symbol % to create the operand. Take for instance you want to perform a wildcard search on the word “cup” where you want all words that begin with the word “cup”. Then the wildcard call would be [like ‘cup%’]. This would return the words [cup, cupcake, cupid, …].
Take a look at the SQL statement below. What is the missing piece of the statement that will perform a wildcard search on the word “train finding all words that contain *train* in any part of the word?

Select * from CatSearch
Where Subject ____________

a. Like “train%”
b. Like “%train”
c. Like “%train%”
d. Like “%t%r%a%i%n%”

Answers:

a. This will only return words that begin with train.
b. This will only return words that end with train.
c. Correct. This will return words that have the word "train" at the beginning, middle or end of the word.
d. This will return many more letters that you probably want.

Scenario 5	Complex Algorithms and Searching	Audio Clip
Siona	This really narrowed my search quite a bit. I think I am getting the hang of it.	C4S5_Siona1
Halimah	Good. See, told you was not a big deal.	C4S5_Hali1
Siona	Have you used any of the other tabs at the top?	C4S5_Siona2
Halimah	Which ones?	C4S5_Hali2
Siona	Electronic Resources, Journals and Serials, Film and Video. There are quite a few.	C4S5_Siona3
Halimah	Oh, I see. These options help to narrow the focus on what types of items you want to search for. So if you only want to search for Journals and Serials, select that option.	C4S5_Hali3

Click on the option called Electronic Resources. Note the filtering capabilities; a dropdown, a textbox and three options for books, journals or both. This algorithm could be written as three separate SQL statements for each of the three options. What if the algorithm was written as:

```
Select * from ElectronicResources where
        (filterType = "Subject") and (searchItem = "Corporation") and
        ((allOption = 1) or (bookOption = 1) or (journalOption = 1))
```

Will this algorithm work?

a. Correct, this algorithm would work
b. You cannot have nested *or* statements
c. The *or* statements should be changed to *and* in order for it to work
d. The parentheses are not in the correct places

Answers:

a. Correct. As written, yes, this algorithm would work
b. Nested *or* statements are allowed
c. Changing the *or* to *and* means that all three options could be selected at the same time which is not possible.
d. The parentheses are in the right places.

Scenario 6	Modularizing	Audio Clip
Siona	Do you have a topic?	C4S6_Siona1
Halimah	Not exactly. There are a few that I am thinking of. History of e-learning, web-based training, to name a few.	C4S6_Hali1
Siona	Those are some good topics. I'm sure you will find quite a bit of information.	C4S6_Siona2
Halimah	Yes. And the good thing is, e-learning is not that old so not that much history to dig through.	C4S6_Hali2

As seen in the previous problem, a series of separate programs or function calls can be rewritten into one or a smaller number of programs, optimizing the amount of code that is required and possibly reducing the amount of time the program needs to run. This is another useful practice that is very helpful in large programs. The technical term for this practice is called:

a. Modularizing
b. Transformation
c. Aliasing
d. Continuation

Answers

a. Correct. Modularizing is the process of breaking down a large program into logical sections, each of which can pass data between them as needed.
b. Transformation is the process of either rephrasing a piece of code using the same programming language or translating a piece of code into another programming language.
c. Aliasing is assuming the identity of another process, item, object, etc. so that the two are no longer distinguishable.
d. Continuation is a control state of a program where when that specific point is reached, the system moves to the next point of execution or to some other predefined point of execution.

Scenario 7	Redundancy	Audio Clip
Siona	Well, looks as if we are both off to a good start. Thanks so much for all of your help!	C4S7_Siona1
Halimah	No problem. Glad I could help. Off to class now.	C4S7_Hali1
Siona	OK. Bye, Halimah!	C4S7_Siona2
Halimah	Bye, Siona!	C4S7_Hali2

The WSU library system is used by thousands of people that are enrolled in the school, alumni or students from all over the world. Considering that the days of paper articles are short-lived, online resources are now more important than ever before. Imagine it is finals week, students are trying to complete research for their papers and something goes wrong with the online library system. One would hope that there would be some type of mechanism in place to prevent the system from crashing. Otherwise, there would be a lot of unhappy students. The practice of implementing some type of failover mechanism to prevent a system from totally going down is called:

a. Modularizing
b. Redundancy
c. Abstraction
d. Encapsulation

Answer:

a. Modularizing is the process of breaking down a large program into logical sections, each of which can pass data between them as needed.
b. Correct. Redundancy is running two simultaneous processes located in different spaces for the sake of increasing reliability and providing failover capabilities.
c. Abstraction is the process of filtering out unnecessary data and information from a given entity in order to provide clarity to the viewer and allow the view to focus on a smaller number of things at one time.
d. Encapsulation is a technique that allows the user to develop programs that will prevent data and relative instructions specific to one object to be inadvertently updated by another object.

Case Study 5 – Can I Afford an Apartment?

After six months of living in a residence hall, Orion has decided to consider other options. He works 30 hours a week and the hall life is not suitable for his lifestyle. He is completing a budgeting exercise on one of the library computers to see if he can afford to rent an apartment next semester. One of his friends, Hedy, stops by his table and begins to discuss apartment rental reminders and tips with him.

Scenario 1	Object Orientation	Audio Clip
Hedy	Hi Orion. What are you up to?	C5S1_Hedy1
Orion	Ya know, I really like staying in the residence hall but I think I want to rent an apartment. Hall life is too distracting for me. So I am trying to put together a budget to see what I can afford.	C5S1_Orion1
Hedy	I can help with that. What do you have so far?	C5S1_Hedy2
Orion	Well, I have listed a few expenses such as heat, rent, renters insurance, cable…	C5S1_Orion2
Hedy	OK. Looks as if you are off to a good start.	C5S1_Hedy3

In *object-oriented programming*, data and the instructions used to manipulate that data are separated into individual objects. These objects are isolated from other objects and contain their own characteristics. For example, a dog and a cat can be two objects. One function specific to a dog is barking. The cat object should not be able to execute this function nor should a dog be able to execute a meow function which would belong to a cat. Object-oriented programming is a very useful technique for large programs or programs with multiple subprograms. For this particular scenario, an apartment could be an object while a campus hall could be another object. There are three primary techniques associates with object-oriented programming. One technique allows the user to develop programs that will prevent data and relative instructions specific to one object to be inadvertently updated by another object. The technical term for this technique is called:

a. Polymorphism
b. Encapsulation
c. Inheritance
d. Abstraction

Answers

a. Polymorphism is a technique that allows the user to rewrite code in one object without having to actually change the code in another inherited object.
b. Correct. Encapsulation is a technique that allows the user to develop programs that will prevent data and relative instructions specific to one object to be inadvertently updated by another object.
c. Inheritance is a technique that allows the user to reuse code from another existing object without having to copy the code to use it.
d. Abstraction is the process of filtering out unnecessary data and information from a given entity in order to provide clarity to the viewer and allow the viewer to focus on a smaller number of things at one time.

Scenario 2	Creating and Referencing a Class	Audio Clip
Orion	The more expenses I list, the scarier it looks.	C5S2_Orion1
Hedy	That is the one good thing about living in the hall. Yes, you have to deal with distractions once in a while but you don’t have to worry too much about bills.	C5S2_Hedy1
Orion	Well, looking at what I have, are there other expenses I should consider?	C5S2_Orion2
Hedy	What about phone, cable, electricity? May help to check online to see if there are other suggestions. Everything is on line these days.	C5S2_Hedy2
Orion	Good point!	C5S2_Orion3

An object is shown below called RentExpense. A class is built to reference the RentExpense object by defining data that relates to rental expenses plus any functions that are used to manipulate that data. Classes contain various declarations for variables, functions, etc. that all relate to the object. Then functions are created within the same object that references the declarations in the class.

```
Class RentExpense{
Public:
        int: allExpense;
        void totalExpense(int);
        void initTotalExpense(int);
}
void RentExpense: initTotalExpense(int amount){
        allExpense = amount;
}
void RentExpense: totalExpense(int amount){
        allExpense = allExpense + amount;
}
```

A new type of expense is added called Heat. To create the Heat instance of RentExpense, it is initialized by the simple call:
RentExpense Heat;

To reference a function in RentExpense use another simple call:
Heat.*function name* (##);

For example, Heat.initTotalExpense(24) will set the variable allExpense to 24 within the function initTotalExpense shown in the class above. What is the result of allExpense if the following functions are executed in the order shown below?

```
Heat.initTotalExpense (55);
Heat.totalExpense (59);
Heat.totalExpense (77);
```

a. 136
b. 77
c. 191
d. 0

Answers:

a. This answer does not perform the initialization step which should first pass the number 55 to initTotalExpense.
b. The function totalExpense that passes values 55 and 59 are not executed.
c. Correct. Calling the three functions will output 55, 114 then 191.
d. The function calls for all three functions were not executed.

Scenario 3	Fun with Classes	Audio Clip
Orion	I never realized that cable was so doggone expensive.	C5S3_Orion1
Hedy	If you get all of the premium channels, yeah; it can get pretty pricy.	C5S3_Hedy1
Orion	I think I may stick with basic cable. I am in school anyway so I shouldn't need those extra channels.	C5S3_Orion2
Hedy	That's true. Besides, if you really want to see a movie, go out with a bunch of friends and treat yourself! It's OK, once in a while.	C5S3_Hedy2

A new function was added to the class that calculates the percentage amount the bill makes up of the income. Note the updates made to the RentExpense object:

```
Class RentExpense{
Public:
        int: allExpense;
        void totalExpense(int);
        void initTotalExpense(int);
        int: incPercent;
        void initIncomePercent(int);
        void incomePercent(int, decimal);
}
void RentExpense: totalExpense(int amount){
        allExpense = allExpense + amount;
}
void RentExpense: initTotalExpense(int amount){
        allExpense = amount;
}
void RentExpense: incomeExpense(int expenseAmt, decimal income){
        incPercent = expenseAmt / income;
}
void RentExpense: initIncomeExpense(){
        incPercent = 0;
```

}

Orion's income is $1400 a month and the cable bill is $125 a month. A new instance of RentExpense was created called Cable. Which set of functions calls will correctly calculate the percentage of the Cable bill?

a. Cable.initIncomePercent();
   Cable.incomePercent();
b. Cable.initIncomePercent();
   Cable.incomePercent(125, 1400);
c. Cable.initIncomePercent();
   Cable.incomePercent(125);
d. Cable.initIncomePercent();
   Cable.incomePercent(1400, 125)

Answers:

a. The values are not being passed to the functions.
b. Correct. The values are being passed and are in the correct sequence.
c. One of the values is not being passed to the functions.
d. The function calls are correct but the values are in the wrong sequence.

Scenario 4	More with Classes	Audio Clip
Hedy	One thing you may want to double-check is the late payment fees.	C5S4_Hedy1
Orion	I don't plan to be late on any of my payments.	C5S4_Orion1
Hedy	We all say that then life happens. You get busy and you forget to pay your bills. Happens to everyone.	C5S4_Hedy2
Orion	Hmmm. Maybe I should look at getting automatic withdrawal from my bank account.	C5S4_Orion2

A function has been added to the class to calculate the late fee based on a percentage of the bill as shown below:

```
Class RentExpense{
Public:
        int: allExpense;
        void initTotalExpense(int);
        void totalExpense(int);
        int: incPercent;
        void initIncomePercent();
```

```
        void incomePercent(int, decimal);
        decimal: lateAmount;
        void initLateExpense();
        void lateExpense(decimal, int);
}
void RentExpense: initTotalExpense(int Amount)
        allExpense = amount;
}
void RentExpense: totalExpense(int Amount){
        allExpense = allExpense + amount;
}
void RentExpense: initIncomePercent()
        incPercent = 0;
}
void RentExpense: incomePercent(int expenseAmt, decimal income)
        incPercent = expenseAmt / income;
}
void RentExpense: initLateExpense()
        incPercent = 0;
}
void RentExpense: lateExpense(decimal latePercent, int expenseAmt)
        lateAmount = expenseAmt * _______________;
}
```

What part of the function is missing based on the information added to the class?

Answer: latePercent

Scenario 5	Multiple Classes	Audio Clip
Hedy	Although the amount may be nominal, you may want to track your recreational expenses in a separate category.	C5S5_Hedy1
Orion	You are right about that. It may not be much left after paying all the bills.	C5S5_Orion1
Hedy	True, but you will build up cash over time. Whatever you do, stay within your budget.	C5S5_Hedy2
Orion	Hah! You are starting to sound like my mom.	C5S5_Orion2
Hedy	Well, I just saw my older brother go through the same thing when he moved out of the hall and into an apartment!	C5S5_Hedy3

A new class has been created called PersonalExpense.

```
Class PersonalExpense{
Public:
        int: totalExpense;
        void initSumExpense();
        void sumExpense (int);
}
void PersonalExpense: initSumExpense (){
        totalExpense = 0;
}
void PersonalExpense: sumExpense (int expense){
        totalExpense = totalExpense + expense;
}
```

Using the new class PersonalExpense, what is wrong with this set of function calls?

```
RentExpense RestaurantExpense;
RestaurantExpense.initSumExpense();
RestaurantExpense.sumExpense(expense);
```

a. There is nothing wrong with this set of function calls.
b. The variable totalExpense is being calculated wrong.
c. The instance RestaurantExpense is initiated with the wrong class.
d. The class is missing a variable.

Answers:

a. RestaurantExpense is initiated with the wrong class
b. The value totalExpense is being calculated correctly.
c. Correct. RestaurantExpense is initiated with RentExpense instead of PersonalExpense. It cannot call the two functions initSumExpense and sumExpense.
d. The class is not missing any variables.

Scenario 6	Inheritance	Audio Clip
Hedy	One thing I did forget to mention is the importance of having an emergency fund.	C5S6_Hedy1
Orion	Emergency fund?	C5S6_Orion1
Hedy	Yes, if you don’t plan for emergencies then that is when they are likely to happen.	C5S6_Hedy2
Orion	How do you plan for an emergency?	C5S6_Orion2
Hedy	You don’t really plan for a specific emergency but you should have some money saved in case of one. What if you are out of	C5S6_Hedy3

	work for 6 months? Can you sustain yourself with what you currently have saved?	

What if you wanted to modify an object so that it contains all of its current characteristics plus one additional one? The catch is that you don't want to allow this one additional characteristic to be available to the other objects. Another nice quality about object-oriented programming is its ability to reuse an object without altering it. You can create another object as an instance of an existing object but give the new object characteristics of its own. This is another common practice in object-oriented programming called:

a. Inheritance
b. Decomposition
c. Polymorphism
d. Transformation

Answer

a. Correct. Inheritance is a technique that allows the user to reuse code from another existing object without having to change the code that belongs to that object.
b. Decomposition is the process of breaking down an entity such as a program or a function into smaller parts, which could eventually be used in other entities.
c. Polymorphism is a technique that allows the user to rewrite code in one object without having to actually change the code in another inherited object.
d. Transformation is the process of either rephrasing a piece of code using the same programming language or translating a piece of code into another programming language.

Scenario 7	Inheritance Example	Audio Clip
Hedy	You may want to move your emergency money into a money market account to try to keep from spending it. Interest is low right now but once you get to, say, $1000 saved, you can then purchase a CD where interest is more generous?	C5S7_Hedy1
Orion	Are CD's safe? Last thing I want to do is put my money somewhere and have it disappear.	C5S7_Orion1
Hedy	Yes, CD's are pretty safe in comparison to other financial products.	C5S7_Hedy2
Orion	OK. Another thing to consider. You need to major in finance and banking.	C5S7_Orion2
Hedy	Nah. I'm majoring in computer science which is one of the coolest fields out there!	C5S7_Hedy3

Another new class has been created called EmergencyFund that will inherit the class RentExpense. Note how the class is declared below showing the inheritance of RentExpense.

This class will be used to calculate interest on the Emergency Fund balance on a monthly basis. In this case, the steps are to declare a new instance of EmergencyFund, initialize the Fund, add to the emergency fund then calculate the interest on the fund. Write the function call that would calculate the emergency fund balance.

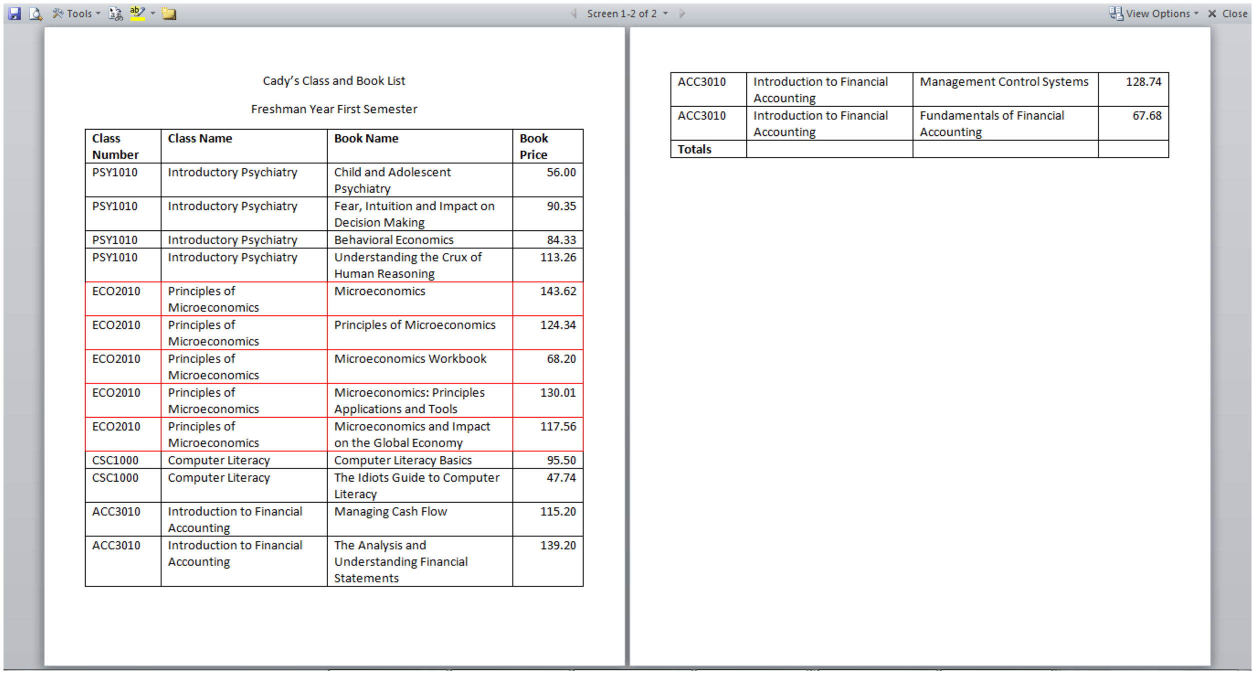
```
Class EmergencyFund: public RentExpense {
Public:
        decimal emerBal;
        void calcEmerBalance (int);
}
void EmergencyFund: calcEmerBalance (decimal interest){
        emerBal = emerBal + (emerBal * interest);
}
```

```
EmergencyFund Savings
Savings.initTotalExpense;
Savings.totalExpense;
Savings.______________________
```

Note the blank line in the set of functions that call the EmergencyFund Class. Complete the function call that would calculate the emergency fund balance.

Answer: CalcEmerBalance(interest);

APPENDIX B: COTHAULE SCREENSHOTS OF AUTHENTIC LEARNING TASKS

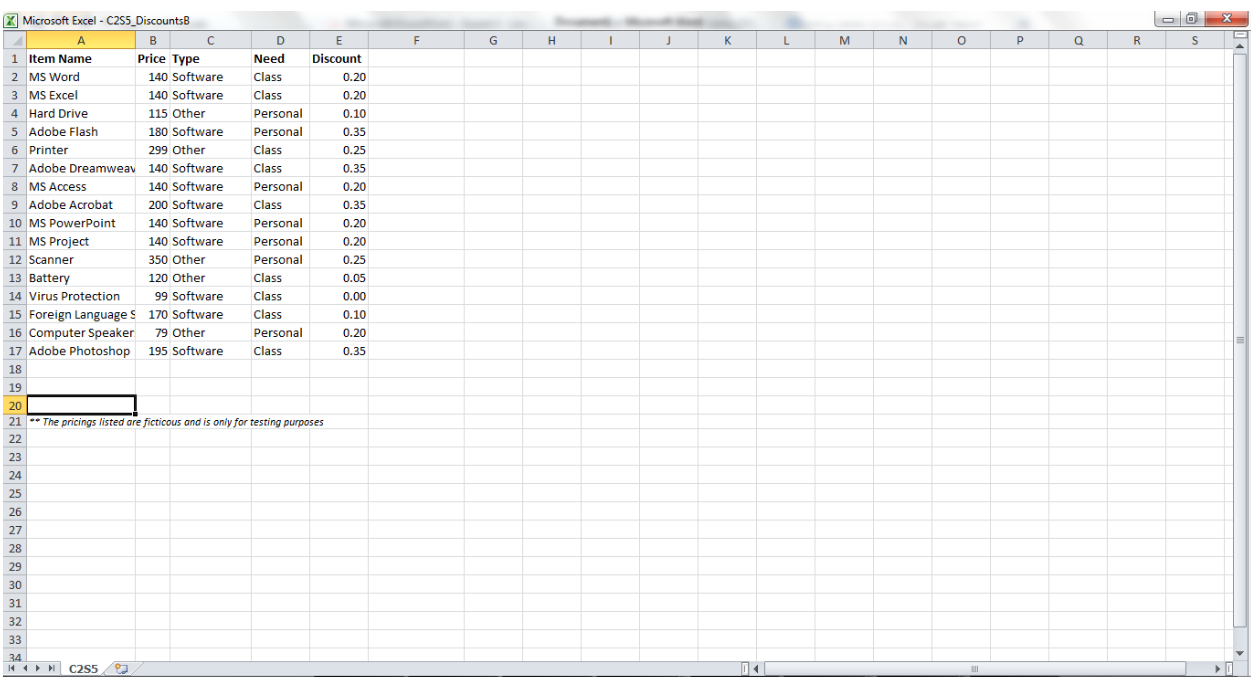


Cady's Class and Book List

Freshman Year First Semester

Class Number	Class Name	Book Name	Book Price
PSY1010	Introductory Psychiatry	Child and Adolescent Psychiatry	56.00
PSY1010	Introductory Psychiatry	Fear, Intuition and Impact on Decision Making	90.35
PSY1010	Introductory Psychiatry	Behavioral Economics	84.33
PSY1010	Introductory Psychiatry	Understanding the Crux of Human Reasoning	113.26
ECO2010	Principles of Microeconomics	Microeconomics	143.62
ECO2010	Principles of Microeconomics	Principles of Microeconomics	124.34
ECO2010	Principles of Microeconomics	Microeconomics Workbook	68.20
ECO2010	Principles of Microeconomics	Microeconomics: Principles Applications and Tools	130.01
ECO2010	Principles of Microeconomics	Microeconomics and Impact on the Global Economy	117.56
CSC1000	Computer Literacy	Computer Literacy Basics	95.50
CSC1000	Computer Literacy	The Idiots Guide to Computer Literacy	47.74
ACC3010	Introduction to Financial Accounting	Managing Cash Flow	115.20
ACC3010	Introduction to Financial Accounting	The Analysis and Understanding Financial Statements	139.20
ACC3010	Introduction to Financial Accounting	Management Control Systems	128.74
ACC3010	Introduction to Financial Accounting	Fundamentals of Financial Accounting	67.68
Totals			

