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Essays on Technology-Mediated Training: Implications for Design and Evaluation

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Essays on Technology-Mediated Training: Implications for Design and Evaluation

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By

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Abstract

Information technology (IT) is increasingly used to impart a variety training skills, and these skills may range from specific software application operations and computer programming to learning about generic business processes. Using IT to assist training is broadly termed "Technology-Mediated Learning" (TML). Following the three essay model, this dissertation examines training interventions in the context of TML. In Essay 1, a thorough literature survey of technology training in Information Systems (IS) was conducted, resulting in clarification of the nomenclature used in TML. Essay 1 also identified of two leading theories used in TML research: (a) social cognitive theory (SCT) (b) cognitive load theory (CLT). These two theories were subsequently explored in detail in Essay 2 and Essay 3. According to SCT, humans learn via observational learning (OL) processes of *attention, retention, production,* and *motivation*. Essay 2 developed and tested a nomological model of relationships among OL processes. Essay 2 also examined the effectiveness of a mental rehearsal training intervention in the technology-mediated training context of Enterprise Resource Planning (ERP) simulation. A between-subjects quasi-experiment with n = 150 was conducted to do so, where the control group received training which espoused vicarious learning as well as enactive learning to form the baseline. The treatment group was exposed to additional mental rehearsal. The results supported the hypothesized model of observational learning. Further, the mental rehearsal (i.e., intervention) group formed knowledge structures that shared greater similarity with ERP experts' knowledge structures compared to the control group. The treatment group also scored significantly higher in terms of business process knowledge and integration knowledge compared to the control group. Essay 3 examined the mechanism behind the effectiveness of mental rehearsal in a technology-mediated training context of Massively Open Online Classes

(MOOCs). To do so, it employed cognitive load theory (CLT). A randomized two-group post-test online experiment was conducted with a sample size of 258 to test the conjecture that mental rehearsal reduced extraneous load while enhanced germane load. Results supported the hypotheses related to germane load and extraneous load. It was also found that mental rehearsal led to the formation of knowledge structures that shared greater similarity to experts' knowledge structures compared to the control group. Thus, supporting the notion that mental rehearsal enhances the effectiveness of training in TML contexts.

Acknowledgements

This dissertation would not have been possible without the support of several people. First and foremost I acknowledge the sacrifice made by my parents, to help me pursue this PhD program. I am thankful to my younger sister Pooja and all my family members for tolerating my absence from nearly every family function and providing unwavering support for my pursuit.

I thank my advisor Prof. Fred Davis for always being supportive of my ideas and for his confidence in me. The freedom he gave me in making various research decisions has made me confident in my ability to work independently. It motivates me to work on more challenging research in years ahead. I also thank my committee members Dr. Cheryl Murphy, Dr. Paul Cronan, and Dr. Srini Venkatraman for their timely and valuable feedback. Their suggestions have greatly benefited my research. My thanks to Tricia Kelly and Alice Frizzell for providing logistics support during the PhD program.

Dedication

This dissertation is lovingly dedicated to my partner Sienna Lei. Her encouragement, constant love, and lavish meals have sustained me through the process.

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Chapter 1

Introduction

Training is very important for workplace performance (Barrett & O'Connell, 2000; Gupta & Bostrom, 2013; Park & Jacobs, 2011). US corporations spent $171 billion was spent on training in 2010, and of this 171 billion, largest amount was spent on information technology (IT) training (ASTD, 2011). Training has been shown to have a positive effect on behavior/skill change (Gupta & Bostrom, 2013). Prior research suggests that this effect size ranging from .60 to .63 (Arthur, Bennett, Edens, & Bell, 2003). However, only 13% of the employees were able to perform the newly learned skills while on the job, and only 3% of the employees were able to translate the training provided to reduce cost and improved quality (ASTD, 2005). Thus, there is a need to understand and evaluate training process in greater detail.

The growth of IT has made it a preferred vehicle to impart training, leading to a prominent category of training called technology-mediated learning (TML) (Gupta & Bostrom, 2013). It is defined as “an environment in which the learner’s interactions with learning materials, peers, and/or instructor are mediated through advanced information technology” (Alavi & Leidner, 2001, p. 2). Use of technology training methods that employ TML has been on the rise (Allen & Seaman, 2015, ASTD, 2011). Over 40% of training is delivered via information technology (ASTD, 2011). In spite of widespread adoption, and use, there is little scientific research on this topic (Alavi & Leidner, 2001; Gupta & Bostrom 2013; Sasidharan &Santhanam, 2006).