Figure B1. Screenshot of task from Case Study 1 Scenario 6

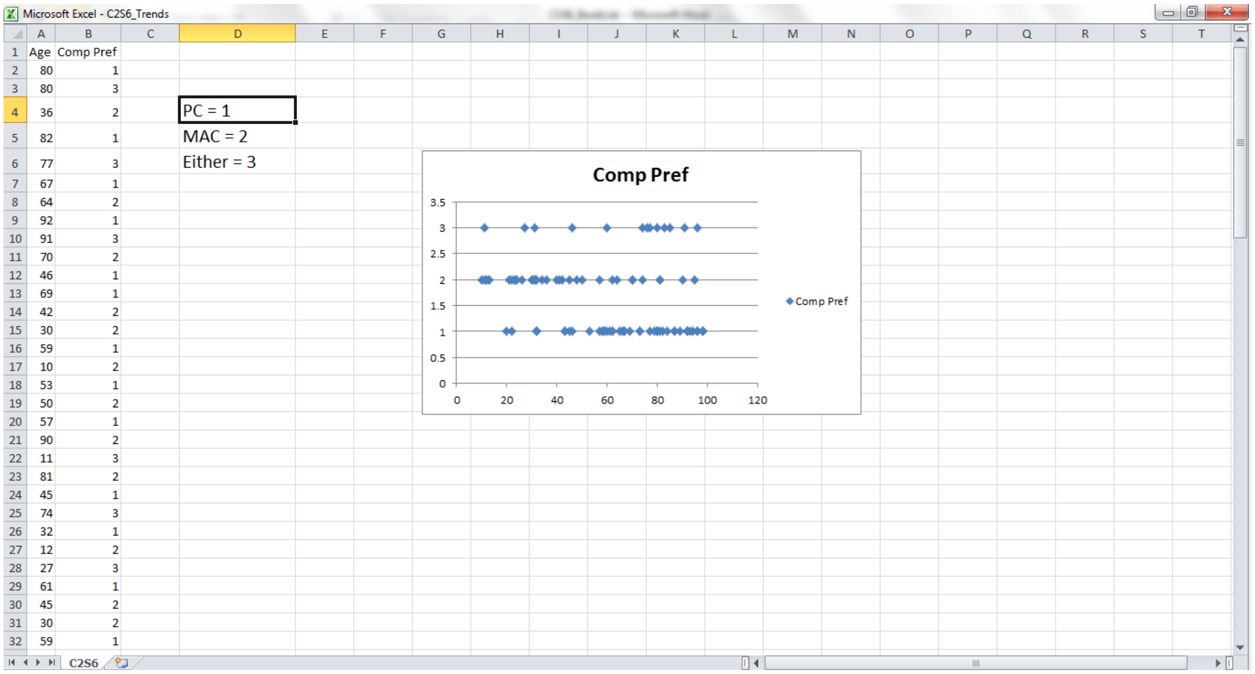


Microsoft Excel - C2S5_DiscountsB

	A	B	C	D	E
1	Item Name	Price	Type	Need	Discount
2	MS Word	140	Software	Class	0.20
3	MS Excel	140	Software	Class	0.20
4	Hard Drive	115	Other	Personal	0.10
5	Adobe Flash	180	Software	Personal	0.35
6	Printer	299	Other	Class	0.25
7	Adobe Dreamweav	140	Software	Class	0.35
8	MS Access	140	Software	Personal	0.20
9	Adobe Acrobat	200	Software	Class	0.35
10	MS PowerPoint	140	Software	Personal	0.20
11	MS Project	140	Software	Personal	0.20
12	Scanner	350	Other	Personal	0.25
13	Battery	120	Other	Class	0.05
14	Virus Protection	99	Software	Class	0.00
15	Foreign Language S	170	Software	Class	0.10
16	Computer Speaker	79	Other	Personal	0.20
17	Adobe Photoshop	195	Software	Class	0.35
21	** The pricings listed are ficticous and is only for testing purposes				

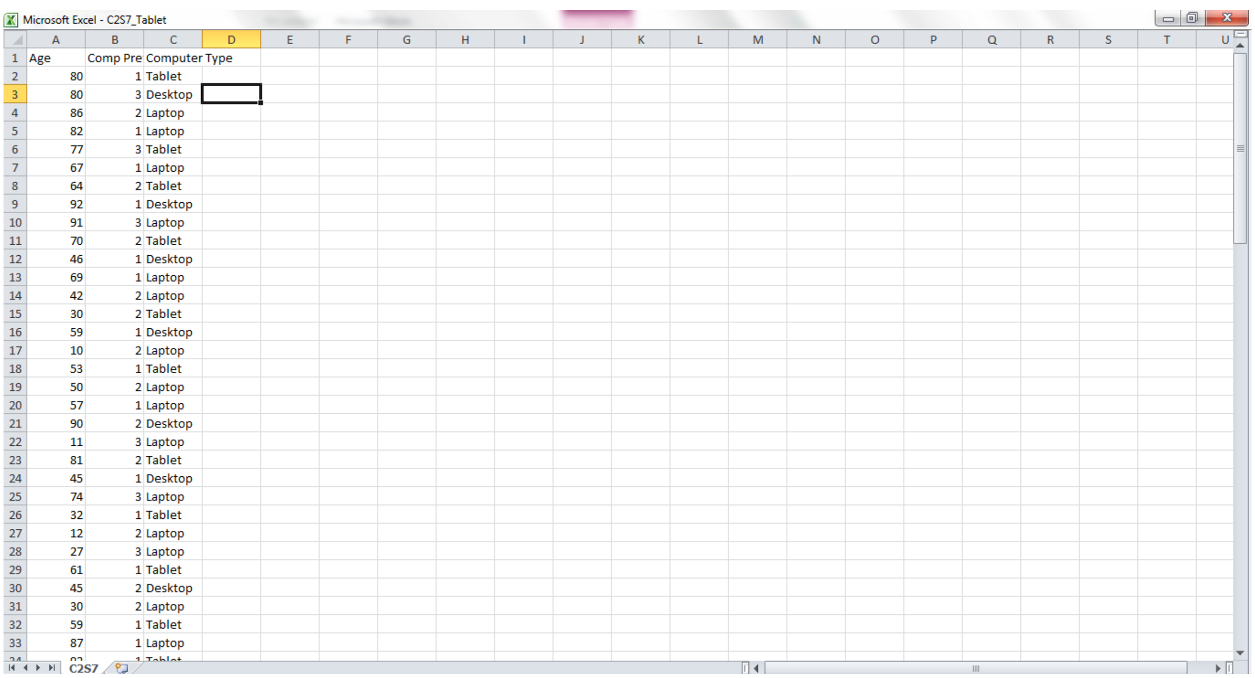
C2S5

Figure B2. Screenshot of task from Case Study 2 Scenario 5



Age	Comp Pref
80	1
80	3
36	2
82	1
77	3
67	1
64	2
92	1
91	3
70	2
46	1
69	1
42	2
30	2
59	1
10	2
53	1
50	2
57	1
90	2
11	3
81	2
45	1
74	3
32	1
12	2
27	3
61	1
45	2
30	2
59	1

Figure B3. Screenshot of task from Case Study 2 Scenario 6



Age	Comp Pre	Computer Type
80	1	Tablet
80	3	Desktop
86	2	Laptop
82	1	Laptop
77	3	Tablet
67	1	Laptop
64	2	Tablet
92	1	Desktop
91	3	Laptop
70	2	Tablet
46	1	Desktop
69	1	Laptop
42	2	Laptop
30	2	Tablet
59	1	Desktop
10	2	Laptop
53	1	Tablet
50	2	Laptop
57	1	Laptop
90	2	Desktop
11	3	Laptop
81	2	Tablet
45	1	Desktop
74	3	Laptop
32	1	Tablet
12	2	Laptop
27	3	Laptop
61	1	Tablet
45	2	Desktop
30	2	Laptop
59	1	Tablet
87	1	Laptop

Figure B4. Screenshot of task from Case Study 2 Scenario 7

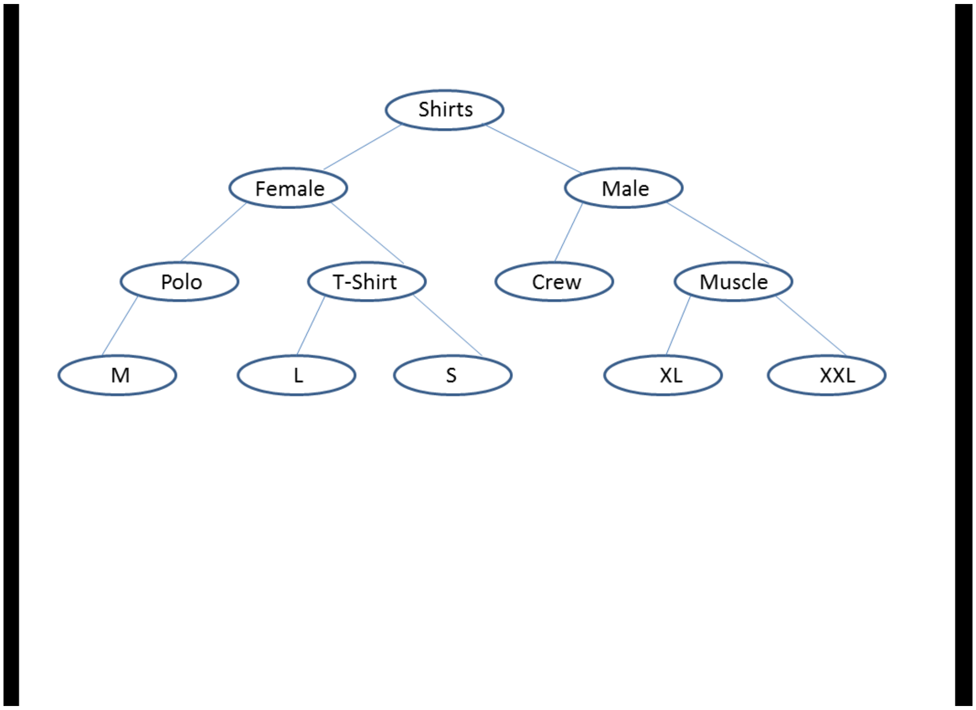


Figure B5. Screenshot of task from Case Study 3 Scenario 7

APPENDIX C: COTHAULE DESIGN STORYBOARD

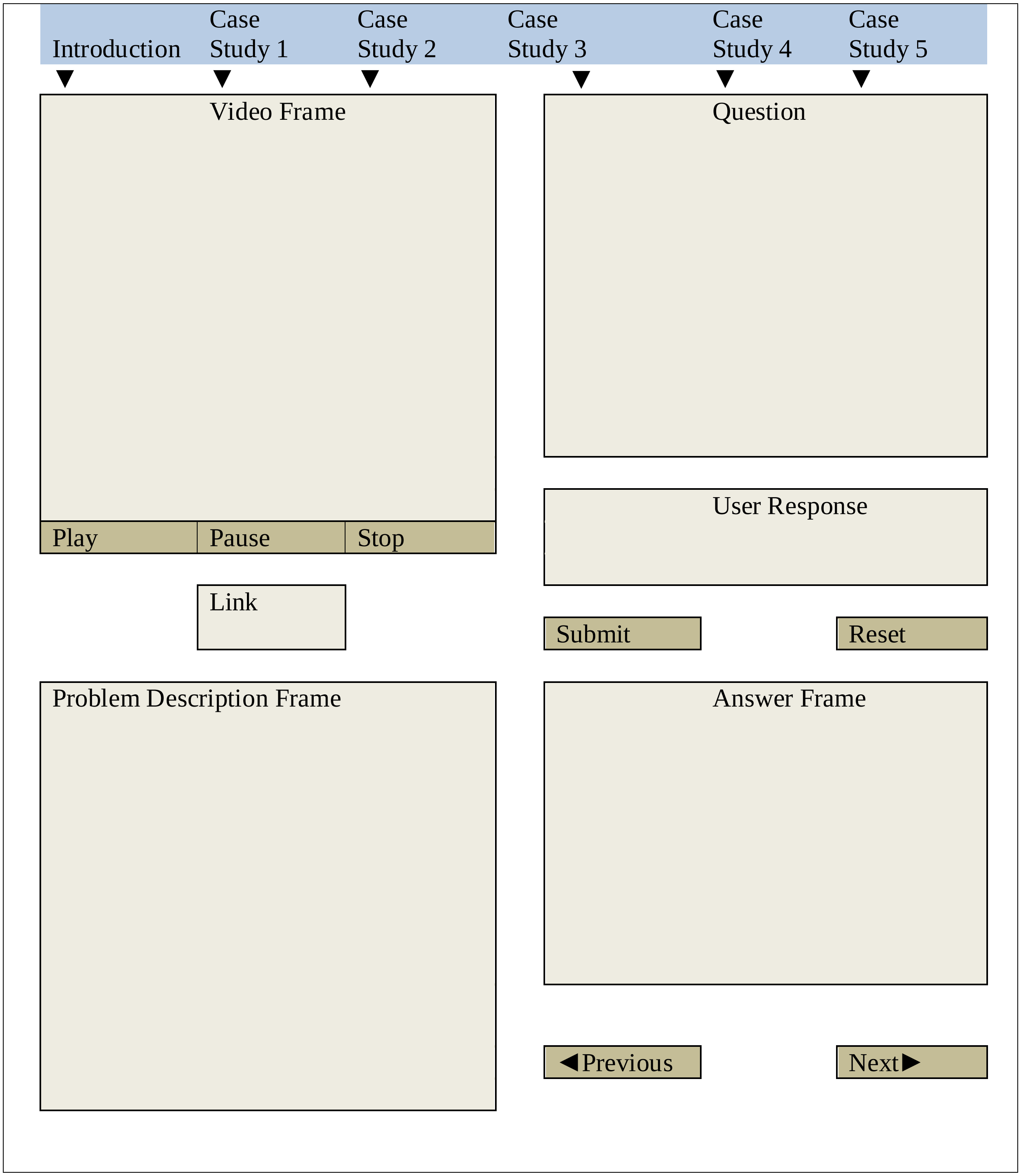


Figure C1. COTHAULE storyboard for the fill-in-the-blank problem. Storyboard was developed using Microsoft Excel and represents one of two primary working screens in COTHAULE.

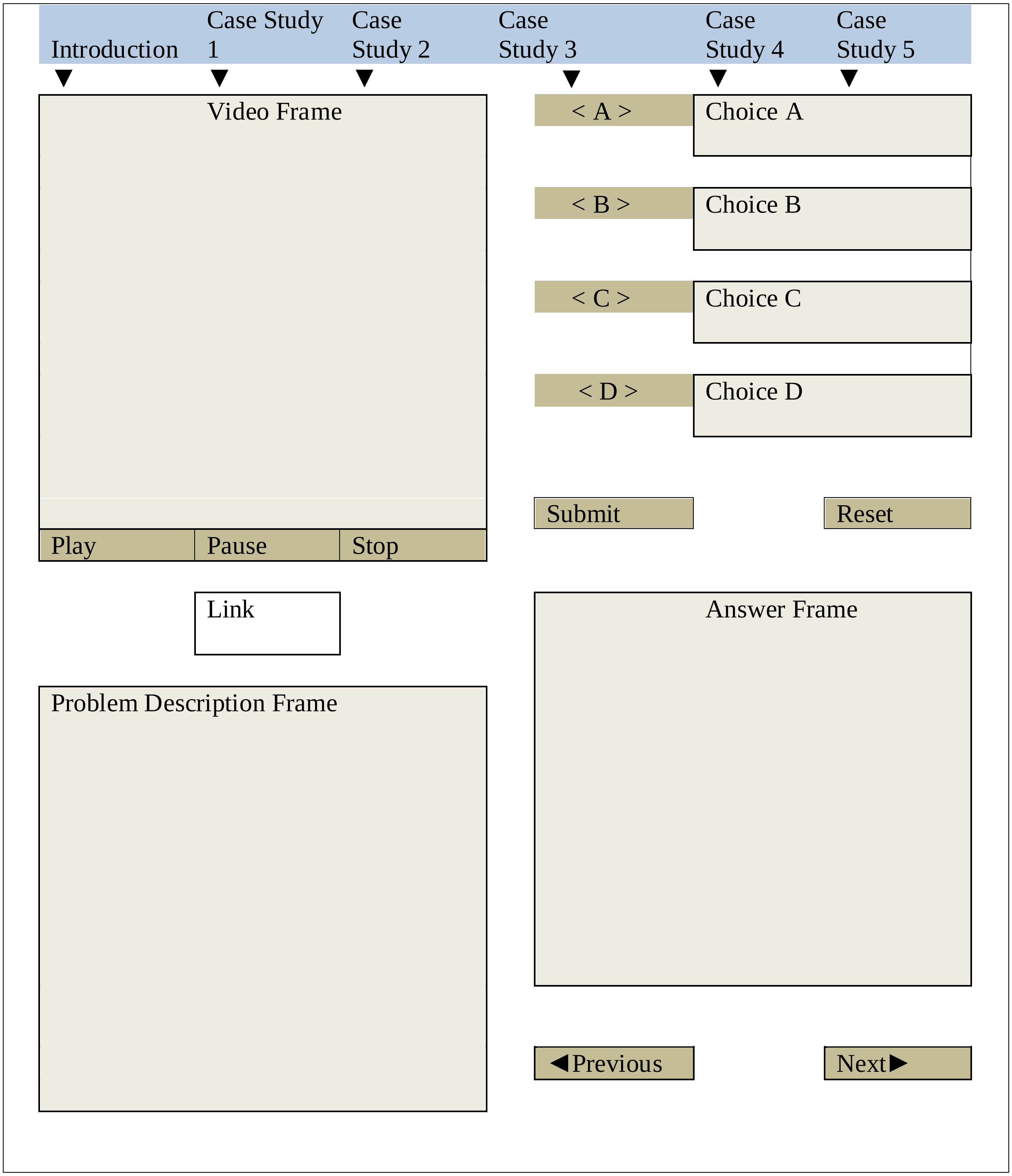


Figure C2. COTHAULE storyboard for the multiple-choice problem. Storyboard was developed using Microsoft Excel and represents one of two primary working screens in COTHAULE.

APPENDIX D: COTHAULE DATABASE SCHEMA

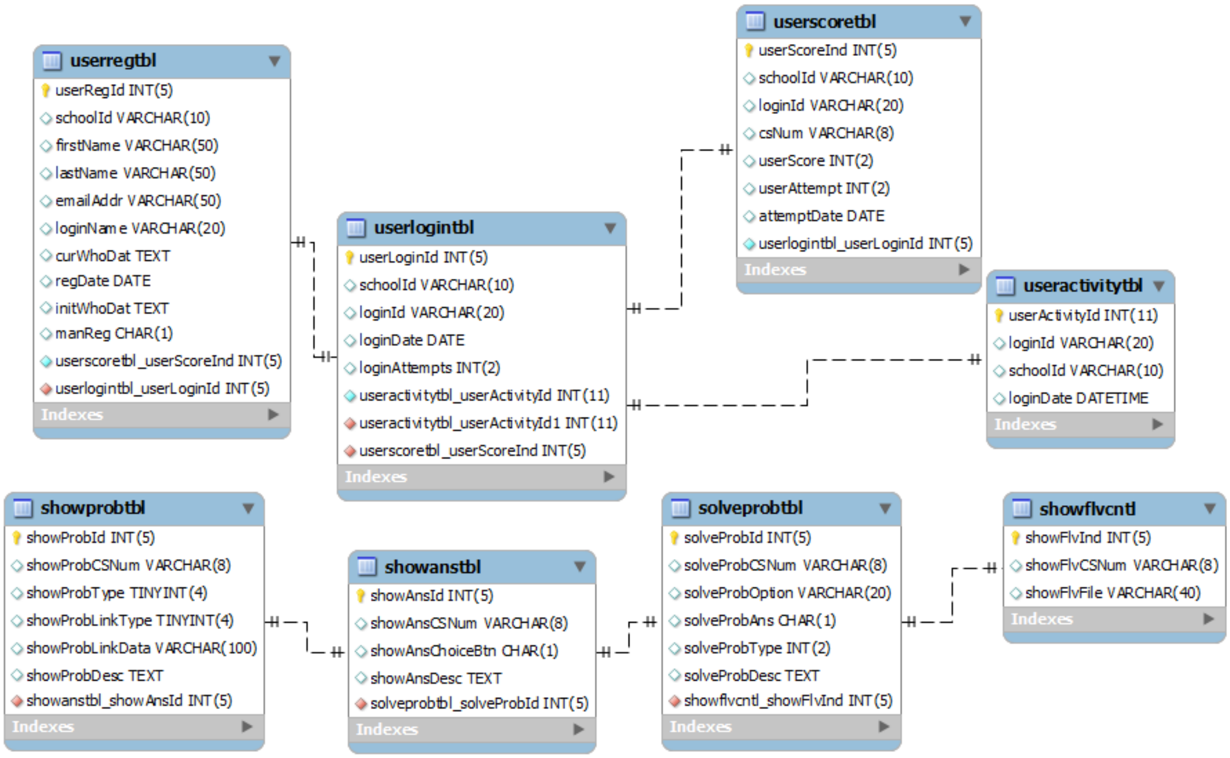


Figure D1. COTHAULE database schema showing all tables designed using MySQL Workbench. The top row of tables is used to format and capture end-user activity while the bottom row of tables is used to store the problems and corresponding answers that would appear to the end-user within the website.

APPENDIX E: COTHAULE SCREENSHOTS

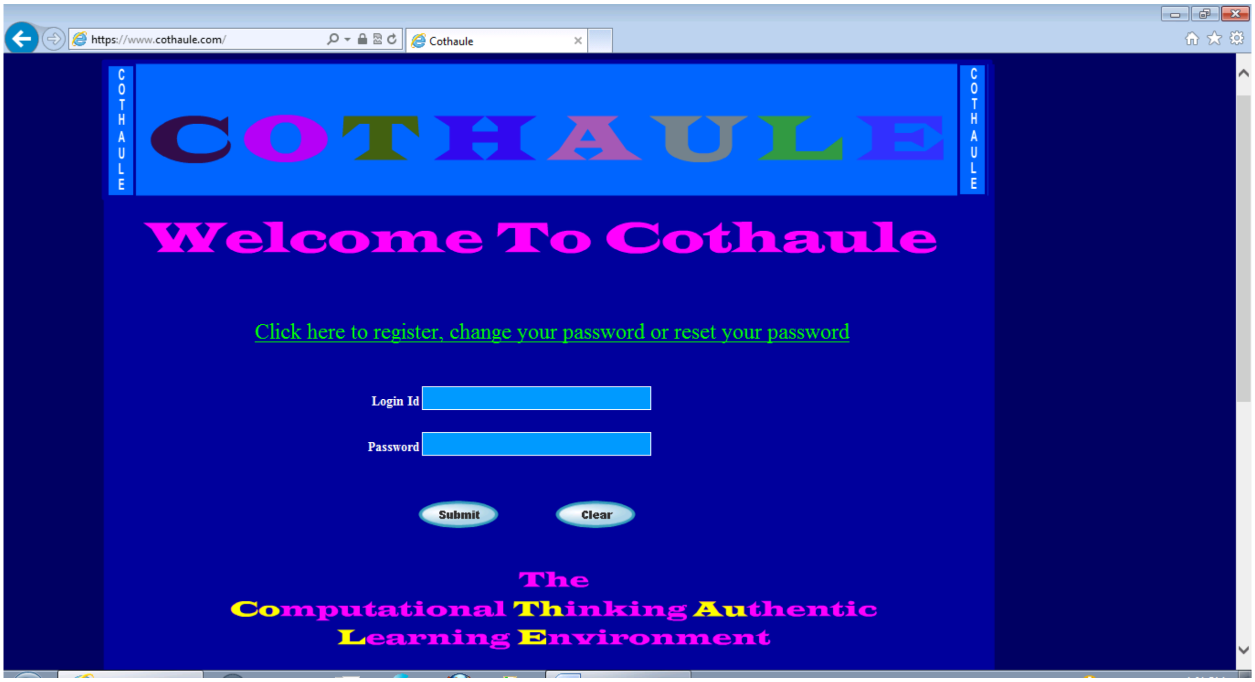


Figure E1. COTHAULE website login screen.

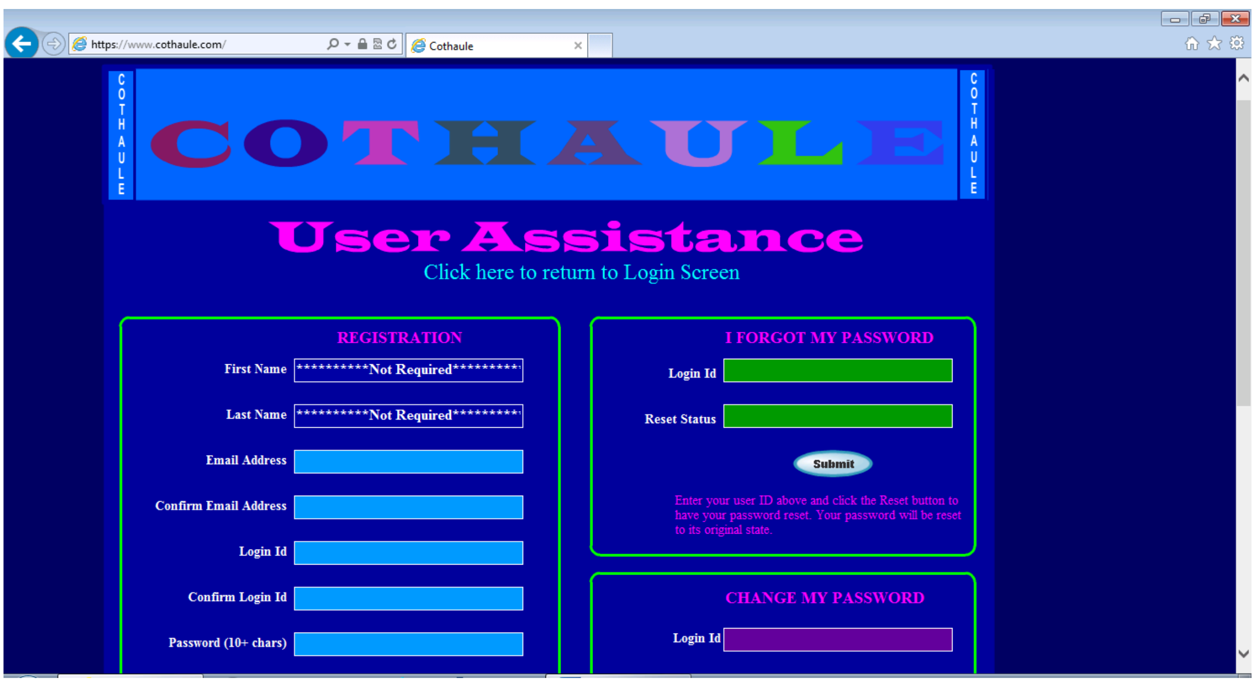


Figure E2. COTHAULE user assistance screen.

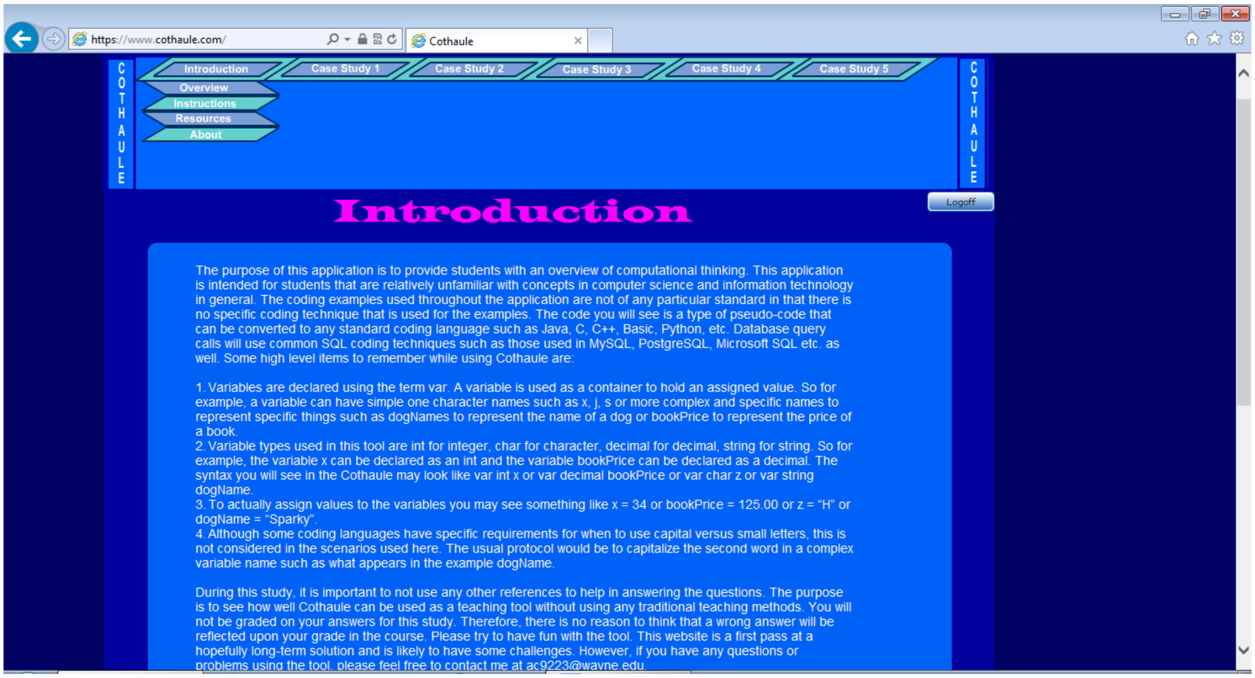


Figure E3. COTHAULE introduction Screen.

Figure E4. COTHAULE overview screen.

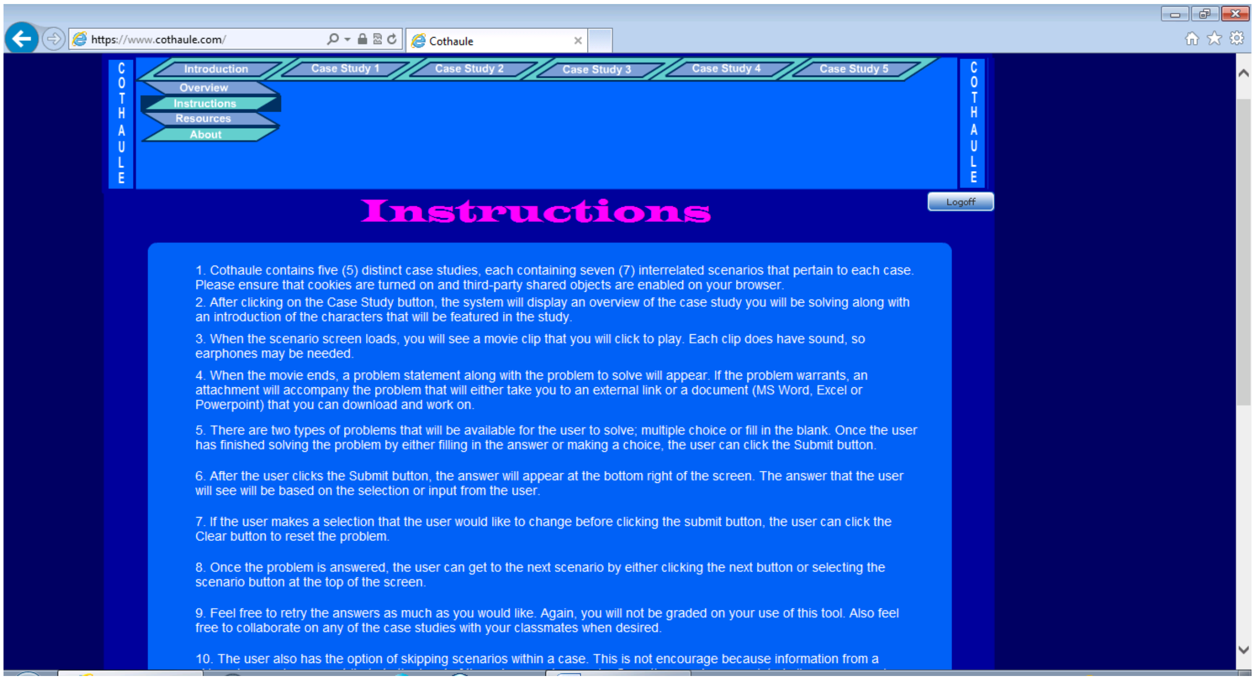


Figure E5. COTHAULE instructions screen.

Figure E6. COTHAULE resources screen.

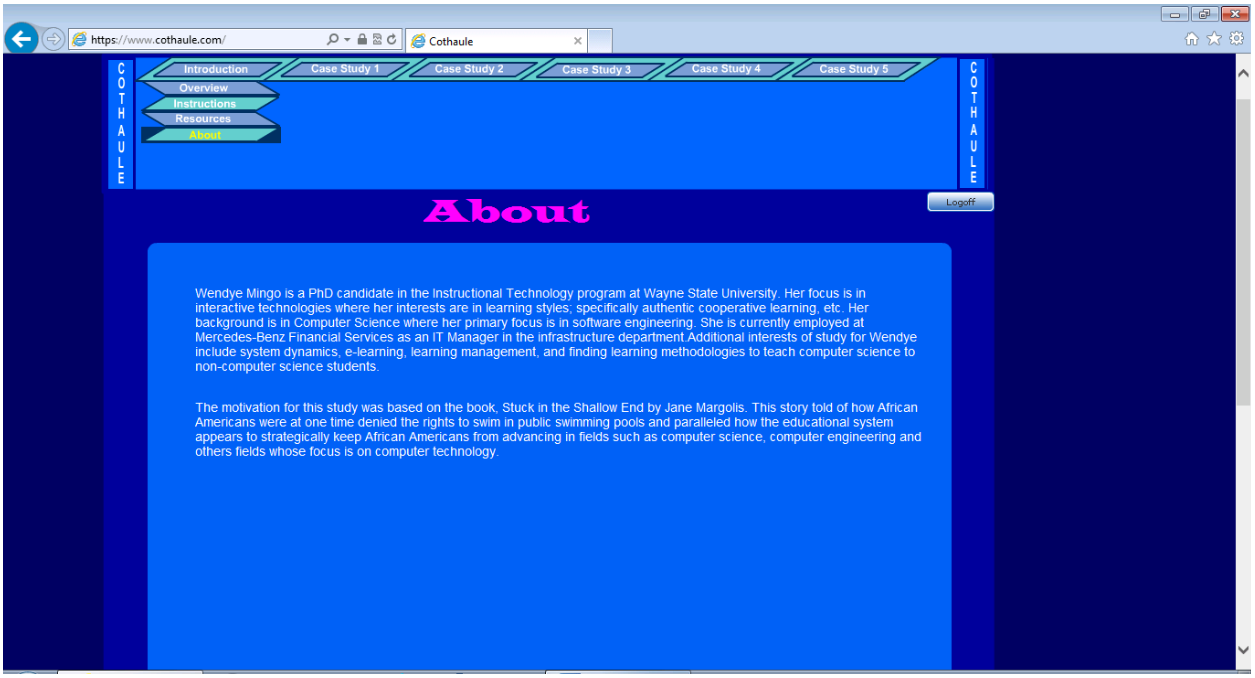


Figure E7. COTHAULE about screen.

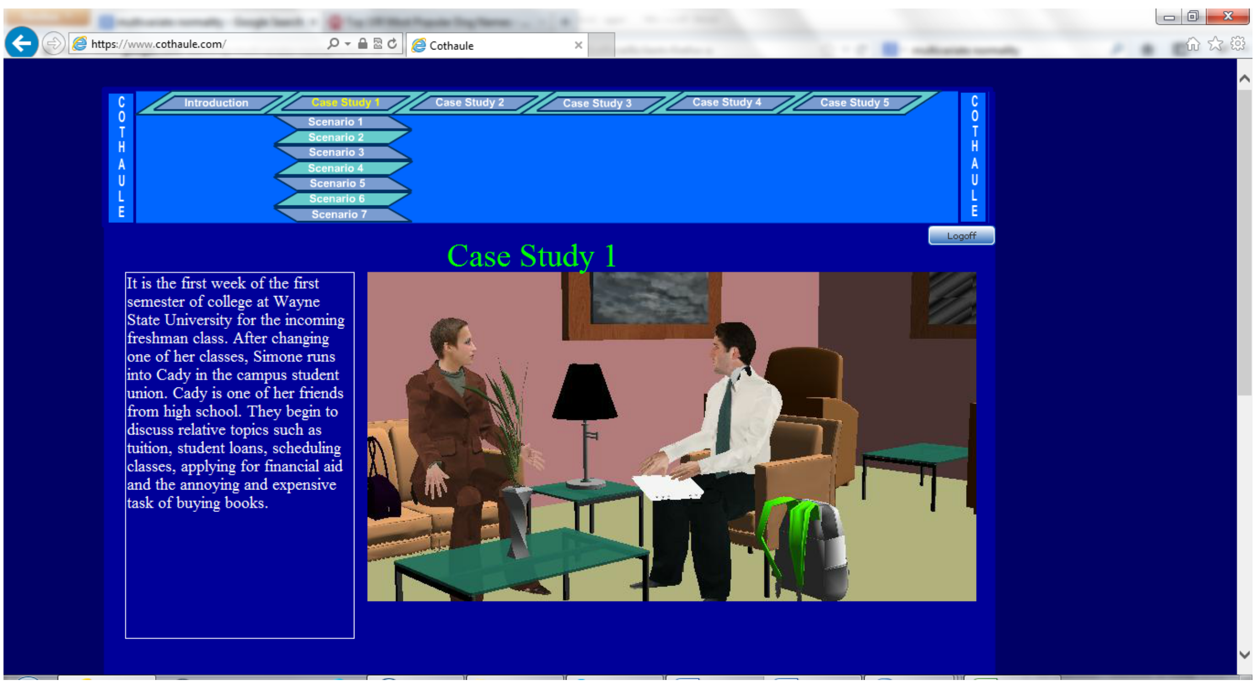


Figure E8. Splash screen for case study one.

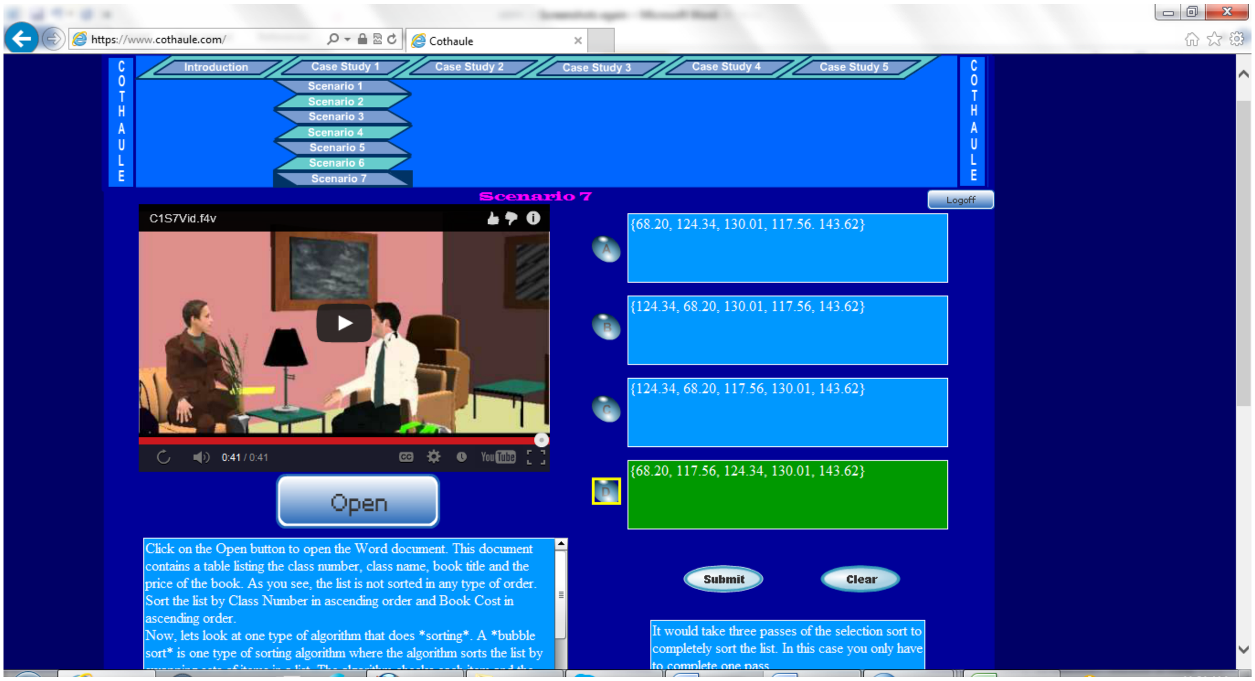


Figure E9. Multiple-choice example with a link to an authentic learning activity. Screenshot was taken from case study one scenario seven.

Figure E10. Fill-in-the-blank example with a link to an authentic learning activity. Screenshot was taken from case study two scenario four.

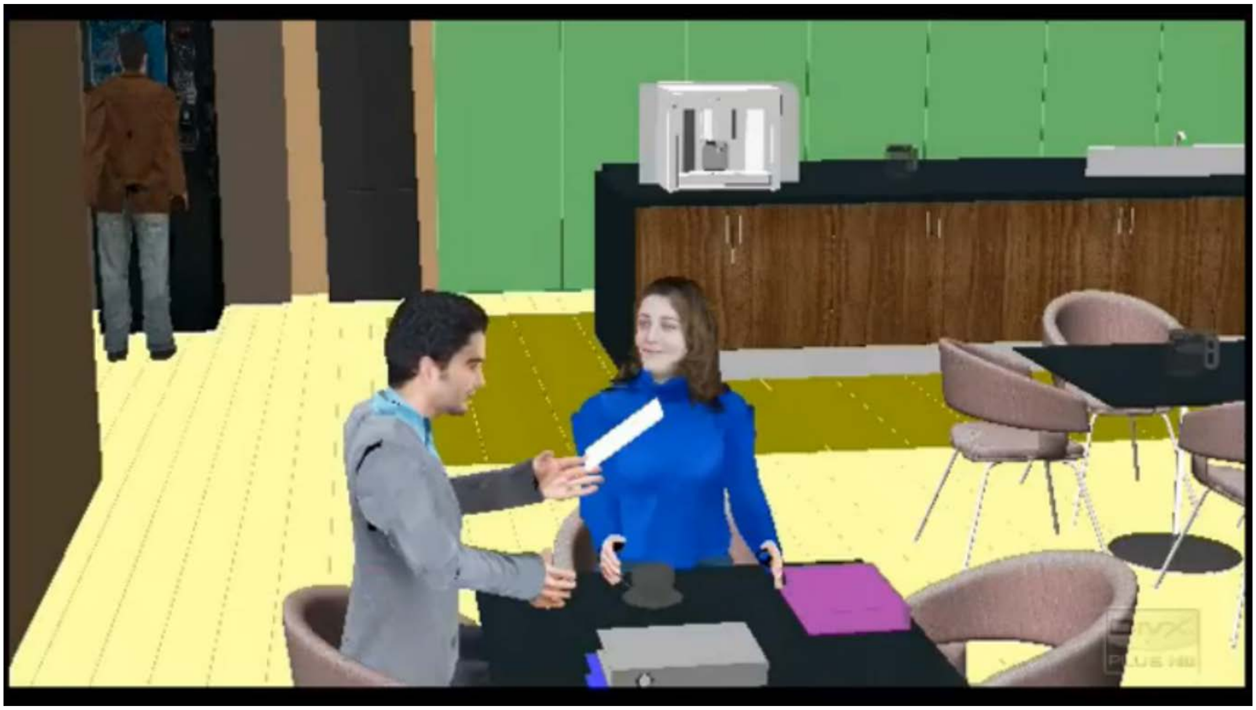


Figure E11. Full screen screenshot of a scenario in case study two.

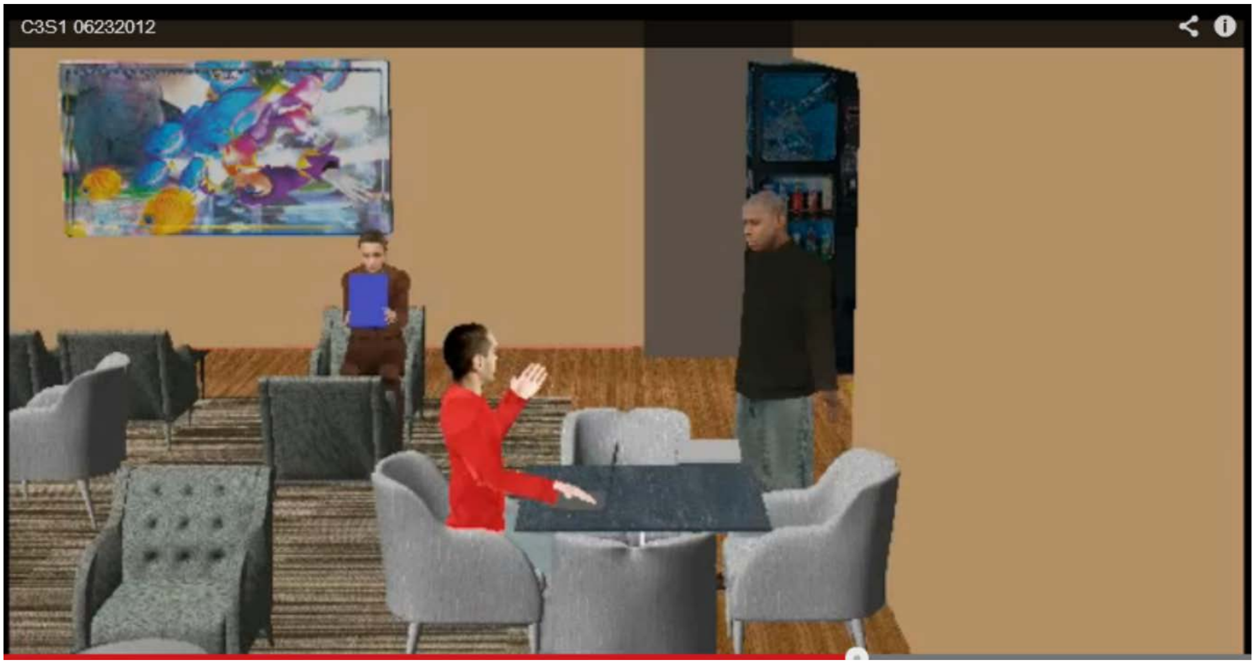


Figure E12. Full screen screenshot of a scenario in case study three.

Figure E13. Full screen screenshot of a scenario in case study four.

Figure E14. Full screen screenshot of a scenario in case study five.

APPENDIX F: COTHAULE FUNCTIONAL AND OPERABILITY TESTING SPREADSHEET

COTHAULE Functional and Operability Testing Spreadsheet

Test Case No.	Name	Action	Test Data	Expected Outcome
Login-1	Valid User ID and Valid Password	Enter the correct Login ID and password	Login Id: ac1111 Password: $hortCake123	The system should route the user to the Introduction splash screen.
Login-2	Invalid User ID and Invalid Password	Enter an incorrect Login ID and an incorrect password	Login Id:xyz123 Password:XYZ123	The system should display a "Login Id not found in the system" message. The system should clear the User Id and Password from the screen.
Login-3	Invalid User ID and Valid password	Enter an incorrect Login ID and a correct password	Login Id:xyz123 Password:XYZ123	The system should display a "Login Id not found in the system" message. The system should clear the User Id and Password from the screen.
Login-4	Valid User ID and Invalid password	Enter a correct user ID and an incorrect password	Login Id:ac1111 Password:XYZ124	The system should display an "Invalid password" message. The system should clear the Login Id and Password from the screen.
Login-5	Runaway User ID	Attempt to enter an infinite number of characters in the Login ID field	Login Id: zzzzzzzzzzzzzzzzzzzz	The system should prevent the user from entering more than 20 characters.
Login-6	Runaway Password	Attempt to enter an infinite number of characters in the Password field	Login Id: ssssssssssssssssssss	The system should prevent the user from entering more than 20 characters.
Login-7	Blank Login Id	The user clicks the Submit button without entering a Login Id.	Login Id:	The system should display a "Login cannot be blank" message.
Login-8	Blank Password	Enter a Login Id but leaves the Password blank	Login Id: ac1111 Password:	The system should display a "Password cannot be blank" message.
Login-9	Lock User ID 2	Enter the same incorrect password with the same valid user ID 6 times	Login Id: ac1111 Password: dddddd	The system should lock the ID and display a "The password is locked. Please contact the administrator" message.
Login-10	Clear	Enter data into the fields and clicks the Clear button	Login Id: ac1111 Password: dddddd	The system should clear the information for both the Login Id and Password.
Register-1	Blank First	Keep the First	First Name:	The system should display a

	Name	Name blank and clicks the Submit button		"First Name is required" message.
Register-2	Blank Last Name	Keep the First Name blank and clicks the Submit button	First Name: John Last Name:	The system should display a "Last Name is required" message.
Register-3	Blank Email Address	Keep the Email Address blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address:	The system should display an "Email Address is required" message.
Register-4	Blank Confirm Email Address	Keep the Confirm Email Address blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: <blank>	The system should display a "Confirm Email Address is required" message.
Register-5	Blank Login Id	Keep the Login Id blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id:	The system should display a "Login Id is required" message.
Register-6	Blank Confirm Login Id	Keep the Confirm Login Id blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id: mydogRusty1 Confirm Login Id:	The system should display a "Confirm Login Id is required" message.
Register-7	Blank Password	Keep the Password blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id: mydogRusty1	The system should display a "Password is required" message.

			Confirm Login Id: az5555 Password:	
Register-8	Blank Confirm Password	Keep the Confirm Password blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id: az5555 Confirm Login Id: az5555 Password: mydogRusty1 Confirm Password:	The system should display a "Confirm Password is required" message.
Register-9	Email Addresses Don't Match	Enter different email addresses in the Email Address and Confirm Email Address fields and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson222@spacely.com Login Id: az5555 Confirm Login Id: az5555 Password: mydogRusty1 Confirm Password: mydogRusty1	The system should display an "Email Address and Confirm Email Address must match" message.
Register-10	Login Ids Don't Match	Enter different login Ids in the Login Id and Confirm Login Id fields and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id: az5555 Confirm Login Id: az7777 Password: mydogRusty1 Confirm Password: mydogRusty1	The system should display a "Login Id and Confirm Login Id must match" message.
Register-11	Passwords	Enter different	First Name: John	The system should display a

	Don't Match	passwords in the New Password and Confirm New Password fields and clicks the Submit button	Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id: az5555 Confirm Login Id: az7777 Password: mydogRusty1 Confirm Password: mydogRusty8	"Password and Confirm Password must match" message.
Register-12	Duplicate Email Address	Submit an entry where the Email Address is already being used by someone else	First Name: Lisa Last Name: Jetson Email Address: LJetson000@spacely.com Confirm Email Address: LJetson000@spacely.com Login Id: ao0000 Confirm Login Id: ao0000 Password: mydogRusty2 Confirm Password: mydogRusty2	The system should display a "This Email Address is already taken" message.
Register-13	Duplicate Login Id	Submit an entry where the Login Id is already being used by someone else	First Name: Lisa Last Name: Jetson Email Address: LJetson000@spacely.com Confirm Email Address: LJetson000@spacely.com Login Id: az5555 Confirm Login Id: az5555 Password: mydogRusty2 Confirm Password: mydogRusty2	The system should display a "This Login Id is already taken" message.
Register-14	Clear	Enter data into the fields and clicks the Clear button	First Name: Willow Last Name: Flintstone Email Address:	The system should clear the information for all of the Registration fields.

			WFlint000@spacely .com Confirm Email Address: WFlint000@spacely .com Login Id: af2222 Confirm Login Id: af2222 Password: mydogBailey99 Confirm Password: mydogBailey99	
Register-15	Password Length	Enter a Password shorter than 10 characters and clicks the Submit button	Password: abcde1234	The system should display a "Passwords must be at least 10 characters long" message.
Register-16	Confirm Password length	Enter a Confirm Password shorter than 10 characters and clicks the Submit button	Password: abcde12345 Confirm Password: abcde1234	The system should display a "Passwords must be at least 10 characters long" message.
Register-17	Invalid Email Address	Enter an invalid format Email Address and clicks the Submit button	Email Address: abc@@@..com	The system should display a "Please enter a valid email address" message.
Register-18	Invalid Confirm Email Address	Enter an invalid format Confirm Email Address and clicks the Submit button	Confirm Email Address: myemail.is.bad.com	The system should display a "Please enter a valid email address" message.
Register-19	Runaway First Name	Attempt to enter an infinite number of characters in the First Name field	Login Id: This is a very very very very very very very long name	The system should prevent the user from entering more than 50 characters.
Register-20	Runaway Last Name	Attempt to enter an infinite number of characters in the Last Name field	Login Id: This is a very very very very very very very long name	The system should prevent the user from entering more than 50 characters.
Register-21	Runaway Email Address	Attempt to enter an infinite number of characters in the Email Address field	Email Address: 201 d' s	The system should prevent the user from entering more than 200 characters.
Register-22	Runaway Confirm Email Address	Attempt to enter an infinite number of characters in the Confirm Email	Email Address: 201 d' s	The system should prevent the user from entering more than 200 characters.

		Address field		
Register-23	Runaway Login Id	Attempt to enter an infinite number of characters in the Login Id field	Login Id: jjjjjjjjjjjjjjjjjjjjj	The system should prevent the user from entering more than 20 characters.
Register-24	Runaway Confirm Login Id	Attempt to enter an infinite number of characters in the Confirm Login Id field	Confirm Login Id: kkkkkkkkkkkkkkk kkkkk	The system should prevent the user from entering more than 20 characters.
Register-25	Runaway Password	Attempt to enter an infinite number of characters in the Password field	Password: pppppppppppppppp ppppp	The system should prevent the user from entering more than 20 characters.
Register-26	Runaway Confirm Password	Attempt to enter an infinite number of characters in the Confirm Password field	Password: ccccccccccccccccc ccc	The system should prevent the user from entering more than 20 characters.
Register-27	Invalid First Name Characters	Attempt to enter non-alphabet characters in the First Name field	First Name: 1234567890)(*&^% %$#@!	The system should prevent the user from entering non-alphabet characters.
Register-28	Invalid Last Name Characters	Attempt to enter non-alphabet characters in the Last Name field	Last Name: 1234567890)(*&^% %$#@!	The system should prevent the user from entering non-alphabet characters.
Register-29				
Register-30				
Forgot Password-1	Valid User ID	Enter a valid user ID into the Login Id field and clicks the Submit button	Login Id: ac1111	The reset status in the system should display a "Your password has been reset" message.
Forgot Password-2	Invalid User ID	Enter an invalid user ID into the Login Id field and clicks the Submit button	Login Id: WhoRU?	The reset status in the system should display a "Login Id not found" message.
Forgot Password-3	Update Reset Status	Attempt to edit the Reset Status textbox		The system should not allow edits in that field
Forgot Password-4	Blank User ID	The user does not enter anything into the Login Id field and clicks the Submit button	Login Id:	The system should return a "Blank Login Id" message.
Forgot Password-5	Runaway Login ID	Attempt to enter an infinite number of characters into the Login Id field	Login Id: rrrrrrrrrrrrrrrrrrrr	The system should prevent the user from entering more than 20 characters.
Change	All Valid	Enter a valid	Login Id: ac1111	The system should display a

Password-1	Data	Login Id, correct Old Password and correct New Passwords and clicks the Submit button	Old Password: $hortCake123 New Password: C@shews456 Confirm Password: C@shews456	"Your password has been changed" message.
Change Password-2	Invalid User ID	Enter an invalid Login Id and correct Current Password and clicks the Submit button	Login Id: ac2222 Old Password: $hortCake123 New Password: C@shews456 Confirm New Password: C@shews456	The system should display a "Login Id not found in the system" message.
Change Password-3	Invalid Current Password	Enter a valid Login Id and invalid password in the Current Password field and clicks the Submit button	Login Id: ac1111 Old Password: gigo24$#@% New Password: C@shews456 Confirm New Password: C@shews456	
Change Password-4	New Password Confirm New Password No Match	Enter different passwords in the New Password and Confirm New Password fields and clicks the Submit button	Login Id: ac1111 Old Password: $hortCake123 Old Password: C@shews456 Confirm Password: C@shews789	The system should display a "New and Confirm New Passwords must match" message.
Change Password-5	Login ID Blank	The user leaves the Login ID field blank and clicks the Submit button	Login Id:	The system should display a "Login Id cannot be blank" message.
Change Password-6	Current Password Blank	The user leaves the Current Password blank and clicks the Submit button	Login Id: ac111 Current Password:	The system should display a "Current Password cannot be blank" message.
Change Password-7	New Password Blank	The user leaves the New Password field blank and clicks the Submit button	Login Id: ac111 Current Password: $hortCake123 New Password:	The system should display a "New Password cannot be blank" message
Change Password-8	Confirm New Password Blank	The user leaves the Confirm New Password field blank and clicks the Submit button	Login Id: ac111 Current Password: $hortCake123 New Password: C@shews456 Confirm New Password:	The system should display a "Confirm New Password cannot be blank" message
Change	Runaway	Attempt to enter	Login Id:	The system should prevent

Password-9	Login ID	an infinite number of characters into the Login Id field	rtrtrtrtrtrtrtrtrtrtr	the user from entering more than 20 characters
Change Password-10	Runaway Old Password	Attempt to enter an infinite number of characters into the Old Password field	Current Password: zxzxzxzxzxzxzxzxzxzxz	The system should prevent the user from entering more than 20 characters
Change Password-11	Runaway New Password	Attempt to enter an infinite number of characters into the Confirm New Password field	New Password: nvnvnvnvnvnvnvnvnvnvn	The system should prevent the user from entering more than 20 characters
Change Password-12	Runaway Confirm New Password	Attempt to enter an infinite number of characters into the Confirm New Password field	Confirm New Password: erererererererererere	The system should prevent the user from entering more than 20 characters
Change Password-13	Clear	Enter data into the fields and clicks the Clear button	Login Id: abc Old Password: xyz New Password: fgh Confirm New Password: lmn	The system should clear the information for all four Change Password fields
Change Password-14	New Password Length	Enter a New Password with less than 10 characters	Login Id: ac1111 Old Password: $hortCake123 New Password: Iamshort1 Confirm New Password: Iamshort2	The system should display a "Passwords must be at least 10 characters long" message
Change Password-15	Confirm New Password Length	Enter a Confirm New Password with less than 10 characters	Login Id: ac1111 Old Password: $hortCake123 New Password: IamNotshort1 Confirm New Password: Iamshort2	The system should display a "Passwords must be at least 10 characters long" message
Introduction -1	Intro Next Page	The user clicks the Next button on the Introduction Page	Click Next	The system should display the Overview screen
Introduction -2	Overview Next Page	The user clicks the Next button on the Overview Page	Click Next	The system should display the Instructions screen
Introduction -3	Instructions Next Page	The user clicks the Next button on the Instructions Page	Click Next	The system should display the Resources screen
Introduction -4	Resources Next Page	The user clicks the Next button on the Resources Page	Click Next	The system should display the About screen
Introduction -5	About Previous	The user clicks the Previous button on	Click Previous	The system should display the Resources screen

	Page	the About Page		
Introduction -6	Resources Previous Page	The user clicks the Previous button on the Resources Page	Click Previous	The system should display the Instructions screen
Introduction -7	Instructions Previous Page	The user clicks the Previous button on the Instructions Page	Click Previous	The system should display the Overview screen
Introduction -8	Overview Previous Page	The user clicks the Previous button on the Overview Page	Click Previous	The system should display the Introduction screen
Introduction -9	Introduction Nav Button	The user clicks the Introduction Nav button at the top of the screen	Click Introduction	The system should display the Introduction screen.
Introduction -10	Overview Nav Button	The user clicks the Overview Nav button at the top of the screen	Click Overview	The system should display the Overview screen.
Introduction -11	Instructions Nav Button	The user clicks the Instructions Nav button at the top of the screen	Click Instructions	The system should display the Instructions screen.
Introduction -12	Resources Nav Button	The user clicks the Resources Nav button at the top of the screen	Click Resources	The system should display the Resources screen.
Introduction -13	About Nav Button	The user clicks the About Nav button at the top of the screen	Click About	The system should display the About screen.
Introduction -14	Mix Intro Button	The user clicks the Next Button on the Introduction screen and then clicks the Instructions Nav button at the top of the screen	Click Next on Instructions, Click Introduction	The system should display the Overview screen then the Instructions screen.
Introduction -15	Mix Overview Button	The user clicks the Previous Button on the Overview screen and then clicks the About Nav button at the top of the screen	Click Previous on Overview, Click About	The system should display the Introduction screen then the About screen.
Introduction -16	Mix Instructions Button	The user clicks the Previous Button on the Instructions screen and then	Click Previous on Instructions, Click About	The system should display the Overview screen then the About screen.

		clicks the About Nav button at the top of the screen		
Introduction -17	Mix Resources Button	The user clicks the Overview Nav button on the top of the Resources screen and then clicks the Next button	Click Overview, Click Next on Overview	The system should display the Overview screen then the Instructions screen.
Introduction -18	Mix About Button	The user clicks the Previous Button on the About screen and then clicks the Introduction button at the top of the screen	Click Previous, Click Introduction	The system should display the Resources screen then the Introduction screen.
Introduction -19	Click CaseStudy-x Button	The user clicks the Previous Button on the Instructions screen and then clicks the Case Study 1 Nav button at the top of the screen	Click Previous on Instructions, Click Case Study *1*	The system should display the Overview screen then the Case Study 1 splash screen.
CaseStudy1-1	CaseStudy1 Next Page	The user clicks the Next button on the Case Study 1 screen	Click Next	The system should display the Scenario 1 screen and loads the movie only.
CaseStudy1-2	Scenario1 Next Page Movie	The user clicks the Next button on the Scenario 1 screen with movie only	Click Next	The system should display the Scenario 2 screen and load the movie only.
CaseStudy1-3	Scenario2 Next Page Movie	The user clicks the Next button on the Scenario 2 screen w/movie only	Click Next	The system should show the Scenario 3 screen and load the movie only.
CaseStudy1-4	Scenario3 Next Page Movie	The user clicks the Next button on the Scenario 3 screen w/movie only	Click Next	The system should show the Scenario 4 screen and load the movie only.
CaseStudy1-5	Scenario4 Next Page Movie	The user clicks the Next button on the Scenario 4 screen w/movie only	Click Next	The system should show the Scenario 5 screen and load the movie only.
CaseStudy1-6	Scenario5 Next Page Movie	The user clicks the Next button on the Scenario 5 screen w/movie only	Click Next	The system should show the Scenario 6 screen and load the movie only.
CaseStudy1-	Scenario6	The user clicks the	Click Next	The system should show the

7	Next Page Movie	Next button on the Scenario 6 screen w/movie only		Scenario 7 screen and load the movie only.
CaseStudy1-8	Scenario7 Prev Page Movie	The user clicks the Previous button on the Scenario 7 screen w/movie only	Click Previous	The system should show the Scenario 6 screen and load the movie only.
CaseStudy1-9	Scenario6 Prev Page Movie	The user clicks the Previous button on the Scenario 6 screen w/movie only	Click Previous	The system should show the Scenario 5 screen and load the movie only.
CaseStudy1-10	Scenario5 Prev Page Movie	The user clicks the Previous button on the Scenario 5 screen w/movie only	Click Previous	The system should display the Scenario 4 screen and load the movie only.
CaseStudy1-11	Scenario4 Prev Page Movie	The user clicks the Previous button on the Scenario 4 screen w/movie only	Click Previous	The system should display the Scenario 3 screen and load the movie only.
CaseStudy1-12	Scenario3 Prev Page Movie	The user clicks the Previous button on the Scenario 3 screen w/movie only	Click Previous	The system should display the Scenario 2 screen and load the movie only.
CaseStudy1-13	Scenario2 Prev Page Movie	The user clicks the Previous button on the Scenario 2 screen w/movie only	Click Previous	The system should display the Scenario 1 screen and load the movie only.
CaseStudy1-14	Scenario1 Prev Page Movie	The user clicks the Previous button on the Scenario 1 screen w/movie only	Click Previous	The system should display the Case Study 1 screen.
C1S1MC-1	Play Movie	The user clicks the play button on the movie control on any screen	Click Play on movie control	The movie clip should play from the beginning.
C1S1MC-2	Replay Movie	The user clicks the stop button on the movie control and then clicks the play button	Click Stop on movie control then click Play	The movie clip should stop playing, return to the beginning then begin playing from the beginning.
C1S1MC-3	Pause Movie	The user clicks the pause button on the movie control and then clicks the	Click Pause on movie control then click Play	The movie clip should pause at its current spot then continue to play from where it was paused.

		play button		
C1S1MC-4	Expand Movie	The user clicks the Full Screen button to expand the movie to full screen	Click Full Screen on movie control	The movie clip should take over the full computer screen.
C1S1MC-5	Contract Movie	The user clicks the Esc button to contract the movie back to original size	Click Esc button on movie control	The movie clip should contract back to its original size.
C1S1MC-6	Show Problem	The end of the movie is reached	Click Play and allow the movie to reach the end	The rest of the screen should load showing the problem description, the multiple-choice problem to solve and a frame to show the answer
C1S1MC-7	Edit Problem	The user clicks in the problem textfield to try to alter it	Click the problem box	The system should not allow edits in the problem textfield.
C1S1MC-8				
C1S1MC-9	Select Choice Letters	The user clicks the A, B, C, D buttons	Click A, B, C, D buttons or any combination of those buttons	The background of the textbox displaying the option should change to green. When another button is clicked, the previously clicked button's text background should turn back to blue while the newly clicked buttons text background turns to green.
C1S1MC-10	Click Clear Button	The user clicks the Clear button	Click Clear button	All option backgrounds should change back to blue.
C1S1MC-11	Submit Correct Choice	The user click the correct letter and clicks the Submit button	Click one of the buttons that is the correct answer and click Submit	A confirmation response should show in the answer frame.
C1S1MC-12	Submit Incorrect Choice	The user clicks the wrong letter and clicks the Submit button	Click one of the buttons that is not the correct answer	A wrong-answer response should show in the answer frame.
C1S2FI-1	Play Movie	The user clicks the play button on the movie control	Click Play on movie control	The movie should begin to play from the beginning.
C1S2FI-2	Replay Movie	The user clicks the stop button on the movie control and then clicks the play button	Click Stop on movie control then click Play	The movie should stop and move the play knob to the beginning of the movie. The movie should restart from the beginning of the movie clip.
C1S2FI-3	Pause Movie	The user clicks the pause button on the movie control	Click *Pause* on movie control then click Play	The movie should stop at the place the user clicks. pause. The movie should resume

		and then clicks the play button		playing where it was paused.
C1S2FI-4	Expand Movie	The user clicks the Full Screen button to expand the movie to full screen	Click Full Screen on movie control	The movie should expand to cover the full screen.
C1S2FI-5	Contract Movie	The user clicks the Esc button to contract the movie back to original size	Click Esc button on movie control	The movie should return to its original size.
C1S2FI-6	Show Problem	The end of the movie is reached	Click Play and allow the movie to reach the end	The movie should plays to the end. At the end of the movie, the rest of the screen should load showing the problem, the 4 choices along with accompanying buttons and a box to show the answer to the problem. It should also shows attachments if applicable and the Next and Previous buttons.
C1S2FI-7	Edit Problem	The user clicks in the problem box to try to alter it	Click the problem box	The system should prevent the user from altering the problem box.
C1S2FI-8	Load Fill-In Problem	The end of the movie is reached	Click Play and allow the movie to reach the end	The movie should play to the end. At the end of the movie, the rest of the screen should load showing the problem overview, the problem to solve along with a box for the user to type in the answer and a box to show the answer to the problem. It should also shows attachments if applicable and the Next and Previous buttons.
C1S2FI-9	Runaway Answer	The user tries to enter an infinite number of characters in the Answer field	Answer: ggggggggggggggg gggggggggggggg	The system should prevent the user from entering more than 30 characters.
C1S2FI-10	Money Fill Correct	Submit a correct dollar amount as the answer in the Fill-In box and click the Submit button	C1S2: 6000.00	The system should show that the answer was correct and returns the appropriate response.
C1S2FI-11	Money Fill No Decimal	Submit a correct dollar amount	C1S2: 6000	The system should show that the answer was correct and

		with no decimal places as the answer in the Fill-In box and click the Submit button		returns the appropriate response.
C1S2FI-12	Money Fill 4 Decimal	Submit a correct dollar amount with 4 decimal places as the answer in the Fill-In box and click the Submit button	C1S2: 6000.0000	The system should show that the answer was correct and returns the appropriate response.
C1S2FI-13	Submit Char Fill Correct	Submit a correct character answer and click the Submit button	C1S4: LastTuition	The system should show that the answer was correct and returns the appropriate response.
C1S2FI-14	Submit Char Fill All Small	Submit a correct character answer using all small letters and click the Submit button	C1S4: lasttuition	The system should show that the answer was correct and returns the appropriate response.
C1S2FI-15	Submit Char Fill All Caps	Submit a correct character answer using all capital letters and click the Submit button	C1S4: LASTTUITON	The system should show that the answer was correct and returns the appropriate response.
C1S2FI-16	Submit Char with spaces	Submit a correct character answer with spaces in between the letters and click the Submit button	C1S4: Last Tuition	The system should show that the answer was correct and returns the appropriate response.
C1S2FI-17	Submit incorrect char answer	Submit an incorrect character answer and click the Submit button.	C1S4: MyWrongAnswer	The system should show that the answer was incorrect and returns the appropriate response.
C1S2FI-18	Click Clear Button	Click the Clear button	Click Clear on CS1 Scenario 2	The system should clear the information from the Fill-In box.
Links-1	Open Word	Click the Open button to view a Word problem.	Click Open on CS1 Scenario 4	The system should prompt the user to open or save a Word document.
Links-2	Open Excel	Click the Open button to view an Excel document	Click Open on CS1 Scenario 5	The system should prompt the user to open or save an Excel document.
Links-3	Open Access	Click the Open button to view an Access database	Click Open on CS1 Scenario 6	The system should prompt the user to open or save an Access document.
Links-4	Open PowerPoint	Click the Open button to view an PowerPoint	Click Open on CS1 Scenario 7	The system should prompt the user to open or save a PowerPoint document.

		presentation		
Links-5	Open Website	Click the *Open* button to view an external website	Click *Open* on CS1 Scenario 3	The system should open a new web page containing the web contents of the URL.

Test Case #	Name	Action	Test Data	Expected Outcome
Login-1	Valid User ID and Valid Password	Enter the correct Login ID and password.	Login Id: ac1111 Password: $hortCake123	The system should route the user to the Introduction splash screen.
Login-2	Invalid User ID and Invalid Password	Enter an incorrect Login ID and an incorrect password	Login Id:xyz123 Password:XYZ123	The system should display a "Login Id not found in the system" message. The system should clear the User Id and Password from the screen.
Login-3	Invalid User ID and Valid password	Enter an incorrect Login ID and a correct password	Login Id:xyz123 Password:XYZ123	The system should display a "Login Id not found in the system" message. The system should clear the User Id and Password from the screen.
Login-4	Valid User ID and Invalid password	Enter a correct user ID and an incorrect password	Login Id:ac1111 Password:XYZ124	The system should display an "Invalid password" message. The system should clear the Login Id and Password from the screen.
Login-5	Runaway User ID	Attempt to enter an infinite number of characters in the Login ID field	Login Id: zzzzzzzzzzzzzzzzzz zzz	The system should prevent the user from entering more than 20 characters
Login-6	Runaway Password	Attempt to enter an infinite number of characters in the Password field	Login Id: ssssssssssssssssssss	The system should prevent the user from entering more than 20 characters.
Login-7	Blank Login Id	The user clicks the Submit button without entering a Login Id.	Login Id:	The system should display a "Login cannot be blank" message.
Login-8	Blank Password	Enter a Login Id but leaves the Password blank	Login Id: ac1111 Password:	The system should display a "Password cannot be blank" message.
Login-9	Lock User ID 2	Enter the same incorrect password with the same valid user ID 6 times	Login Id: ac1111 Password: dddddd	The system should lock the ID and display a "The password is locked. Please contact the administrator" message.
Login-10	Clear	Enter data into the fields and clicks the Clear button	Login Id: ac1111 Password: dddddd	The system should clear the information for both the Login Id and Password.
Register-1	Blank First Name	Keep the First Name blank and clicks the Submit button	First Name:	The system should display a "First Name is required" message.

Register-2	Blank Last Name	Keep the First Name blank and clicks the Submit button	First Name: John Last Name:	The system should display a "Last Name is required" message.
Register-3	Blank Email Address	Keep the Email Address blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address:	The system should display an "Email Address is required" message.
Register-4	Blank Confirm Email Address	Keep the Confirm Email Address blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address:	The system should display a "Confirm Email Address is required" message.
Register-5	Blank Login Id	Keep the Login Id blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id:	The system should display a "Login Id is required" message.
Register-6	Blank Confirm Login Id	Keep the Confirm Login Id blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id: mydogRusty1 Confirm Login Id:	The system should display a "Confirm Login Id is required" message.
Register-7	Blank Password	Keep the Password blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id: mydogRusty1 Confirm Login Id: az5555 Password:	The system should display a "Password is required" message.

Register-8	Blank Confirm Password	Keep the Confirm Password blank and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id: az5555 Confirm Login Id: az5555 Password: mydogRusty1 Confirm Password:	The system should display a "Confirm Password is required" message.
Register-9	Email Addresses Don't Match	Enter different email addresses in the Email Address and Confirm Email Address fields and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson222@spacely.com Login Id: az5555 Confirm Login Id: az5555 Password: mydogRusty1 Confirm Password: mydogRusty1	The system should display an "Email Address and Confirm Email Address must match" message.
Register-10	Login Ids Don't Match	Enter different login Ids in the Login Id and Confirm Login Id fields and clicks the Submit button	First Name: John Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id: az5555 Confirm Login Id: az7777 Password: mydogRusty1 Confirm Password: mydogRusty1	The system should display a "Login Id and Confirm Login Id must match" message.
Register-11	Passwords Don't Match	Enter different passwords in the New Password and Confirm New	First Name: John Last Name: Jetson Email Address: JJetson000@spacely	The system should display a "Password and Confirm Password must match" message.

		Password fields and clicks the Submit button	.com Confirm Email Address: JJetson000@spacely.com Login Id: az5555 Confirm Login Id: az7777 Password: mydogRusty1 Confirm Password: mydogRusty8	
Register-12	Duplicate Email Address	Submit an entry where the Email Address is already being used by someone else	First Name: Lisa Last Name: Jetson Email Address: JJetson000@spacely.com Confirm Email Address: JJetson000@spacely.com Login Id: ao0000 Confirm Login Id: ao0000 Password: mydogRusty2 Confirm Password: mydogRusty2	The system should display a "This Email Address is already taken" message.
Register-13	Duplicate Login Id	Submit an entry where the Login Id is already being used by someone else	First Name: Lisa Last Name: Jetson Email Address: LJetson000@spacely.com Confirm Email Address: LJetson000@spacely.com Login Id: az5555 Confirm Login Id: az5555 Password: mydogRusty2 Confirm Password: mydogRusty2	The system should display a "This Login Id is already taken" message.
Register-14	Clear	Enter data into the fields and clicks the Clear button	First Name: Willow Last Name: Flintstone Email Address: WFlint000@spacely.com Confirm Email	The system should clear the information for all of the Registration fields.

			Address: WFlint000@spacely.com Login Id: af2222 Confirm Login Id: af2222 Password: mydogBailey99 Confirm Password: mydogBailey99	
Register-15	Password Length	Enter a Password shorter than 10 characters and clicks the Submit button	Password: abcde1234	The system should display a "Passwords must be at least 10 characters long" message.
Register-16	Confirm Password length	Enter a Confirm Password shorter than 10 characters and clicks the Submit button	Password: abcde12345 Confirm Password: abcde1234	The system should display a "Passwords must be at least 10 characters long" message.
Register-17	Invalid Email Address	Enter an invalid format Email Address and clicks the Submit button	Email Address: abc@@@..com	The system should display a "Please enter a valid email address" message.
Register-18	Invalid Confirm Email Address	Enter an invalid format Confirm Email Address and clicks the Submit button	Confirm Email Address: myemail.is.bad.com	The system should display a "Please enter a valid email address" message.
Register-19	Runaway First Name	Attempt to enter an infinite number of characters in the First Name field	Login Id: This is a very very very very very very very long name	The system should prevent the user from entering more than 50 characters.
Register-20	Runaway Last Name	Attempt to enter an infinite number of characters in the Last Name field	Login Id: This is a very very very very very very very long name	The system should prevent the user from entering more than 50 characters.
Register-21	Runaway Email Address	Attempt to enter an infinite number of characters in the Email Address field	Email Address: 201 d' s	The system should prevent the user from entering more than 200 characters.
Register-22	Runaway Confirm Email Address	Attempt to enter an infinite number of characters in the Confirm Email Address field	Email Address: 201 d' s	The system should prevent the user from entering more than 200 characters.
Register-23	Runaway Login Id	Attempt to enter an infinite number	Login Id: jjjjjjjjjjjjjjjjjjjj	The system should prevent the user from entering more

		of characters in the Login Id field		than 20 characters.
Register-24	Runaway Confirm Login Id	Attempt to enter an infinite number of characters in the Confirm Login Id field	Confirm Login Id: kkkkkkkkkkkkkkkkkkkkk	The system should prevent the user from entering more than 20 characters.
Register-25	Runaway Password	Attempt to enter an infinite number of characters in the Password field	Password: ppppppppppppppppppppp	The system should prevent the user from entering more than 20 characters.
Register-26	Runaway Confirm Password	Attempt to enter an infinite number of characters in the Confirm Password field	Password: ccccccccccccccccccc	The system should prevent the user from entering more than 20 characters.
Register-27	Invalid First Name Characters	Attempt to enter non-alphabet characters in the First Name field	First Name: 1234567890)(*&^%%$#@!	The system should prevent the user from entering non-alphabet characters.
Register-28	Invalid Last Name Characters	Attempt to enter non-alphabet characters in the Last Name field	Last Name: 1234567890)(*&^%%$#@!	The system should prevent the user from entering non-alphabet characters.
Register-29				
Register-30				
Forgot Password-1	Valid User ID	Enter a valid user ID into the Login Id field and clicks the Submit button	Login Id: ac1111	The reset status in the system should display a "Your password has been reset" message.
Forgot Password-2	Invalid User ID	Enter an invalid user ID into the Login Id field and clicks the Submit button	Login Id:WhoRU?	The reset status in the system should display a "Login Id not found" message.
Forgot Password-3	Update Reset Status	Attempt to edit the Reset Status textbox		The system should not allow edits in that field.
Forgot Password-4	Blank User ID	The user does not enter anything into the Login Id field and clicks the Submit button	Login Id:	The system should return a "Blank Login Id" message.
Forgot Password-5	Runaway Login ID	Attempt to enter an infinite number of characters into the Login Id field	Login Id: rrrrrrrrrrrrrrrrrrrr	The system should prevent the user from entering more than 20 characters.

APPENDIX G: COTHAULE USABILITY TESTING PROCEDURES

Category	Questions	Excel.	Good	Fair	Poor	Comments
Look and feel	There are no commercials or external pop-ups appearing in the website.					
	The website is not overwhelming with special effects.					
Theme	The theme adequately depicts a college campus environment.					
	The scenes adequately depict scenarios that college students could experience.					
Interface and functionality design	The animation in the animation frame adequately depicts each case study.					
	The problem frame visibly shows the problems that the end user will solve.					
	The answer frame provides enough spacing for the user to answer the questions.					
	The solution frame visibly shows the solution that the end user will view.					
Navigation design	The menu options navigate the end-user to the correct screen.					
	The Next and Previous buttons navigate the end-user to the correct screen.					
	The tool allows the user to navigate to any screen at will without errors.					
Graphic design	The graphics are of good quality, not fuzzy or distorted.					
	The colors used are not too bright or glaring to the end-user.					
Interaction and feedback standards	The problem frame adequately portrays the problem once the video ends.					
	The solution frame properly shows the solution based on the answer given by the end-user.					
Animation and special	The animation is free of system stalls.					

effects	The animation is free of graphical distortions while processing.
Audio treatments	A variety of voices and accents are used in the animation tool.
	The animation uses a good mix of both male and female voices.
	The voices are properly assigned to the correct genders in the animation.
	The voices are clear and understandable.
Database design	The data from the database properly appears in the correct frame at the correct time.
	The data entered by the end user is properly captured in the database.
	The database is properly normalized to optimize performance response.
	The database is designed as to not allow erroneous data duplication.
Performance	Transitions between the user screens take no longer than five seconds.
	The tool is void of system crashes.
	The tool is void of syntax errors.
	The tool is able to run on the Internet Explorer, Netscape and Safari browsers
Security	The tool cannot be accessed by an end-user without a user id and password.
	The tool displays a concise error when the incorrect user id is used.
	The tool displays a concise error when the incorrect password is used.
	The tool locks the user out when too many (5 or more) failed attempts have occurred.

Note*:* Displays the template for the COTHAULE usability testing procedures that were captured in an Excel spreadsheet over a period of 2 months. The table contains 33 tests comparing the usability of COTHAULE to guidelines listed in Lee and Owens (2004).

APPENDIX H: COMPUTATIONAL THINKING AUTHENTIC LEARNING PARTICIPANT QUESTIONNAIRE

1. What is your first name or preferred name?
2. What is your email address?
3. What is your gender?
4. What is your age range?
5. What is your ethnic background?
6. What is your college rank?
7. What academic program are you in or plan to join?
8. What is your intended major?
9. Are you comfortable with using a computer?
10. Are you comfortable with navigating a computer animated game?

APPENDIX I: COMPUTATIONAL THINKING PRETEST

1. Each of the four items below is an example of either a stack or a queue. Which one is different from the other three?
    a. A street parade
    b. A cafeteria tray dispenser
    c. Airplanes sitting on a runway
    d. Cars on an assembly line
2. A queue uses logic that comes from an acronym called:
    a. DITO
    b. LIFO
    c. FIFO
    d. LILO
3. Each of the four items below is an example of either a tree or a graph. Which one is different from the other three?
    a. A company organization chart
    b. People linked on LinkedIn
    c. The floor plan of the Detroit Auto Show
    d. A map of the Wayne State University campus
4. You have an Excel spreadsheet named StudentClasses with 5 columns. The column headers are StudentName, Gender, ClassNumber, ClassSection and BuildingName. The spreadsheet is filled with data relative to those columns. You filter the data based on Gender and ClassSection selecting males in class section 10045 and then you sort the filtered data by StudentName. The equivalent SQL statement that will perform a similar filter and order command is:
    a. Select all from StudentClasses where
    (Gender = "Male") and (ClassSection = 10045)
    Order by Gender
    b. Select all from StudentClasses where
    (Gender = "Male") or (ClassSection = 10045)
    Order by StudentName
    c. Select all from StudentClasses where
    (Gender = "Male") and (ClassSection = 10045)
    Order by StudentName
    d. Select all from StudentClasses where
    Gender = ("Male" and ClassSection) = 10045
    Order by StudentName

5. This search algorithm named MaxItem contains an array called BigArray. The algorithm is supposed to return the largest item in an array. What is syntactically wrong with this

algorithm that will prevent it from working properly?

```
MaxItem(bigArray [0…n – 1])
maxNum = bigArray [0]
For j = 1 to n – 1 do
        If bigArray [j] < maxNum
            maxNum = bigArray [j]
Loop
Return maxNum
```

a. The For loop should loop from j = 1 to n + 1 instead of n – 1
b. The logic should read bigArray [j] > maxNum instead of bigArray[j] < maxNum
c. The Return maxNum command should be before the Loop statement instead of after the Loop statement
d. There is nothing wrong with this algorithm

6. In a bubble sort, the set of integers are sorted by comparing each number and the next number and swapping the two numbers into the correct order from the beginning of the array to the end. This process is repeated until the entire array has been sorted. After completing only one pass of a bubble sort using the numbers {52, 37, 4, 71, 24, 18}, what is the order of the numbers?
   a. {37, 4, 52, 24, 18, 71}
   b. {4, 18, 24, 37, 52, 71}
   c. {37, 18, 24, 4, 52, 71}
   d. {24, 37, 4, 18, 71, 52}
7. Here is an array named SpringBreak[0…n] that contains the names of 10 popular spring break cities {Acapulco, Cancun, Miami, Nassau, New Orleans, New York, Palo Alto, Panama City, San Juan, Virginia Beach}. The term SpringBreak[5] returns which city?
   a. New Orleans
   b. New York
   c. Palo Alto
   d. Virginia Beach
8. Which one of these four programming syntax items is an example of a Conditional Statement?
   a. For… Loop
   b. Case Statement
   c. While… Do
   d. Repeat…Until

9. Given an array of numbers S={2, 3, 4, 5, 6, 8, 9}. You used a backtracking algorithm to find the combination of all numbers that sum to the amount of 12. Each number can only

be used one time. How many sets of numbers should the algorithm produce?

a. 2
b. 3
c. 4
d. 5

10. A post office kiosk can complete a number of transactions without the need of visiting the service desk. Each option on the screen represents a separate object that can be executed without impact to or input from the other options on the screen. The practice of breaking down a system to independent objects so that the system is easier to manage and understand is known as:
    a. Transformation
    b. Decomposition
    c. Randomization
    d. Aliasing
11. You are doing research on College Study Practices. You collected data in an Excel spreadsheet containing Student Names, Age and Daily Study Hours. The data is loaded into a scatterplot placing Age on the y-axis and Daily Study Hours on the x-axis. Each dot represents the name of each student. You removed the students' names to include only the data that will help to show the trend in the graph. This process is known as:
    a. Decomposition
    b. Abstraction
    c. Reduction
    d. Simulation
12. One technique used in object-oriented programming that prevents data from one object to be inadvertently updated by another object is called:
    a. Polymorphism
    b. Encapsulation
    c. Inheritance
    d. Abstraction
13. You have two machines that are dependent on each other. The first machine produces output that is input for the second machine. The first machine will take two (2) hours to run and the second machine will take three (3) hours to run. Say that you had 5 sets of tasks to run through these machines. If you waited for each set to complete in its entirety, it will take you 25 hours to complete all 5 sets. If you were to start the next instance of task one as soon as the previous instance of task one completed instead of waiting for both task one and two to complete, how much time would it take to complete all 5 sets?
    a. 10 hours
    b. 14 hours
    c. 17 hours
    d. 22 hours

14. Here is an object called SalesTaxes that keeps track of the amount you are spending on sales taxes:

```
Class SalesTaxes {
Public:
        decimal: totalTaxes;
        void calcTaxes (decimal, decimal);
        void initTaxes();
}
void SalesTaxes: calcTaxes (decimal amount, decimal taxPercent){
        totalTaxes = totalTaxes + taxPercent * amount;
}
void SalesTaxes: initTaxes (){
        totalTaxes = 0;
}
```

What is the result of totalTaxes after the following functions are called in this order?

```
initTaxes();
calcTaxes(4.00, 0.06)
calcTaxes(5.00, 0.04)
```

   a. 0.25
   b. 1.00
   c. 0.37
   d. 0.44

15. Error Handling is an important part of programming and life in general. This is the practice of preparing to handle situations in case something goes wrong. For example, having extra money in an overdraft account in case you overspend your checking account or an air force pilot having a parachute in case the plane malfunctions. Note the function for converting pounds to kilograms and kilograms to pounds. What is one error handling check that this function is missing?

```
Function WeightConversion(char weightType, decimal weightAmt):float
If weightType = “Kilograms”
        Return myWeight = weightAmt x 2.2
Else If weightType = “Pounds”
        Return myWeight = weightAmt / 2.2
Else
Return -1
End If
```

   a. The function should check that weightType is either Kilograms or Pounds
   b. The function should check that weightAmt is always greater than 0.
   c. The function should check that weightAmt is always a whole number
   d. The function should check that the denominator is always 2.2

16. Which of the examples below is not an example of prefetching and caching?
    a. Loading books into a book bag for class
    b. Prepping a work station for an assembly line
    c. Dismantling a computer
    d. Loading a video clip for it to play
17. The process of having a function call itself as part of the function to calculate the solution is called:
    a. Recursion
    b. Iteration
    c. Polymorphism
    d. Decomposition
18. Note the nested programming example below that has a "For…Loop" inside of a "While…Loop". How many times will the "While Loop" call the "For Loop":

```
N = 0;
While N <= 20 do
        For J = 0 to 5
                N = N + 1
        Loop
End While
```

    a. 4
    b. 5
    c. 6
    d. 7
19. You have a list of groceries containing a capacity amount and a price. The goal is to purchase the items that will feed the most people for under $50.00. The options are showing in the following table:

Capacity	4	2	7	9
Price	16	9	30	24

    What would be the maximum number of people that can be fed for $50.00?
    a. 14
    b. 15
    c. 16
    d. 22
20. Each of the four items below is an example of either asynchronous or synchronous communication. Which one is different from the other three?
    a. Cell phone call
    b. Skype
    c. Twitter
    d. Meeting among coworkers

21. The strategic guessing and problem-solving techniques that are commonly used in search engines to produce search results such as Google or Bing is called:
    a. Statistics
    b. Heuristics
    c. Logistics
    d. Poristics
22. Based on the complex If-Then-Else statement, if Sales = $65,000 and Recruits = 15, then the bonus is equal to what percentage?

If (Sales > 100,000) and (Recruits > 20) Then
    Bonus = 25%
Else if (Sales > 100,000) and (Recruits <= 20) and (Recruits > 10)
    Bonus = 20%
Else if (Sales > 100,000) and (Recruits <= 10)
    Bonus = 15%
Else if (Sales <= 100,000) and (Sales > 50,000) and (Recruits > 20)
    Then Bonus = 15%
Else if (Sales <= 100,000) and (Sales > 50,000) and (Recruits <= 20) and (Recruits > 10)
    Then Bonus = 10%
Else if (Sales <= 100,000) and (Sales > 50,000) and (Recruits <= 10)
    Then Bonus = 5%
Else if (Sales < 50,000) and (Recruits > 20)
    Then Bonus = 5%
Else Bonus = 0%

    a. 25%
    b. 20%
    c. 15%
    d. 10%
23. You have a Word Document containing a table that has five columns. The column headers are BookTitle, Author, RetailPrice, StudentDiscount and StudentPrice. The Word equation in the StudentPrice Column reads =(B1 – C1 * 100). The following function calls the functions below: GetStudentPrice(240, 0.20)

Which function will **not** return the correct answer?

    a. Function GetStudentPrice(RetailPrice, StudentDiscount)

StudentPrice = RetailPrice – (StudentDiscount * 100)
Return StudentPrice
End Function

    b. Function GetStudentPrice(RetailPrice, StudentDiscount)

StudentDiscount = StudentDiscount * 100
StudentPrice = RetailPrice – StudentDiscount
Return StudentPrice

End Function

c. Function GetStudentPrice(RetailPrice, StudentDiscount)

Return StudentPrice = RetailPrice – (StudentDiscount * 100)

End Function

d. Function GetStudentPrice(RetailPrice, StudentDiscount)

StudentPrice = (RetailPrice – StudentDiscount) * 100

Return StudentPrice

End Function

24. An Excel document uses column B to as input for the following equation: =IF(A1>100000, A1*0.25, IF(A1>75000, A1*0.2, IF(A1>50000, A1*0.15, A1*0))). This equation is repeated for ten (10) B cells where there is an equivalent A cell containing a value. The Excel function used to calculate the average of the amounts in column B is =SUM(B1:B10)/COUNT(A1:A10). Which algorithm will also correctly calculate the average amount?

a. COUNT = 10;

```
For J = 1 to COUNT  do
SUM = SUM + B[J]
Loop
AVG=SUM/COUNT
```

b. COUNT = 10

```
For J = 1 to COUNT  do
SUM = SUM + B[J]
Loop
AVG=SUM + COUNT
```

c. COUNT = 10

```
For J = 1 to COUNT do
SUM = B[J]
AVG=SUM/COUNT
Loop
```

d. COUNT = 10

```
For J = 1 to COUNT do
        SUM = B[J] + 1
Loop
AVG=SUM/COUNT
```

25. You have an Object represented as an Access Table called Student containing studentName, studentID, studentAge and creditsCarried. The equation to sum the credits as the student registers for class is:

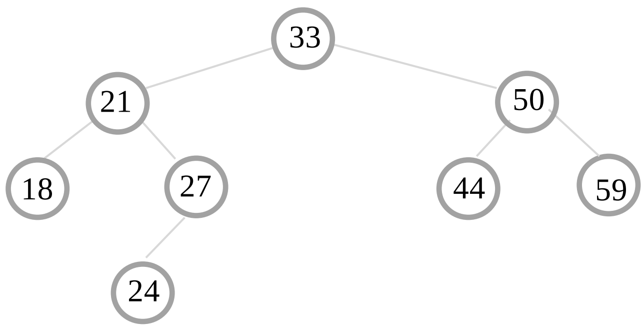
```
void Students: calcCredits (int numCredits){
        creditsCarried = creditsCarried * _________;
}
```

Note the part of the function that is missing. Which item belongs in that space?

a. Students
b. calcCredits
c. creditsCarried
d. numCredits

26. Here is a picture of a binary tree. To traverse a non-empty binary tree in **pre-order** format apply the concept [root, left, right]. What is the output of the tree if traversed in pre-order format?

a. 33, 21, 18, 27, 24, 50, 44, 59
b. 18, 21, 27, 24, 33, 44, 50, 59
c. 59, 50, 44, 33, 27, 24, 21, 18
d. 18, 24, 27, 21, 44, 59, 50, 33



APPENDIX J: COMPUTATIONAL THINKING POSTTEST

1. Each of the four items below is an example of either a stack or a queue. Which one is different from the other three?
    a. A tennis ball container
    b. A cafeteria tray dispenser
    c. People waiting to pay for their groceries
    d. A truck loaded with furniture
2. A stack uses logic that comes from an acronym called:
    a. DITO
    b. LIFO
    c. FIFO
    d. LILO
3. Each of the four items below is an example of either a tree or a graph. Which one is different from the other three?
    a. A company organization chart
    b. A project plan
    c. A pyramid selling scheme
    d. A map of the Wayne State University campus
4. You have an Excel spreadsheet named Movies with 6 columns. The column headers are MovieName, Year, Genre, RunTime, Rating and Director. The spreadsheet is filled with data relative to those columns. You filter the data based on Genre and Rating selecting the Drama genre that has an R rating and then you sort the filtered data by MovieName and Year. The equivalent SQL algorithm that will perform a similar filter command is:
    a. Select all from Movies where

    (Genre = "Drama") and (Rating = "R")

    Order by Year, MovieName
    b. Select all from Movies where

    (Genre = "Drama") and (Rating = "R")

    Order by MovieName
    c. Select all from Movies where

    (Genre = "Drama") and (Rating = "R")

    Order by MovieName, Year
    d. Select all from Movies where

    (Genre = "Drama")

    Order by MovieName, Year
5. This search algorithm named MinItem contains an array called SmallArray. The algorithm is supposed to return the smallest item in an array. Which response is correct as to why this function may not work?

    MinItem(smallArray [0…n – 1])

```
minNum = SmallArray [1];
For j = 1 to n – 1 do
        If SmallArray [j] < minNum
            minNum = SmallArray[j]
Loop
Return minNum
```

a. Since the For loop is looping from j = 1 to n – 1, this algorithm may not work.
b. Since the logic read SmallArray [j] < minNum instead of SmallArray[j] > minNum, this algorithm may not work.
c. If the smallest number is in the first position of the array, this algorithm may not work.
d. This algorithm will work in all situations.

6. In a bubble sort, the set of integers are sorted by comparing each number and the next number and swapping the two numbers into the correct order from the beginning of the array to the end. This process is repeated until the entire array has been sorted. After completing only one pass of a bubble sort using the numbers {47, 99, 34, 61, 5, 18, 20}, what is the order of the numbers?
    a. {47, 34, 61, 5, 18, 20, 99}
    b. {5, 18, 20, 34, 47, 61, 99}
    c. {34, 47, 18, 61, 5, 20, 99}
    d. {5, 47, 18, 34, 61, 99, 20}
7. Here is an array named FastFood[0…n] that contains the names of 10 popular fast food restaurants {McDonalds, Wendy's, Burger King, KFC, Subway, Jimmy Johns, Little Caesar, Pizza Hut, Taco Bell, Chickafilet}. The array call FastFood [4] returns which restaurant?
    a. Burger King
    b. KFC
    c. Subway
    d. Jimmy Johns
8. Which one of these four programming syntax items is an example of an Iteration Statement?
    a. While…Do
    b. Case Statement
    c. If-Then-Else
    d. Switch
9. Given an array of numbers S={1, 2, 3, 4, 5, 7, 8, 9}. You used a backtracking algorithm to find the combination of all numbers that sum to the amount of 15. Each number can only be used one time. How many sets of numbers should the algorithm produce?
    a. 5
    b. 6

c. 7
d. 8

10. A photo kiosk can complete a number of transactions without requiring help from the service clerk. Which one of the four serves as an example of decomposition that the photo kiosk would use in servicing the customers?
    a. Requiring the customer to set up a user ID and password to use the system.
    b. Using a function that calls itself as part of the calculation to calculate the total amount of photography services purchased.
    c. Using digital imagery to remove the background in the photograph of a person and replacing it with a background of Hawaii.
    d. Allowing a person to upload photos to the kiosk without requiring the person to first decide whether or not to create a photo book.
11. You are doing research on College Drinking Habits. You collected data in an Excel spreadsheet containing Student Age, Stress Level and Number of Drinks per Week and loaded the data into a scatterplot graph. You want to show the relationship between Stress Level and Number of Drinks per Week. How can abstraction be applied to make the graph easier to display the relationship?
    a. Making the graph 3-dimensional instead of 2-dimensional
    b. Moving the Stress Level to the x-Axis
    c. Removing the Students Ages from the graph
    d. Removing the Number of Drinks per week from the graph
12. You have a class called Activity that contains variables ActivityName, CalPerHour and Time. You created another class called Dance that contains variables DanceType and Vigor and is declared as an instance of Activity. So your declaration looks like:
    Class Activity
        String: ActivityName
        Int: CalPerHour
        Time: Time
    Class Dance: public Activity
        String: DanceType
        Char: Vigor
    The declaration of the Dance class is applying an object-oriented programming technique called:
    a. Polymorphism
    b. Encapsulation
    c. Inheritance
    d. Abstraction
13. You have a small business restoring computers on the side to bring in some extra income. If a computer is having a problem, you use a separate hard drive component to back up the computer’s hard drive then use a software package to image the hard drive to its

original state. The first task takes one (1) hour to run and the other task takes two (2) hours to run. Say that you had 5 computers to restore. If you waited for each set of restore tasks to complete in its entirety before starting the next one, it will take you 15 hours to restore all 5 computers. Say you decided to overlap the process by starting the image process as soon as the backup was completed and also started the next back up instead of waiting for both the backup and imaging to complete. If you did this routine for all five computers, how much time would it take for you to complete the job?

a. 9 hours
b. 11 hours
c. 13 hours
d. 15 hours

14. Here is an object called Fahrenheit that converts the temperature from Celsius to Fahrenheit and calculate the average Fahrenheit temperature:

```
Class Fahrenheit {
Public:
        decimal: avgFah;
        decimal: currentFah;
        decimal: tempCalls;
        void celToFah (decimal);
void calcAvgFah (decimal, decimal);
        void initFah();
}
void Fahrenheit: celToFah (decimal Celcius){
        currentFah = (9 / 5) * celcius + 32;
        totalFah = totalFah + currentFah;
        tempCalls = tempCalls + 1;
}
void Fahrenheit: calcAvgFah (){
        avgFah = TotalFah / tempCalls;
}
void Fahrenheit: initFah (){
        totalFah = 0;
        tempCalls = 0;
        avgFah = 0;
}
```

What is the result of avgFah after the following functions are called in this order?

1. initFah();
2. celToFah (16)
3. celToFah (19)
4. celToFah (20)

5. calcAvgFah()

   a. 88.2
   b. 100.1
   c. 56
   d. 90.6

15. Error Handling is an important part of programming and life in general. This is the practice of preparing to handle situations in case something goes wrong. For example, having an electric stove automatically shut itself off after being on so long or having antilock brakes on a car that kicks in when the car hits ice or high water. Note the function for the quadratic equation below. What is one error handling check that this function should include?

    Function Quadratic(a, b, c):decimal
    Var firstPart = 4 * a * c
    Var secondPart = sqrt(b)
    Var bottomPart = 2 * a
    Var topPart = firstPart + secondPart
    topPart = squareRoot(topPart)
    topPart = topPart – b
    output = topPart / bottomPart

    a. The function should check that b is always positive.
    b. The function should check that a is never 0.
    c. The function should check that c is always greater than a.
    d. The function should check that the result of bottomPart is less than the result of topPart.

16. Which of the four examples below is an example of prefetching and caching?
    a. The clipboard function in Word
    b. The join function between two tables in Access
    c. The equation capability in Excel
    d. The Slide Sorter function in PowerPoint

17. The following function uses what type of process to complete the calculation:

    Function iHaveAHeadache(int intensity): decimal
    If intensity > 100
    return 100
    Else
    Return iHaveAHeadAche(intensity x 2)

    a. Polymorphism
    b. Iteration
    c. Recursion
    d. Decomposition

18. Note the nested programming example below that has a “While…Loop” inside of a

"While…Loop". What is the final value of n once the algorithm finishes executing?

```
n = 0;
j = 0
While n <= 10 do
        n = n + 1
        While j < 10
                j = j + 1
        End While
End While
```

a. 80
b. 90
c. 100
d. 110

19. You have a list of books containing an importance ranking and a price. You have been given a book voucher for $200.00. The goal is to purchase the greatest number of books with the most importance to you while staying under $200.00. The options are showing in the following table:

Book Importance	4	3	5	2	1
Price	47	90	75	54	32

What would be the most you would spend when purchasing the maximum number of books possible, staying under the $200.00 limit?

a. 169
b. 176
c. 191
d. 197

20. Each of the four items below is an example of either asynchronous or synchronous communication. Which one is different from the other three?

a. Email
b. Walkie Talkie
c. YouTube
d. Blog

21. The strategic guessing and problem-solving techniques that are commonly used in search engines to produce search results such as Google or Bing is called heuristics. In which situation heuristics would likely not apply?

a. Hacking a website
b. Business P&L projections
c. Expert review of a problem
d. Diagnosing a patient in the ER room

22. Based on the complex If-Then-Else statement, if Loss = 100,000 and Fines = 500, then

the Penalty is equal to what percentage?

If (Loss > 500,000) and (Fines > 300) Then

Penalty = 70%

Else if (Loss > 500,000) and (Fines <= 300) and (Fines > 100)

Penalty = 50%

Else if (Loss > 500,000) and (Fines <= 100)

Penalty = 30%

Else if (Loss <= 500,000) and (Loss > 250,000) and (Fines > 300)

Then Penalty = 30%

Else if (Loss <= 500,000) and (Loss > 250,000) and (Fines <= 300) and (Fines > 100)

Then Penalty = 25%

Else if (Loss <= 500,000) and (Loss > 250,000) and (Fines <= 100)

Then Penalty = 15%

Else Penalty = 0%

a. 70%
b. 30%
c. 20%
d. 0%

23. You have a Word Document containing a table that has two columns. The column headers are Years and DepreciatedValue. The Word equation in the DepreciatedValue Column reads = (15000 – 970 * Left). The following function calls the functions below:

CurrentValue = Depreciation(7)

Which function will return the correct answer?

a. Function Depreciation (Year)

DepreciatedValue = (15000 – Year) * 970

Return DepreciatedValue

End Function

b. Function Depreciation (Year)

DepreciatedValue = 15000 – (970 * year)

Return DepreciatedValue

End Function

c. Function Depreciation (Year)

Return DepreciatedValue = 15000 – (970 / year)

End Function

d. Function Depreciation ()

DepreciatedValue = 15000 – (970 * year)

Return DepreciatedValue

End Function

24. An Excel document uses column C as input for the following equation:

=IF(AND(A2>B2,A2-B2>1000),(A2-B2)*0.5,(IF(AND(A2>B2,A2-B2<=1000),300,0))).

Cell A holds the amount of the profit, Cell B holds the amount of the loss and Cell C calculates the Dividend. What is this formula doing?

a. If the Profit is less than the Loss and the difference is greater than $1000, calculate the Dividend as the difference multiplied by 50%. If the Profit is greater than the Loss and the difference is less than or equal to $1000, make the dividend $300. Otherwise make the dividend 0.
b. If the Profit is greater than the Loss and the difference is greater than $1000, calculate the Dividend as the difference multiplied by 30%. If the Profit is greater than the Loss and the difference is less than or equal to $1000, make the dividend $500. Otherwise make the dividend 0.
c. If the Profit is greater than the Loss and the difference is greater than $1000, calculate the Dividend as the difference multiplied by 50%. If the Profit is greater than the Loss and the difference is less than or equal to $1000, make the dividend $300. Otherwise make the dividend 0.
d. If the Profit is greater than the Loss and the difference is greater than $1000, calculate the Dividend as the difference multiplied by 50%. If the Profit is greater than the Loss and the difference is less than or equal to $500, make the dividend $300. Otherwise make the dividend equal to the Loss.

25. You have an object represented as an Access Table called BasketBall containing the variables athleteName, jerseyNumber, position, numOfGames, totalPoints and pointsPerGame. You have another object called GameStats containing points, rebounds and assists. There is a function owned by the Basketball class called calcPPG:

```
void Basketball: calcPPG (int gamePoints){
        numOfGames = numOfGames + 1
        totalPoints = totalPoints + gamePoints
                pointsPerGame = totalPoints / numOfGames
}
```

There is a function owned by the GameStats class called sumPoints:

```
        void GameStats: sumPoints(int pointsIn){
                points = points + pointsIn
        }
```

The following calls are made for this class:

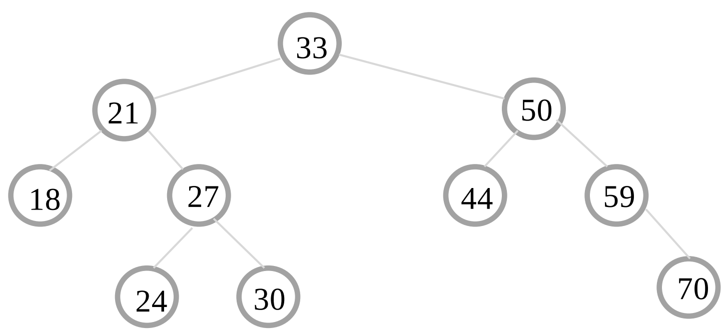
```
Basketball Warriors
Basketball Roberts
Roberts.sumPoints(10)
Roberts.sumPoints(12)
var int sumOfPoints = Roberts.points
Warriors.calcPPG(sumOfPoints)
```

Is there anything wrong with these series of function calls?

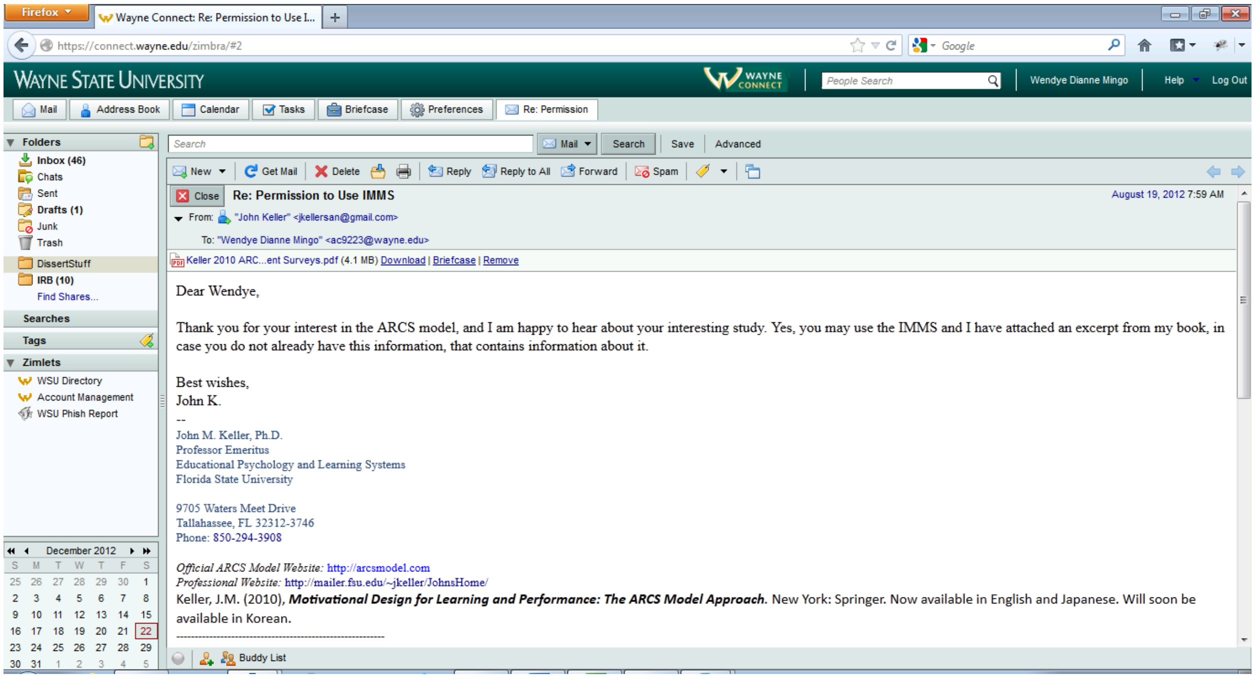
a. Yes. The function used to calculate the points per game is wrong.

b. Yes. Roberts cannot call the function sumPoints because it is declared as an instance of Basketball.
c. Yes. The variable sumOfPoints cannot be allowed to be set to a variable belonging to a class.
d. No. There is nothing wrong with these series of function calls.

26. Here is a picture of a binary tree. To traverse a non-empty binary tree in **pre-order** format apply the concept [root, left, right]. What is the output of the tree if traversed in pre-order format?
    a. 18, 21, 24, 27, 30, 33, 44, 50, 59, 70
    b. 33, 21, 18, 27, 24, 30, 50, 44, 59, 70
    c. 18, 24, 30, 27, 21, 44, 70, 59, 50, 33
    d. 70, 59, 50, 44, 33, 30, 27, 24, 21, 18



APPENDIX K: IMMS PERMISSION TO USE


Re: Permission to Use IMMS

From: "John Keller" <jkellersan@gmail.com>

To: "Wendye Dianne Mingo" <ac9223@wayne.edu>

August 19, 2012 7:59 AM

Keller 2010 ARC...ent Surveys.pdf (4.1 MB)

Dear Wendye,

Thank you for your interest in the ARCS model, and I am happy to hear about your interesting study. Yes, you may use the IMMS and I have attached an excerpt from my book, in case you do not already have this information, that contains information about it.

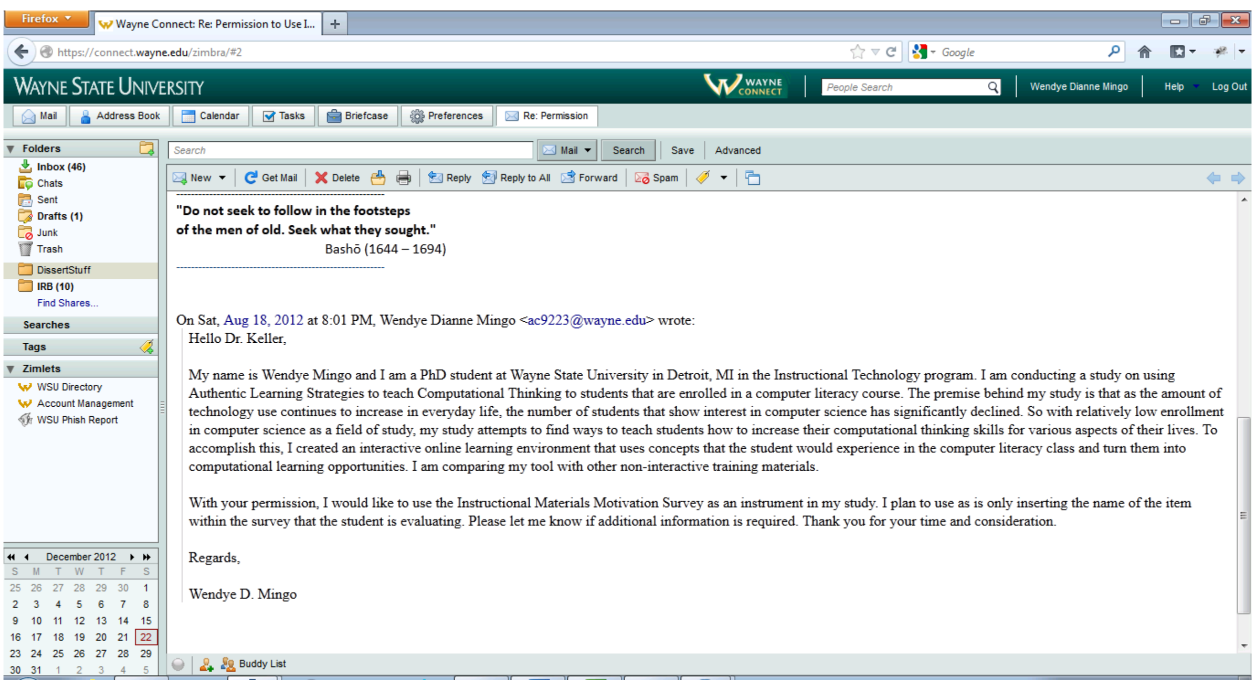
Best wishes,
John K.

--
John M. Keller, Ph.D.
Professor Emeritus
Educational Psychology and Learning Systems
Florida State University

9705 Waters Meet Drive
Tallahassee, FL 32312-3746
Phone: 850-294-3908

Official ARCS Model Website: http://arcsmodel.com
Professional Website: http://mailer.fsu.edu/~jkeller/JohnsHome/
Keller, J.M. (2010), ***Motivational Design for Learning and Performance: The ARCS Model Approach.*** New York: Springer. Now available in English and Japanese. Will soon be available in Korean.

Figure K1. Screenshot of first page of email for permission to use IMMS. Shows permission being granted to use the Instructional Materials Motivation Survey from Dr. John M. Keller.


"Do not seek to follow in the footsteps of the men of old. Seek what they sought."
Bashō (1644 – 1694)

On Sat, Aug 18, 2012 at 8:01 PM, Wendye Dianne Mingo <ac9223@wayne.edu> wrote:

Hello Dr. Keller,

My name is Wendye Mingo and I am a PhD student at Wayne State University in Detroit, MI in the Instructional Technology program. I am conducting a study on using Authentic Learning Strategies to teach Computational Thinking to students that are enrolled in a computer literacy course. The premise behind my study is that as the amount of technology use continues to increase in everyday life, the number of students that show interest in computer science has significantly declined. So with relatively low enrollment in computer science as a field of study, my study attempts to find ways to teach students how to increase their computational thinking skills for various aspects of their lives. To accomplish this, I created an interactive online learning environment that uses concepts that the student would experience in the computer literacy class and turn them into computational learning opportunities. I am comparing my tool with other non-interactive training materials.

With your permission, I would like to use the Instructional Materials Motivation Survey as an instrument in my study. I plan to use as is only inserting the name of the item within the survey that the student is evaluating. Please let me know if additional information is required. Thank you for your time and consideration.

Regards,

Wendye D. Mingo

Figure K2. Screenshot of second page of email for permission to use IMMS. Shows permission being requested by me to use the Instructional Materials Motivation Survey.

APPENDIX L: INSTRUCTIONAL MATERIALS MOTIVATION SURVEY

1. When I first looked at [this lesson], I had the impression that it would be easy for me.
2. There was something interesting at the beginning of [this lesson] that got my attention.
3. [This material] was more difficult to understand than I would like for it to be.
4. After reading the introductory information, I felt confident that I knew what I was supposed to learn from [this lesson].
5. Completing the exercises in [this lesson] gave me a satisfying feeling of accomplishment.
6. It is clear to me how the content of [this material] is related to things I already know.
7. Many of the pages had so much information that it was hard to pick out and remember the important points.
8. [These materials] are eye-catching.
9. There were stories, pictures, or examples that showed me how [this material] could be important to some people.
10. Completing [this lesson] successfully was important to me.
11. The quality of the writing helped to hold my attention.
12. [This lesson] is so abstract that it was hard to keep my attention on it.
13. As I worked on [this lesson], I was confident that I could learn the content.
14. I enjoyed [this lesson] so much that I would like to know more about this topic.
15. The pages of [this lesson] look dry and unappealing.
16. The content of [this material] is relevant to my interests.
17. The way the information is arranged on the pages helped keep my attention.
18. There are explanations or examples of how people use the knowledge in [this lesson].
19. The exercises in [this lesson] were too difficult.
20. [This lesson] has things that stimulated my curiosity.
21. I really enjoyed studying [this lesson].
22. The amount of repetition in [this lesson] caused me to get bored sometimes.
23. The content and style of writing in [this lesson] convey the impression that its content is worth knowing.
24. I learned some things that were surprising or unexpected.
25. After working on [this lesson] for a while, I was confident that I would be able to pass a test on it.
26. [This lesson] was not relevant to my needs because I already knew most of it.
27. The wording of feedback after the exercises, or of other comments in [this lesson], helped me feel rewarded for my effort.
28. The variety of reading passages, exercises, illustrations, etc. helped keep my attention on [the lesson].
29. The style of writing is boring.
30. I could relate the content of [this lesson] to things I have seen, done, or thought about in my own life.
31. There are so many words on each page that it is irritating.

32. It felt good to successfully complete [this lesson].
33. The content of [this lesson] will be useful to me.
34. I could not really understand quite a bit of the material in [this lesson].
35. The good organization of the content helped me be confident that I would learn [this material].
36. It was a pleasure to work on such a well-design lesson.

APPENDIX M: CONSENT FORM

The Effects of Using Authentic Learning Strategies to Develop Computational Thinking Skills in Computer Literacy Students

Research Information Sheet
Title of Study: The Effects of Using Authentic Learning Strategies to Develop Computation Thinking Skills in Computer Literacy Students

Principal Investigator (PI): Wendye D. Mingo
Instructional Technology
(248) 915 5927

Purpose:
You are being asked to be in a research study of the benefits of authentic learning strategies and computational thinking skills because you are currently an undergraduate student who is enrolled in the CSC1000 course. This study is being conducted at Wayne State University.

Study Procedures:
If you take part in the study, you will be asked to complete a demographics survey, a motivation assessment survey, review electronic learning materials and complete two assessments, a pretest and a posttest.

- There will be an experimental and control group for this study. The experimental group will receive access to the online learning tool called COTHAULE and the control group will have access to online training on Java programming and Standard Query Language (SQL) basics. By random assignment, you will either be assigned to the experimental group or the control group.
- As the participant, there are four general steps you will complete as part of the research study. First you will complete an online survey that will ask some general demographic questions about yourself. In the second step, you will participate in an electronic pretest assessment that will measure your initial understanding of computational thinking. In the third step, you will be provided the learning material to review at your own convenience for one week. In the fourth step, at the end of the week, you will take a posttest to reassess your understanding of computational thinking and evaluate your motivation of the learning materials that you were provided.
- Questions asked in this study will be multiple-choice, fill-in-the-blank or short answer. The problems will involve answering questions and completing tasks that you would normally perform either in a computer literacy course or on a daily basis that have some relevancy to computational thinking. None of the questions are personal or invasive. Therefore, students will not have the option of not answering some of the questions and remaining in the study.
- The entire study will take a maximum of 9 hours to complete over 3 weeks. The online student profile survey should take no longer than 15 minutes to complete. The pretest and posttest will each take no longer than 1.5 hours to complete. The learning materials will be reviewed on your own and should take no longer than 5 hours to complete over a five-day period. The motivation assessment survey should take no longer than 20 minutes to complete. The completion of the posttest and motivation survey concludes your participation in this study.

Benefits:
As a participant in this research study, there may be no direct benefit for you; however, information from this study may benefit other people now or in the future.

Risks:

Submission/Revision Date: [08/19/2012] Page 1 of 2
Protocol Version #: [3]

HIC Date: 5/08

Figure M1. First page showing the screenshot of the consent form provided to the computer literacy students to request participation.

The Effects of Using Authentic Learning Strategies to Develop Computational Thinking Skills in Computer Literacy Students

Risks:
There are no known risks at this time to participation in this study.

Costs:
There will be no costs to you for participation in this research study.

Compensation:
For taking part in this research study, you will be compensated for your time and inconvenience. You will receive 3% of extra credit for completing the study. If you chose not to participate in the study, you will still have the opportunity to receive the 3% of extra credit by completing an alternative extra credit assignment.

Confidentiality:
You will be identified in the research records by an encoding number. All information retained during this study will be encrypted during transit.

Voluntary Participation /Withdrawal:
Taking part in this study is voluntary. You may choose not to take part in this study, or if you decide to take part, you can change your mind later and withdraw from the study. You are free to not answer any questions or withdraw at any time. Your decision will not change any present or future relationships with Wayne State University or its affiliates.

Questions:
If you have any questions about this study now or in the future, you may contact Wendye Mingo or one of her research team members at the following phone number (313) 577-1680. If you have questions or concerns about your rights as a research participant, the Chair of the Human Investigation Committee can be contacted at (313) 577-1628. If you are unable to contact the research staff, or if you want to talk to someone other than the research staff, you may also call (313) 577-1628 to ask questions or voice concerns or complaints.

Participation:
By completing and submitting the questionnaire, you are agreeing to participate in this study.

APPROVAL PERIOD

AUG 3 0 '12 MAY 0 9 '13

WAYNE STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Submission/Revision Date: [08/19/2012]
Protocol Version #: [3]

Page 2 of 2

HIC Date: 5/08

Figure M2. Second page showing the screenshot of the consent form provided to the computer literacy students to request participation.

APPENDIX N: DATA CLEANSING AND VALIDATION PROCEDURES

Table Name	Table Description	SQL Query	No. Rows
demogInPretest	Contains access ID's that match from the SM_DemogResults table and SM_PretestResults table	insert into demogInPretest(accessId) select distinct(q0002) from SM_DemogResults where upper(q0002) in (select upper(q0002) from SM_PretestResults)	540
demogNotInPretest	Contains access ID's that match from the SM_DemogResults table and are not in the SM_PretestResults table	insert into demogNotInPretest(accessId) select distinct(q0002) from SM_DemogResults where upper(q0002) not in (select upper(q0002) from SM_PretestResults)	83
demogInPosttest	Contains access ID's that match from the SM_DemogResults table and SM_PosttestResults table	insert into demogInPosttest(accessId) select distinct(q0002) from SM_DemogResults where upper(q0002) in (select upper(q0002) from SM_PosttestResults)	292
demogNotInPosttest	Contains access ID's that are in the SM_DemogResults table but are not in the SM_PosttestResults table	insert into demogNotInPosttest(accessId) select distinct(q0002) from SM_DemogResults where upper(q0002) not in (select upper(q0002) from SM_PosttestResults)	331
pretestNotInDemog	Contains access ID's that are in the SM_PretestResults table but are not in the SM_DemogResults table	insert into pretestNotInDemog(accessId) select distinct(q0002) from SM_PretestResults where upper(q0002) not in (select upper(q0002) from SM_DemogResults)	28
posttestNotInDemog	Contains access ID's that are in the SM_PosttestResults table but are not in the SM_DemogResults	insert into posttestNotInDemog(accessId) select distinct(q0002) from SM_PosttestResults where upper(q0002) not in	171

	table	(select upper(q0002) from SM_DemogResults)	
pretestInPosttest	Contains access ID’s that match in the SM_PretestResults table and in the SM_PosttestResults table	insert into pretestInPosttest(accessId) select distinct(q0002) from SM_PretestResults where upper(q0002) in (select upper(q0002) from SM_PosttestResults)	280
pretestNotInPosttest	Contains access ID’s that are in the SM_PretestResults table but are not in the SM_PosttestResults table	insert into pretestNotInPosttest(accessId) select distinct(q0002) from SM_PretestResults where upper(q0002) not in (select upper(q0002) from SM_PosttestResults)	288
posttestNotInPretest	Contains access ID’s that are in the SM_PosttestResults table but are not in the SM_PretestResults table	insert into posttestNotInPretest(accessId) select distinct(q0002) from SM_PosttestResults where upper(q0002) not in (select upper(q0002) from SM_PretestResults)	183
demogInCothaule	Contains access ID’s that match in the SM_DemogResults table and the formatuserregtbl table	insert into demogInCothaule(accessId) select distinct(q0002) from SM_DemogResults where upper(q0002) in (select upper(loginName) from formatuserregtbl)	226
demogNotInCothaule	Contains access ID’s that are in the SM_DemogResults table but are not in the formatuserregtbl table	insert into demogNotInCothaule(accessId) select distinct(q0002) from SM_DemogResults where upper(q0002) not in (select upper(loginName) from formatuserregtbl)	397
pretestInCothaule	Contains access ID’s that match in the SM_PretestResults table and the Cothaule formatuserregtbl table	insert into pretestInCothaule(accessId) select distinct(q0002) from SM_PretestResults where upper(q0002) in (select upper(loginName) from formatuserregtbl)	222

pretestNotInCothaule	Contains access ID's that are in the SM_PretestResults table but are not in the Cothaule formatuserregtbl table	insert into pretestNotInCothaule(accessId) select distinct(q0002) from SM_PretestResults where upper(q0002) not in (select upper(loginName) from formatuserregtbl)	346
posttestInCothaule	Contains access ID's that match in the SM_PosttestResults table and the Cothaule formatuserregtbl table	insert into posttestInCothaule(accessId) select distinct(q0002) from SM_PosttestResults where upper(q0002) in (select upper(loginName) from formatuserregtbl)	143
posttestNotInCothaule	Contains access ID's that are in the SM_PosttestResults table but are not in the Cothaule formatuserregtbl table	insert into posttestNotInCothaule(accessId) select distinct(q0002) from SM_PosttestResults where upper(q0002) not in (select upper(loginName) from formatuserregtbl)	320
prepostInCothaule	Contains access ID's that match in the pretestInPosttest table and in the Cothaule formatuserregtbl table	insert into prepostInCothaule(accessId) select distinct(accessId) from pretestInPosttest where upper(accessId) in (select upper(loginName) from formatuserregtbl)	115
prepostNotInCothaule	Contains access ID's that are in the pretestInPosttest table but are not in the Cothaule formatuserregtbl table	insert into prepostNotInCothaule(accessId) select distinct(accessId) from pretestInPosttest where upper(accessId) not in (select upper(loginName) from formatuserregtbl)	165
demogInPrePosttest	Contains access ID's that match in the pretestInPosttest table and the SM_DemogResults table	insert into demogInPrePosttest(accessId) select distinct(q0002) from SM_DemogResults where upper(q0002) in (select upper(accessId) from pretestInPosttest)	269
demogNotInPrePosttest	Contains access ID's that are in the	insert into demogNotInPrePosttest(accessId)	354

	pretestInPosttest table but are not in the SM_DemogResults table	select distinct(q0002) from SM_DemogResults where upper(q0002) not in (select upper(accessId) from pretestInPosttest)	
demogPrePostInCothaule	Contains access ID's that match in the demogInPrePosttest table and the Cothaule formatuserregtbl table	insert into demogPrePostInCothaule (accessId) select distinct(accessId) from demogInPrePosttest where upper(accessId) in (select upper(loginName) from formatuserregtbl)	111
demogPrePostNotInCothaule	Contains access ID's that are in the demogInPrePosttest table but are not in the formatuserregtbl table	insert into demogPrePostNotInCothaule (accessId) select distinct(accessId) from demogInPrePosttest where upper(accessId) not in (select upper(loginName) from formatuserregtbl)	158

APPENDIX O: PRETEST SUMMARY RESULTS

Q#	Question Topic	Pretest Experimental		Pretest Control		Totals	
		Right (%)	Wrong (%)	Right (%)	Wrong (%)	Right (%)	Wrong (%)
1	Data Structures – Stacks and Queues	49 (42.6)	66 (57.4)	76 (53.4)	87 (46.6)	125 (45.0)	153 (55.0)
2	Data Structures – Stacks and Queues	28 (24.3)	87 (75.7)	41 (25.2)	122 (74.8)	69 (24.8)	209 (75.2)
3	Data Structures – Trees and Graphs	13 (11.3)	102 (88.7)	17 (10.4)	146 (89.6)	30 (10.8)	248 (89.2)
4	Simple SQL Statements	52 (45.2)	63 (54.8)	72 (44.2)	91 (55.8)	124 (44.6)	154 (55.4)
5	Arrays	40 (34.8)	75 (65.2)	55 (33.7)	108 (66.3)	95 (34.2)	183 (65.8)
6	Bubble Sorts	29 (25.2)	86 (74.8)	38 (23.3)	125 (76.7)	67 (24.1)	211 (75.9)
7	*Locating Objects in Arrays*	*15 (13.0)*	*100 (87.0)*	*30 (18.4)*	*133 (81.6)*	*45 (16.2)*	*233 (83.8)*
8	Iteration versus Conditional Stmts.	29 (25.2)	86 (74.8)	42 (25.8)	121 (74.2)	71 (25.5)	207 (74.5)
9	Backtracking	38 (33.0)	77 (67.0)	50 (30.7)	113 (69.3)	88 (31.7)	190 (68.3)
10	Decomposition	65 (56.5)	50 (43.5)	99 (60.7)	64 (39.6)	164 (59.0)	114 (41.0)
11	Abstraction	38 (33.0)	77 (67.0)	50 (30.7)	113 (69.3)	88 (31.7)	190 (68.3)
12	Class Construction	40 (34.8)	75 (65.2)	65 (39.9)	98 (60.1)	105 (37.8)	173 (62.2)
13	Pipelining	28 (24.3)	87 (75.7)	55 (33.7)	108 (66.3)	83 (29.9)	195 (70.1)
14	Formulas in classes	16 (13.9)	99 (86.1)	26 (16.0)	137 (84.0)	42 (15.1)	236 (84.9)
15	Error Handling	37 (32.2)	78 (67.8)	69 (42.3)	94 (57.7)	106 (38.1)	172 (61.9)
16	Prefetching and Caching	60 (52.2)	55 (47.8)	72 (44.2)	91 (55.8)	132 (47.5)	146 (52.5)
17	Recursion	30 (26.1)	85 (73.9)	47 (28.8)	116 (71.2)	77 (27.7)	201 (72.3)
18	Looping	34 (29.6)	81 (70.4)	45 (27.6)	118 (72.4)	79 (28.4)	199 (71.6)
19	Knapsack	40 (34.8)	75 (65.2)	57 (35.0)	106 (65.0)	97 (34.9)	181 (65.1)
20	Asynchronous vs.	31	84	25	138	56	222

	Synchronous Comm.	(27.0)	(73.0)	(15.3)	(84.7)	(20.1)	(79.9)
21	Heuristics	24 (20.9)	91 (79.1)	33 (20.2)	130 (79.8)	57 (20.5)	221 (79.5)
22	Complex if-then-else Stmts.	22 (19.1)	93 (80.9)	28 (17.2)	135 (82.8)	50 (18.0)	228 (82.0)
23	Understanding Functions	16 (13.9)	99 (86.1)	29 (17.8)	134 (82.2)	45 (16.2)	233 (83.8)
24	Excel Formulas	30 (26.1)	85 (73.9)	36 (22.1)	127 (77.9)	66 (23.7)	212 (76.3)
25	Class Function Calls	31 (27.0)	84 (73.0)	41 (25.2)	122 (74.8)	72 (25.9)	206 (74.1)
26	Tree Traversals	16 (13.9)	99 (86.1)	24 (14.7)	139 (85.3)	40 (14.4)	238 (85.6)

Note: Question 7 was discarded from the statistical results because of a consistent low score for both experimental and control groups across the pretest and posttest. The Q# column represents the test number.

APPENDIX P: POSTTEST SUMMARY RESULTS

Q#	Question Topic	Posttest Exp.		Posttest Control		Total	
		Right (%)	Wrong (%)	Right (%)	Wrong (%)	Right (%)	Wrong (%)
1	Data Structures – Stacks and Queues	48 (41.7)	67 (58.3)	82 (50.3)	81 (49.7)	130 (46.8)	148 (53.2)
2	Data Structures – Stacks and Queues	40 (34.8)	75 (65.2)	57 (35.0)	106 (65.0)	97 (34.9)	181 (65.1)
3	Data Structures – Trees and Graphs	41 (35.7)	74 (64.3)	66 (40.5)	97 (59.5)	107 (38.5)	171 (61.5)
4	Simple SQL Statements	40 (34.8)	75 (65.2)	53 (32.5)	110 (67.5)	93 (33.5)	185 (66.5)
5	Arrays	31 (27.0)	84 (73.0)	35 (21.5)	128 (78.5)	66 (23.7)	212 (76.3)
6	Bubble Sorts	40 (34.8)	75 (65.2)	60 (36.8)	103 (63.2)	100 (36.0)	178 (64.0)
7	*Locating Objects in Arrays*	*21 (18.3)*	*94 (81.7)*	*44 (27.0)*	*119 (73.0)*	*65 (23.4)*	*213 (76.6)*
8	Iteration versus Conditional Stmts.	45 (39.1)	70 (60.9)	63 (38.7)	100 (61.3)	108 (38.8)	170 (61.2)
9	Backtracking	19 (16.5)	96 (83.5)	29 (17.8)	134 (82.2)	48 (17.3)	230 (82.7)
10	Decomposition	25 (21.7)	90 (78.3)	32 (19.6)	131 (80.4)	57 (20.5)	221 (79.5)
11	Abstraction	29 (25.2)	86 (74.8)	36 (22.1)	127 (77.9)	65 (23.4)	213 (76.6)
12	Class Construction	29 (25.2)	86 (74.8)	36 (22.1)	127 (77.9)	65 (23.4)	213 (76.6)
13	Pipelining	40 (34.8)	75 (65.2)	53 (32.5)	110 (67.5)	93 (33.5)	185 (66.5)
14	Formulas in classes	32 (27.8)	83 (72.2)	42 (25.8)	121 (74.2)	74 (26.6)	204 (73.4)
15	Error Handling	46 (40.0)	69 (60.0)	56 (34.4)	107 (65.6)	102 (36.7)	176 (63.3)
16	Prefetching and Caching	28 (24.3)	87 (75.7)	44 (27.0)	119 (73.0)	72 (25.9)	206 (74.1)
17	Recursion	33 (71.3)	82 (28.7)	46 (28.2)	117 (71.8)	79 (28.4)	199 (71.6)
18	Looping	32 (27.8)	83 (72.2)	41 (25.2)	122 (74.8)	73 (26.3)	205 (73.7)
19	Knapsack	31 (27.0)	84 (73.0)	54 (33.1)	109 (66.9)	85 (30.6)	193 (69.4)
20	Asynchronous vs. Synchronous	58 (50.4)	57 (49.6)	85 (52.1)	78 (47.9)	143 (51.4)	135 (48.6)

	Comm.						
21	Heuristics	29 (25.2)	86 (74.8)	36 (22.1)	127 (77.9)	65 (23.4)	213 (76.6)
22	Complex if-then-else Stmts	48 (41.7)	67 (58.3)	75 (46.0)	88 (54.0)	123 (44.2)	155 (55.8)
23	Understanding Functions	43 (37.4)	72 (62.6)	69 (42.3)	94 (57.7)	112 (40.3)	166 (59.7)
24	Excel Formulas	39 (33.9)	76 (66.1)	56 (34.4)	107 (65.6)	95 (34.2)	183 (65.8)
25	Class Function Calls	44 (38.3)	71 (61.7)	58 (35.6)	105 (64.4)	102 (36.7)	176 (63.3)
26	Tree Traversals	37 (32.2)	78 (67.8)	52 (31.9)	111 (68.1)	89 (32.0)	189 (68.0)

Note: Question 7 was discarded from the statistical results because of a consistent low score for both experimental and control groups across the pretest and posttest. The Q# column represents the test number.

APPENDIX Q: IMMS SUMMARY DATA

Table Q1

Experimental Group IMMS Results

No.	Not True (%)	Slightly True (%)	Mod. True (%)	Mostly True (%)	Very True (%)	∑	Mean	Median	Mode
1C	67 (35.6)	42 (22.3)	53 (28.2)	12 (6.4)	14 (7.4)	428	2.277	2	1
2A	72 (38.3)	45 (23.9)	47 (25.0)	17 (9.0)	7 (3.7)	406	2.160	2	1
3C	*19 (10.1)*	*35 (18.6)*	*54 (28.7)*	*45 (23.9)*	*35 (18.6)*	*606*	*3.223*	*3*	*3*
4C	40 (21.3)	63 (33.5)	59 (31.4)	16 (8.5)	10 (5.3)	457	2.431	2	2
5S	57 (30.3)	44 (23.4)	52 (27.7)	22 (11.7)	13 (6.9)	454	2.415	2	1
6R	37 (19.7)	55 (29.3)	64 (34.0)	21 (11.2)	11 (5.9)	478	2.543	3	3
7C	*27 (14.4)*	*26 (13.8)*	*52 (27.7)*	*43 (22.9)*	*40 (21.3)*	*607*	*3.229*	*3*	*3*
8A	61 (32.4)	42 (22.3)	51 (27.1)	22 (11.7)	12 (6.4)	446	2.830	3	3
9R	27 (14.4)	38 (20.2)	77 (41.0)	32 (17.0)	14 (7.4)	532	2.692	3	3
10R	45 (23.9)	34 (18.1)	59 (31.4)	34 (18.1)	16 (8.5)	506	2.447	2	3
11A	49 (26.1)	49 (26.1)	55 (29.3)	27 (14.4)	8 (4.3)	460	2.809	3	3
12A	*35 (18.6)*	*48 (25.5)*	*51 (27.1)*	*26 (13.8)*	*28 (14.9)*	*528*	*2.809*	*3*	*3*
13C	46 (24.5)	52 (27.7)	55 (29.3)	26 (13.8)	9 (4.8)	464	2.468	2	3
14S	77 (41.0)	39 (20.7)	53 (28.2)	13 (6.9)	6 (3.2)	396	2.106	2	1
15A	*29 (15.4)*	*47 (25.0)*	*64 (34.0)*	*26 (13.8)*	*22 (11.7)*	*529*	*2.814*	*3*	*3*
16R	64 (34.0)	47 (25.0)	49 (26.1)	21 (11.2)	7 (3.7)	424	2.255	2	1
17A	55 (29.3)	53 (28.2)	55 (29.3)	16 (8.5)	9 (4.8)	435	2.314	2	1
18R	28 (14.9)	50 (26.6)	76 (40.4)	23 (12.2)	11 (5.9)	503	2.676	3	3
19C	*29 (15.4)*	*30 (16.0)*	*48 (25.5)*	*44 (23.4)*	*37 (19.7)*	*594*	*3.156*	*3*	*3*
20A	50 (26.6)	55 (29.3)	57 (30.3)	16 (8.5)	10 (5.3)	445	2.367	2	3
21S	82 (43.6)	51 (27.1)	43 (22.9)	10 (5.3)	2 (1.1)	363	1.931	2	1
22A	*23 (12.2)*	*49 (26.1)*	*47 (25.0)*	*41 (21.8)*	*28 (14.9)*	*566*	*3.011*	*3*	*2*
23R	32 (17.0)	49 (26.1)	68 (36.2)	27 (14.4)	12 (6.4)	502	2.670	3	3
24A	43 (22.9)	54 (28.7)	54 (28.7)	25 (13.3)	12 (6.4)	473	2.516	2	2
25C	69 (36.7)	37 (19.7)	57 (30.3)	16 (8.5)	9 (4.8)	423	2.250	2	1
26R	*92 (48.9)*	*32 (17.0)*	*44 (23.4)*	*16 (8.5)*	*4 (2.1)*	*372*	*1.979*	*2*	*1*
27S	51 (27.1)	44 (23.4)	56 (29.8)	26 (13.8)	11 (5.9)	466	2.479	2	3
28A	44 (23.4)	51 (27.1)	71 (37.8)	15 (8.0)	7 (3.7)	454	2.415	2	3
29A	*27 (14.4)*	*42 (22.3)*	*50 (26.6)*	*40 (21.3)*	*29 (15.4)*	*566*	*3.011*	*3*	*3*
30R	43 (22.9)	54 (28.7)	64 (34.0)	22 (11.7)	5 (2.7)	456	2.426	2	3
31A	*34 (18.1)*	*46 (24.5)*	*51 (27.1)*	*25 (13.3)*	*32 (17.0)*	*539*	*2.867*	*3*	*3*
32S	38 (20.2)	37 (19.7)	49 (26.1)	30 (16.0)	34 (18.1)	549	2.920	3	3
33R	51 (27.1)	54 (28.7)	51 (27.1)	24 (12.8)	8 (4.3)	448	2.383	2	2
34C	*24 (12.8)*	*33 (17.6)*	*52 (27.7)*	*48 (25.5)*	*31 (16.5)*	*593*	*3.154*	*3*	*3*
35C	41 (21.8)	52 (27.7)	64 (34.0)	24 (12.8)	7 (3.7)	468	2.489	3	3
36S	42 (22.3)	55 (29.3)	57 (30.3)	26 (4.3)	8 (4.3)	467	2.484	2	3

Note: The survey items were rewarded one point for Not True up to five points for Very True. Questions from the IMMS that are stated in the negative are italicized. The letters next to the numbers in the Number column represent which ARCS subscale items the question refers to. The No. column represents the number of the question in the scale.

Table Q2

Control Group IMMS Results

No.	Not True (%)	Slightly True (%)	Mod. True (%)	Mostly True (%)	Very True (%)	∑	Mean	Median	Mode
1C	60 (19.5)	86 (27.9)	93 (30.2)	45 (14.6)	24 (7.8)	811	2.633	3	3
2A	83 (26.9)	84 (27.3)	91 (29.5)	40 (13.0)	10 (3.2)	734	2.383	2	3
3C	*67 (21.8)*	*58 (18.8)*	*87 (28.2)*	*54 (17.5)*	*42 (13.6)*	*870*	*2.825*	*3*	*3*
4C	45 (14.6)	79 (25.6)	92 (29.9)	63 (20.5)	29 (9.4)	876	2.844	3	3
5S	58 (18.8)	72 (23.4)	88 (28.6)	48 (15.6)	42 (13.6)	868	2.818	3	3
6R	47 (15.3)	65 (21.1)	104 (33.8)	57 (18.5)	35 (11.4)	892	2.896	3	3
7C	*34 (11.0)*	*66 (21.4)*	*90 (29.2)*	*71 (23.1)*	*47 (15.3)*	*955*	*3.101*	*3*	*3*
8A	76 (24.7)	84 (27.3)	88 (28.6)	42 (13.6)	18 (5.8)	766	2.487	2	3
9R	29 (9.4)	69 (22.4)	113 (36.7)	58 (18.8)	39 (12.7)	933	3.029	3	3
10R	43 (14.0)	40 (13.0)	95 (30.8)	64 (20.8)	66 (21.4)	994	3.227	3	3
11A	60 (19.5)	79 (25.6)	87 (28.2)	60 (19.5)	22 (7.1)	829	2.692	3	3
12A	*75 (24.4)*	*60 (19.5)*	*83 (26.9)*	*51 (16.6)*	*39 (12.7)*	*843*	*2.737*	*3*	*3*
13C	34 (11.0)	74 (24.0)	80 (26.0)	86 (27.9)	34 (11.0)	936	3.039	3	4
14S	100 (32.5)	76 (24.7)	69 (22.4)	45 (14.6)	18 (5.8)	729	2.367	2	1
15A	*50 (16.2)*	*81 (26.3)*	*82 (26.6)*	*51 (16.6)*	*44 (14.3)*	*882*	*2.864*	*3*	*3*
16R	98 (31.8)	79 (25.6)	76 (24.7)	42 (13.6)	13 (4.2)	717	2.328	2	1
17A	65 (21.1)	83 (26.9)	87 (28.2)	47 (15.3)	26 (8.4)	810	2.630	3	3
18R	28 (9.1)	78 (25.3)	111 (36.0)	67 (21.8)	24 (7.8)	905	2.938	3	3
19C	*79 (25.6)*	*47 (15.3)*	*85 (27.6)*	*54 (17.5)*	*43 (14.0)*	*859*	*2.789*	*3*	*3*
20A	71 (23.1)	87 (28.2)	88 (28.6)	40 (13.0)	22 (7.1)	779	2.529	2	3
21S	95 (30.8)	88 (28.6)	82 (26.6)	26 (8.4)	17 (5.5)	706	2.292	2	1
22A	*28 (9.1)*	*70 (22.7)*	*87 (28.2)*	*63 (20.5)*	*60 (19.5)*	*981*	*3.185*	*3*	*3*
23R	39 (12.7)	77 (25.0)	112 (36.4)	58 (18.8)	22 (7.1)	871	2.828	3	3
24A	40 (13.0)	64 (20.8)	95 (30.8)	73 (23.7)	36 (11.7)	925	3.003	3	3
25C	63 (20.5)	75 (24.4)	94 (30.5)	54 (17.5)	22 (7.1)	821	2.666	3	3
26R	*114 (37.0)*	*56 (18.2)*	*80 (26.0)*	*37 (12.0)*	*21 (6.8)*	*719*	*2.334*	*2*	*1*
27S	68 (22.1)	85 (27.6)	98 (31.8)	38 (12.3)	19 (6.2)	779	2.529	3	3
28A	62 (20.1)	72 (23.4)	96 (31.2)	53 (17.2)	25 (8.1)	831	2.698	3	3
29A	*46 (14.9)*	*86 (27.9)*	*79 (25.6)*	*46 (14.9)*	*51 (16.6)*	*894*	*2.903*	*3*	*2*
30R	50 (16.2)	90 (29.2)	106 (34.4)	40 (13.0)	22 (7.1)	818	2.656	3	3
31A	*57 (18.5)*	*78 (25.3)*	*73 (23.7)*	*57 (18.5)*	*43 (14.0)*	*875*	*2.841*	*3*	*2*
32S	41 (13.3)	67 (21.8)	82 (26.6)	48 (15.6)	70 (22.7)	963	3.127	3	3
33R	52 (16.9)	73 (23.7)	96 (31.2)	60 (19.5)	27 (8.8)	861	2.796	3	3
34C	*71 (23.1)*	*62 (20.1)*	*94 (30.5)*	*44 (14.3)*	*37 (12.0)*	*838*	*2.721*	*3*	*3*
35C	54 (17.5)	80 (26.0)	103 (33.4)	46 (14.9)	25 (8.1)	832	2.701	3	3
36S	51 (16.6)	73 (23.7)	95 (30.8)	58 (18.8)	31 (10.1)	869	2.821	3	3

Note: The survey items are rewarded one point for Not True up to five points for Very True. Questions from the IMMS that stated in the negative are italicized. The letters next to the numbers in the Number column represent which ARCS subscale items the question refers to. The No. column represents the number of the question in the scale.

APPENDIX R: MANOVA ASSUMPTION TESTING

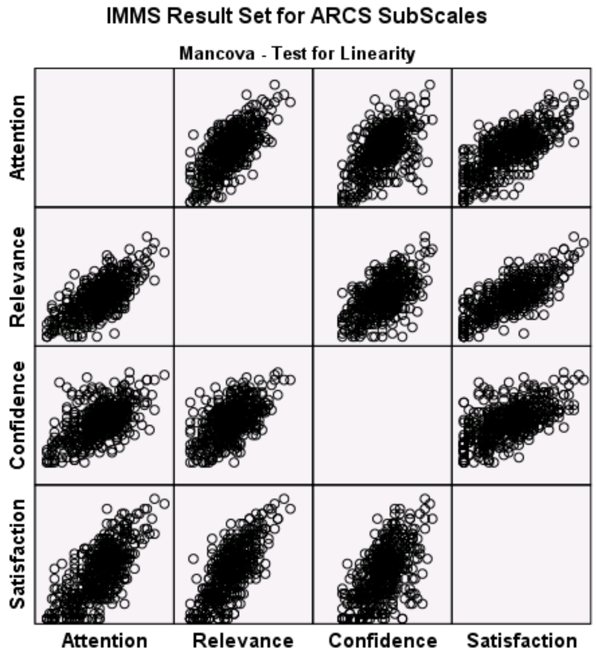


Figure R1. Evidence of test for linearity.

Table R1

Descriptive Statistics Showing Evidence of Test for Outliers

	N	Min.	Max.	Sum	Mean	Std. Dev.	Skewness		Kurtosis	
	Stat.	Stat.	Stat.	Stat.	Stat.	Stat.	Stat.	Std. Error	Stat.	Std. Error
Attention	496	12	59	16470	33.21	8.387	-.291	.110	.179	.219
Relevance	496	13	45	12725	25.66	5.554	.152	.110	.263	.219
Confidence	496	9	45	12546	25.29	6.896	-.020	.110	.053	.219
Satisfaction	496	6	30	7609	15.34	5.110	.080	.110	-.388	.219
Relevance	*495*	*13*	*43*	*12680*	*25.62*	*5.491*	*.090*	*.110*	*.110*	*.219*

Note. Table displays evidence of the check for skewness and kurtosis. The outlier was identified and removed from the Relevance subscale. The bottom row displays the adjusted maximum statistic.

Table R2

Z-Score Adjustment Table for ARCS Subscale Items

	Initial Z-Scores			Adjusted Z-Scores		
	N	Min.	Max.	N	Min.	Max.
Zscore: Attention	496	-2.52847	3.07561	496	-2.52847	3.07561
Zscore: Relevance	*496*	*-2.27852*	*3.48294*	*495*	*-2.29757*	*3.16583*
Zscore: Confidence	496	-2.36270	2.85734	496	-2.36270	2.85734
Zscore: Satisfaction	496	-1.82779	2.86853	496	-1.82779	2.86853
Valid N (listwise)	496			495		

Note: The table displays the actual adjusted z-scores after a score in the Relevance subscale was removed. The z - score was lowered from 3.48 to 3.17.

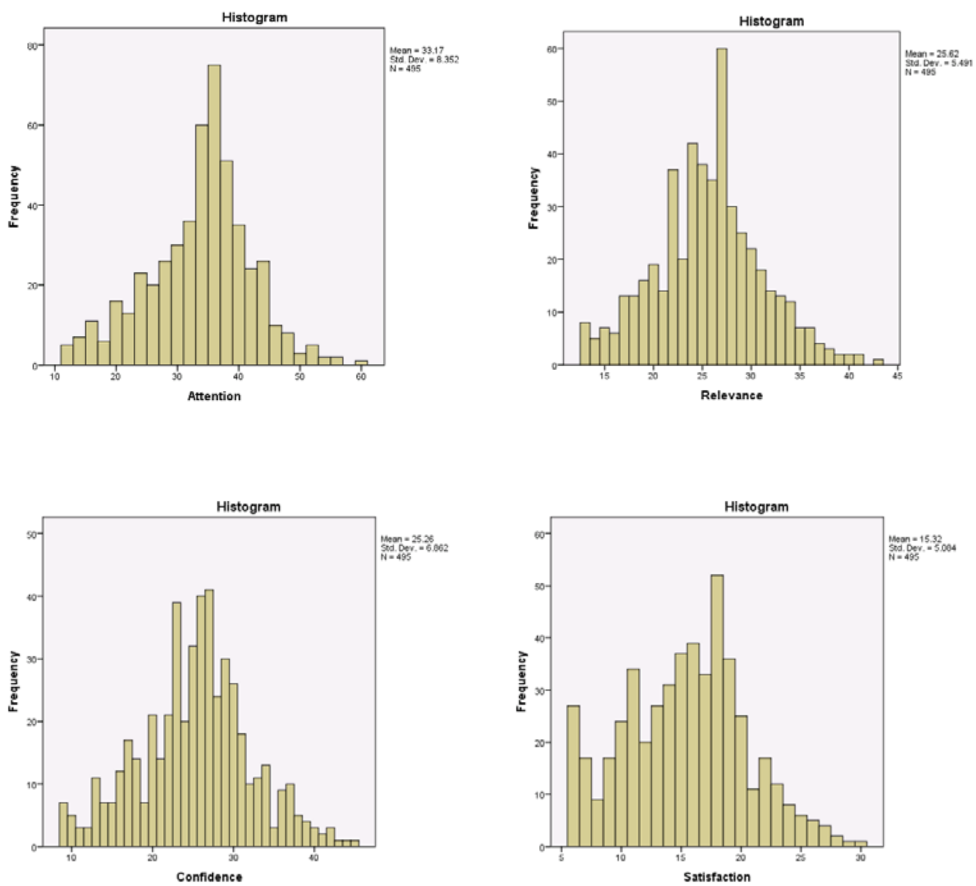


Figure R2. Evident of multivariate normality testing. Graphs reveal primarily a normal distribution for each of the ARCS subscale items.

Table R3

Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Attention	0.014	1	493	.905
Relevance	0.058	1	493	.809
Confidence	4.622	1	493	.032
Satisfaction	0.020	1	493	.887

Note: a. Design: Intercept + WhichGroup.

Table R4

Evidence of Robust Test of Equality of Means

		Statistic[a]	df1	df2	Sig.
Attention	Welch	5.610	1	407.126	.018
	Brown-Forsythe	5.610	1	407.126	.018
Relevance	Welch	13.293	1	412.106	.000
	Brown-Forsythe	13.293	1	412.106	.000
Confidence	Welch	26.019	1	450.167	.000
	Brown-Forsythe	26.019	1	450.167	.000
Satisfaction	Welch	12.340	1	413.789	.000
	Brown-Forsythe	12.340	1	413.789	.000

Note: a. Asymptotically F distributed.

Table R5

Evidence of the Test for Absence of Multicollinearity and Singularity

	Attention Collinearity Stats.		Relevance Collinearity Stats.		Confidence Collinearity Stats.		Satisfaction Collinearity Stats.	
	Tol.	VIF	Tol.	VIF	Tol.	VIF	Tol.	VIF
Attention	--------	--------	.453	2.207	.435	2.296	.481	2.079
Relevance	.415	2.407	--------	--------	.393	2.544	.485	2.063
Confidence	.402	2.487	.442	2.263	--------	-------	.624	1.604
Satisfaction	.627	1.595	.617	1.621	.362	2.761	-------	---------

APPENDIX S: IMMS OPEN-ENDED RAW DATA FEEDBACK

The following items show the experimental group raw data feedback for each of the questions in the IMMS. Responses were copied as is without editing. Any personal information was removed.

1. When I first looked at COTHAULE, I had the impression that it would be easy for me.
    a. It made me not want to continue, it sounds like a completely different language.
    b. I don't know anything about programming.
    c. I don't even know what COTHAULE is...
    d. looked like a basic website and too colorful
    e. Some questions looked really easy but others I had no idea.
    f. The scenarios were simple but solving the equations were hard.
    g. Cant read it
    h. I dont know what cothaule means
    i. The videos seemed to be a luring tactic, but became a bit too dry and even annoying at times. Especially, after the relevance of videos and lengthy questionnaires seemed to have very little correlation to me.
    j. The website appeared to be childish in a manner. The appearance on the first page. Attracting and unprofessional colors.
    k. Seemed very outdated compared to our current programs used today.
2. There was something interesting at the beginning of COTHAULE that got my attention.
    a. Knowing it was extra credit for my computers class!
    b. the 3d model videos were used
    c. The graphic design of the people.
    d. The fact that the characters were discussing real-life Wayne State issues.
    e. Yes, initially the videos seemed to be an eye catcher given that I am a visual person and like to see visuals when it comes to learning.
    f. I thought that is appearance was off putting.
3. COTHAULE was more difficult to understand that I would like for it to be.
    a. It kept getting even harder as it went on.
    b. Some of the problems were hard to solve.
    c. Only to the fact, that I never new if the instructor was seeing what I had already completed, since I never was brought back to a specific point when I left and returned to the program.
4. After reading the introductory information, I felt confident that I knew what I was supposed to learn from COTHAULE.
    a. Didn't even know how to start at first because the faq page ends without mentioning how to start.
    b. I felt I was I supposed to solve the problems based on the information I was given but that was not the case.
    c. The instructions were vague and I had no clue what I was supposed to be doing. There were no clear instructions on what I was looking for.
5. Completing the exercises in COTHAULE gave me a satisfying feeling of accomplishment.
    a. Very difficult

    b. Once I figured out the hard problems I felt very accomplished.
    c. Didnt really finish all the way
6. It is clear to me how the content of COTHAULE is related to things I already know.
    a. I have no idea what any of this stuff is or how it even relates to anything.
    b. Besides the training exercises, I was not taught most of this stuff in class.
    c. The characters in COTHAULE were very relatable.
    d. Some of the questions seemed to be logical enough but the mathematical formulas were confusing to me.
7. Many of the (web) pages had so much information that it was hard to pick out and remember the important points
    a. No responses
8. COTHAULE was eye-catching.
    a. I didn't like the animation and the computerized talking, it was creepy to me.
    b. Hurt my eyes.
    c. First time seeing and hearing something like that very interesting.
    d. To the fact that it seems outdated.
9. There were stories, pictures, or examples that showed me how COTHAULE could be important to some people.
    a. I have gone through some of the issues that COTHAULE displayed.
    b. I mostly enjoyed the library research scenario
10. Completing COTHAULE successfully was important to me.
    a. No responses
11. The quality of the writing helped to hold my attention.
    a. I think there shouldn't be too many ""big"" words used because it makes the text harder to read.
    b. The writing was very informative.
    c. The questions were too lengthy and not so clear but that might also be because of my confusion about the formulas and what I need to do
12. COTHAULE is so abstract that it was hard to keep my attention on it..
    a. I wasn't sure what was asked of me. I didn't get an introduction about what the subject was about. I felt like I was watching entertaining videos but not sure what I needed to answer for
13. As I worked on COTHAULE, I was confident that I could learn the content.
    a. Learning the content was hard but not impossible
14. I enjoyed COTHAULE so much that I would like to know more about computational thinking.
    a. I feel like the videos were fun to watch well except I would restructure the decor and avoid use of ultra-bright colors because at sometimes I felt like I was more focused on the colors than the conversation taking place in the video
15. The (web) pages of COTHAULE look dry and unappealing.
    a. It more or less to moist and appealing to the wrong age group.
16. The content of COTHAULE is relevant to my interests.
    a. I liked that the videos related real life student issues and integrated them into the Computational Thinking videos. However, the questions to me made no sense but then again that might be due to my lack of interest in formulas and numbers

17. The way the information is arranged on the (web) pages helped keep my attention.
    a. *No responses*
18. There are explanations or examples of how people use the knowledge in COTHAULE.
    a. There were several explanations and examples
19. The exercises in COTHAULE were too difficult.
    a. Some were very hard while others were simple
20. COTHAULE has things that stimulated my curiosity.
    a. Boring and computerized talking was so mono tone and the people were creepy.
    b. The reading and understanding of the content stimulated my curiosity.
    c. The concept is something different
21. I really enjoyed studying COTHAULE.
    a. It was really frustrating
    b. It was very interesting.
    c. Not true
22. The amount of repetition in COTHAULE caused me to get bored sometimes.
    a. Not true
23. The content and style of writing in COTHAULE convey the impression that its content is worth knowing.
    a. Some of the information was very informative.
    b. Not true
24. I learned some things that were surprising or unexpected.
    a. Mod true
25. After working on COTHAULE for awhile, I was confident that I would be able to pass a test on it.
    a. I got confused and felt like i would never pass a test if this were graded on it. i didnt know how to do the info
26. COTHAULE was not relevant to my needs because I already knew most of it.
    a. I didnt know any of it
    b. Mostly true
27. The wording of feedback after the exercises, or of other comments in COTHAULE, helped me feel rewarded for my effort.
    a. I didn't see feedback.
    b. Not true
    c. I enjoyed that I was given the correct answers but was very frustrated with the last scenario. I tried everything and it still would not provide an answer and that made me feel challenged.
28. The variety of reading passages, exercises, illustrations, etc., helped keep my attention on COTHAULE.
    a. Very plain
    b. Not true
    c. The illustrations/videos seemed to be a good learning tool
29. The style of writing is boring.
    a. Mod True

   b. The questions were too lengthy and I felt very uninterested in reading even further. At other times, I felt discouraged to even solve the problem after having reading half the question. I wasn't sure what my mission was?

30. I could relate the content of COTHAULE to things I have seen, done or thought about in my own life.
    a. I really had a difficult time understanding this and trying to understand why I was taking this for a computer class.
    b. Mod True
31. There are so many words on each (web) page that it is irritating.
    a. Very true
    b. The excel sheets were challenge because I had no prior knowledge and no instructions on what to do.
32. It felt good to successfully complete COTHAULE.
    a. I was glad it was over with
    b. Very true
    c. I completed a project
33. The content of COTHAULE will be useful to me.
    a. Mostly true
34. I could not really understand quite a bit of the material in COTHAULE.
    a. It was confusing
    b. I know nothing about programming and felt very lost while participating.
    c. Mostly true
35. The good organization of the content helped me be confident that I would learn this material.
    a. Slightly true
36. It was a pleasure to work on such a well-designed website.
    a. just would have helped if it were less confusing
    b. Interesting at least if it was a study to test us.
    c. Not true
    d. The web-designed website could be a success if instructions were added to it especially in the beginning. Also, an introduction about the subject itself would help
    e. I wouldn't call it well-designed.

The following items show the control group raw data feedback for each of the questions in the IMMS. Responses were copied as is without editing.

1. When I first looked at the Online Training, I had the impression that it would be easy for me.
   a. I could definitely try but I am not familiar with the material
   b. It helps that students are given more than one chance to answer the questions correctly.
   c. Seemed like a lot of work but easy.
   d. I am horrible with comprehension of critical thinking and logic so it was a insurmountable information.
   e. They were way too long so I could only skim them
   f. It did at first.
   g. Thought it would be easy to really get an A

    h. No comment

2. There was something interesting at the beginning of the Online Training that got my attention.
    a. I was interested in learning a little about how computers work.
    b. I wanted to look them up , so that i could give the correct answer .
    c. I did it for extra credit
    d. It was cool to see the black lady's website she made to help young girls. There is an exceptionally low percentage of black and/or hispanic people who graduate with a degree the STEM field so to see one
    e. Java script being such a big deal and i never knew about it before.
    f. yes because i didn't know some stuff about Microsoft at first.
    g. Very interesting learning about some of the things on the computer that i had no idea about
    h. the teaching system is well organized
3. The Online Training was more difficult to understand that I would like for it to be.
    a. Being unfamiliar with computers and logic I found the information to be very difficult to understand and interpret
    b. I think that this class is outdated, most of the people forced to take it like myself have grown up with computers and have no need to sit in a class 2 hours a week doing things that we learned when we were 8.
    c. Because i really wanted to get all the answers correct .
    d. I really do like being able to interactively learn with a professor instead of just reading text.
    e. It was to long
4. After reading the introductory information, I felt confident that I knew what I was supposed to learn from the Online Training.
    a. I got a rough idea of what I needed to learn.
    b. Was i suppose to learn that i really did not know how to answer these type of question .
    c. This had nothing to do with the online materials
5. Completing the exercises in the Online Training gave me a satisfying feeling of accomplishment.
    a. It accomplishes nothing because its all things I already know, I just skip right to the assessment in each section and do the quiz.
    b. I wasn't sure if I performed the exercises correctly.
    c. I really felt not that bright of a person after taking test .
    d. I wasnt able to complete them. I could only skim the materials
    e. yes because i was finally done.
6. It is clear to me how the content of the Online Training is related to things I already know.
    a. I do see some relationships between my previous knowledge of computers, and that which I learned later.
    b. The thing I find difficult with the online learning. I do many of the f
    c. Because it was stuff that we did our whole life.
    d. Not sure about this question
7. Many of the (web) pages had so much information that it was hard to pick out and remember the important points.

   a. A lot of the times, it was easier to answer the questions first to know what information is important to retain.
   b. Yes it was hard for me to find the information
   c. Yes because it was so much at once.
8. The Online Training was eye-catching.
   a. It's all extremely boring and huge waste of time and money.
   b. I really wanted to know what the answers were and i wished i knew how to come up with correct answer .
   c. Too much happening to focus on a specific topic.
   d. It was boring and long.
9. There were stories, pictures, or examples that showed me how the Online Training could be important to some people.
   a. I find this was helpful using sam.
   b. Yes because that's not the only thing they talked about on there.
10. Completing the Online Training successfully was important to me.
   a. I had a desire to learn more about the content.
   b. Yes because i really need extra credit to pass this class.
   c. I got 100% on all my assignments
   d. I plan on getting an A in this class and getting as many 100%'s is the only way to go.
   e. Yes because i was done.
   f. Hoping i maintain my A's with the online assignments
11. The quality of the writing helped to hold my attention.
   a. It was hard to understand.
   b. Not really because it was just writing.
12. The Online Training is so abstract that it was hard to keep my attention on it.
   a. I didn't care for it.
13. As I worked on the Online Training, I was confident that I could learn the content.
   a. I could learn materials if i was able to look questions up on line and get correct answer.
   b. The book was more helpful than online learning. It was easier to pick out the main topics of study.
   c. I already knew it.
   d. It didn't cover whole material that would be on exam
14. I enjoyed the Online Training so much that I would like to know more about computational thinking.
   a. I am interested in learning more.
   b. Maybe programming such as matlab. but not this.
   c. I'm more into Philosophy but this in some aspects could be very helpful.
   d. Not really i like my major.
15. The (web) pages of the Online Training look dry and unappealing.
   a. Because it was.
16. The content of the Online Training is relevant to my interests.
   a. Education major, csc not really my thing, but i can value the knowledge.
   b. I work for a cell phone company and learn much more advanced technologies than what we learn about in this class. The things we go over in this class are not current.

   c. The book was more relevant to my studies. Except for the sam modules
   d. I am a Psychology major with a Sociology minor (not for long, I plan on switching to something else) so what really interests me is Social Science.
   e. I did care for it but then again i didn't.
17. The way the information is arranged on the (web) pages helped keep my attention.
    a. Not really.
    b. Had to replay some of the material, because it was a little confusing.
18. There are explanations or examples of how people use the knowledge in the Online Training.
    a. Depends on what you mean
    b. Yes they explained some of it.
19. The exercises in the Online Training were too difficult.
    a. I didn't do the exercises, but the content was too difficult.
    b. Not at all because it was easy.
    c. It wasn't difficult but it would not take the alternate way to complete exercises.
20. The Online Training has things that stimulated my curiosity.
    a. I was curious about the information itself, but the text did little to keep my attention.
    b. Once again. Too much happening and material thrown at the students to really grasp the concepts. I believe teacher to student has a more promising future than computer to student.
    c. Not really didn't care for it
21. I really enjoyed studying the Online Training.
    a. Some parts were interesting, and some were not.
    b. Didn't care for it.
22. The amount of repetition in the Online Training caused me to get bored sometimes.
    a. There is was not enough repetition
    b. material was not repetitive that much
    c. It was to long.
    d. It helped refreshing my memory
23. The content and style of writing in the Online Training convey the impression that its content is worth knowing.
    a. Yes i would have liked the correct answers.
    b. Didn't care once more.
24. I learned some things that were surprising or unexpected.
    a. Already knew it once more.
25. After working on the Online Training for a while, I was confident that I would be able to pass a test on it.
    a. Pass as in > 60% or pass as in achieve a good grade (> B)
    b. The online did not help me with the exam. all the material i studied came from the book.
    c. I didn't get to work with it as much as I would have liked to.
    d. Because i knew it.
26. The Online Training was not relevant to my needs because I already knew most of it.
    a. Some of the problems appeared more complicated because of the equations.
    b. Yes

27. The wording of feedback after the exercises, or of other comments in the Online Training, helped me feel rewarded for my effort.
    a. There was feedback? -- nothing more than ""task complete
    b. I didn't see these because I didn't get to the practice.
    c. I guess.
28. The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the Online Training.
    a. Uncaring for this.
29. The style of writing is boring.
    a. Not boring i just did not know answers .
    b. True
30. I could relate the content of the Online Training to things I have seen, done or thought about in my own life.
    a. I had no way of relating the difficult to understand material to my life which made it harder to understand. The material itself was a hard read and dry for someone like myself who has had no prior exposure to the subject matter.
    b. I don't know.
31. There are so many words on each (web) page that it is irritating.
    a. On some of the question .
    b. All of it.
32. It felt good to successfully complete the Online Training.
    a. I completed but i felt kind of empty because i felt like i did not know many answers .
    b. I only got to skim the materials.
    c. Yes
33. The content of the Online Training will be useful to me.
    a. If i understood yes.
    b. Idk
34. I could not really understand quite a bit of the material in the Online Training.
    a. I understood it. However, there was too much given to retain.
    b. Yes
35. The good organization of the content helped me be confident that I would learn this material.
    a. Idk
36. It was a pleasure to work on such a well-designed lesson.
    a. The website did weird things when I would log off and try to log back in right, like say I was still in a session.
    b. Yes

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ABSTRACT

THE EFFECTS OF APPLYING AUTHENTIC LEARNING STRATEGIES TO DEVELOP COMPUTATIONAL THINKING SKILLS IN COMPUTER LITERACY STUDENTS

by

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May 2013

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This study attempts to determine if authentic learning strategies can be used to acquire knowledge of and increase motivation for computational thinking. Over 600 students enrolled in a computer literacy course participated in this study which involved completing a pretest, posttest and motivation survey. The students were divided into an experimental and control group based on class meeting day. The experimental group was given access to an authentic learning tool called COTHAULE. COTHAULE, which is an acronym that stands for Computational Thinking Authentic Learning Environment, is a website that was developed using a variety of technologies. The intellection behind COTHAULE was to take every-day experiences that could pertain to life in a college campus environment and merge them with computational thinking concepts and the learning objectives of a common computer literacy course. Examples of experiences were formed into five case studies each containing seven scenarios that read like a conversation taking place between students. The basic functionality of the tool was to load a video clip into the website for the student to watch for each scenario then present the student with an authentic learning activity and problem to solve. The authentic

learning activities involved such topics as searching, sorting and filtering tables using software such as Microsoft Word and Excel and translating the activities into computational thinking concepts. A control group received a set of traditional textbook style online learning materials.

A pretest and posttest was used to measure learning for each group. The study concluded that although there was a significant increase in learning between the pretest and posttest for both groups, there was no significant difference in learning by one group over the other group. The study also concluded that the motivation of the control group was significantly greater than the experimental group. There were some gaps in the COTHAULE tool as it compares to the expectations of an authentic learning environment and should be revisited. Improvements to the overall design of COTHAULE should also be considered.

AUTOBIOGRAPHICAL STATEMENT

I am currently employed as the Infrastructure Service Manager in the Information Technology Infrastructure (ITI) Division of Mercedes-Benz Financial Services (MBFS) USA, LLC in Farmington Hills, Michigan. My primary responsibility is oversight of data center operations, which includes over 100 servers that hosts applications used to run the daily business for the company. I am also responsible for overseeing change management in the areas of database administration, Websphere engineering, enterprise application integration (EAI), mainframe support and UNIX support. Prior to my position in ITI, I was employed as an applications manager for seven years in the Financial Services division of MBFS. During that time, I managed a number of transformational projects including the launches of a new contract origination system and a new credit evaluation system on the Java 2 Enterprise Edition (J2EE) platform. I was a recipient of two team president's awards in 2008 and 2009, and the recipient of an individual president's award in 2010.

I was previously employment at the Internal Revenue Service (IRS) for nine years where I was a programmer for the first four years and then promoted to an Information Systems manager. Although I spent most of my tenure programming in COBOL, I often volunteered to work on new technologies as they were introduced to the company and successfully led first time projects using Teradata, Visual Basic and Microsoft Access.

I completed my Bachelor of Science degree in computer science at the University of Detroit in 1992 and my Master of Arts degree in computer science at Wayne State University in 1999. My passion for technology came with the trials in trying to succeed in such a challenging field. During that time, there were very few female students and fewer Black students that were interested in computer science. Unfortunately, the lack of interest has not changed much over time. Whenever possible, I try to capitalize on opportunities to teach or speak to young students in order to encourage them to pursue fields in information technology. Throughout my career, I have participated in computer camps for high school students, speaking to students at high school career days, teaching technology seminars at conferences and hosting technology-day activities on my job. This is important to me seeing how technology is now such an integral part of our lives and how the number of qualified individuals needed to fulfill information technology jobs continue to lag behind industry demand. More so, it is difficult to find any occupation that does not rely on computer technology to some degree. As an advocate of computational thinking for all, I hope that my doctoral degree in instructional technology will enable me to implement innovative teaching ideas that will help people obtain a better understanding of this viable topic.