The focus of this research is on theoretically grounding TML in existing and prevalent behavior modeling training (BMT). BMT is rooted in observational learning (OL) processes as prescribed by the social cognitive framework (Bandura, 1969). According to Bandura, humans learn and acquire new skills through four processes of observational learning *(attention, retention, production and motivation).* There has been recent work on observational learning (OL) in IS (Davis & Yi 2004; Gupta & Bostrom, 2013; Yi & Davis, 2003). However, interrelationships between OL processes as predicted by Bandura (1969) have not been explored empirically, as well investigation of the prevalent training interventions such as mental rehearsal in a technology-mediated environment is an under-researched area (Gupta & Bostrom, 2013). Essay 2 explores above mentioned topic in detail.

Prior research has shown that interventions such as mental rehearsal are useful in increasing the effectiveness of training. Fields where mental rehearsal has been successfully applied range from information technology, music, neurology to sports. (Bernardi, Schories, Jabusch, Colombo, & Altenmueller, 2013; Clowes & Knowles, 2013; Decker, 1982; Decker & Nathan, 1985; Marcus, Vakharia, Kirkman, Murphy, & Nandi, 2013). Why and how interventions such as mental rehearsal are effective is not well understood. Research in this area is at its inception and scant (Leahy & Sweller, 2004; 2008). Essay 3 explores this question in detail.

This dissertation focused on gaining a deeper understanding of the training process. It was aimed at equipping researchers and practitioners to design efficient training interventions in a technology-mediated context as well as to develop better evaluation mechanisms. Overall, it accomplished following three research goals encapsulated in three essays.

1) In essay 1, a thorough literature survey on TML was conducted to find out novel ways to extend TML research. The result of this literature survey indicated that there was a lack of scientific research on theoretically grounded models of TML. It was concluded that *social cognitive theory* (SCT) (Bandura, 1969) and *cognitive load theory* (CLT) (Sweller,

1988) offer a potential theoretical lens to study TML. In the remaining two essays surveys, and experiments were conducted to examine TML in conjunction with mentioned theories. Note that training materials in this dissertation were based on behavior modeling training (BMT). BMT was chosen as it is one the most prevalent training techniques (Desai, Richards, & Eddy, 2000; Johnson & Marakas, 2000; Yi & Davis, 2003). BMT is rooted in observational learning (OL) processes as prescribed by the social cognitive framework (Bandura, 1969). In terms of intervention, mental rehearsal was chosen as it has been shown to be effective in variety of fields (Bernardi, Schories, Jabusch, Colombo, & Altenmueller, 2013; Clowes, & Knowles, 2013; Davis & Yi, 2004; Marcus, Vakharia, Kirkman, Murphy, & Nandi, 2013; Yi & Davis, 2003). Essay 2 dealt with the exploration of OL processes, and also examined the effectiveness of training intervention. Essay 3 investigated the mechanism behind the efficacy of mental rehearsal using CLT i.e. what makes mental rehearsal effective? Essay 2 and Essay 3 are described in brief in the following paragraphs.

2) Essay 2 had two specific goals:

    (a) **To examine the interplay between OL processes:** As explained earlier, in spite of recent IS research on OL, the inter-relationships between OL processes are not well understood and have not been empirically examined as put forth by Bandura's SCT. A nomological model hypothesizing relationships between various OL processes was proposed and tested to fill this research gap. Note that this dissertation does not distinguish OL processes based on the type of learning. The training intervention contained both vicarious learning aspects (i.e. BMT) and enactive learning aspects (i.e. practice using simulation). However, the goal was to examine interrelationships between OL processes irrespective of which type of learning invokes it. Results partially supported the relationships hypothesized in observational learning's nomological model.

(b) **To examine the effectiveness of a training intervention which combines observational learning, and mental rehearsal in a technology-mediated context:** As we have seen in prior arguments, mental rehearsal intervention has proven effective. However, its effectiveness in a technology-mediated and real-life context such as a complex ERP simulation has not been tested. To test whether the intervention was effective in a more complex, real-life settings; a between-subjects quasi-experiment was conducted where the control group received training which espoused vicarious learning as well as enactive to form the baseline. The treatment group was exposed to additional mental rehearsal. The effectiveness of mental rehearsal was evident by a higher score on the pertinent training outcomes for the intervention group relative to the control group.

3) In essay 3, an online experiment was conducted to examine the mechanism underlying efficacy of mental rehearsal using cognitive load theory in the context of TML. Specifically, I hypothesized that mental rehearsal would increase germane load, and reduce the extraneous load. The hypotheses were tested in the context of technology-mediated learning offered by Massively Open Online Classes (MOOC) computer programming videos. The study results supported hypotheses.

Figure 1 presents the summary of dissertation chapters in a pictorial form.

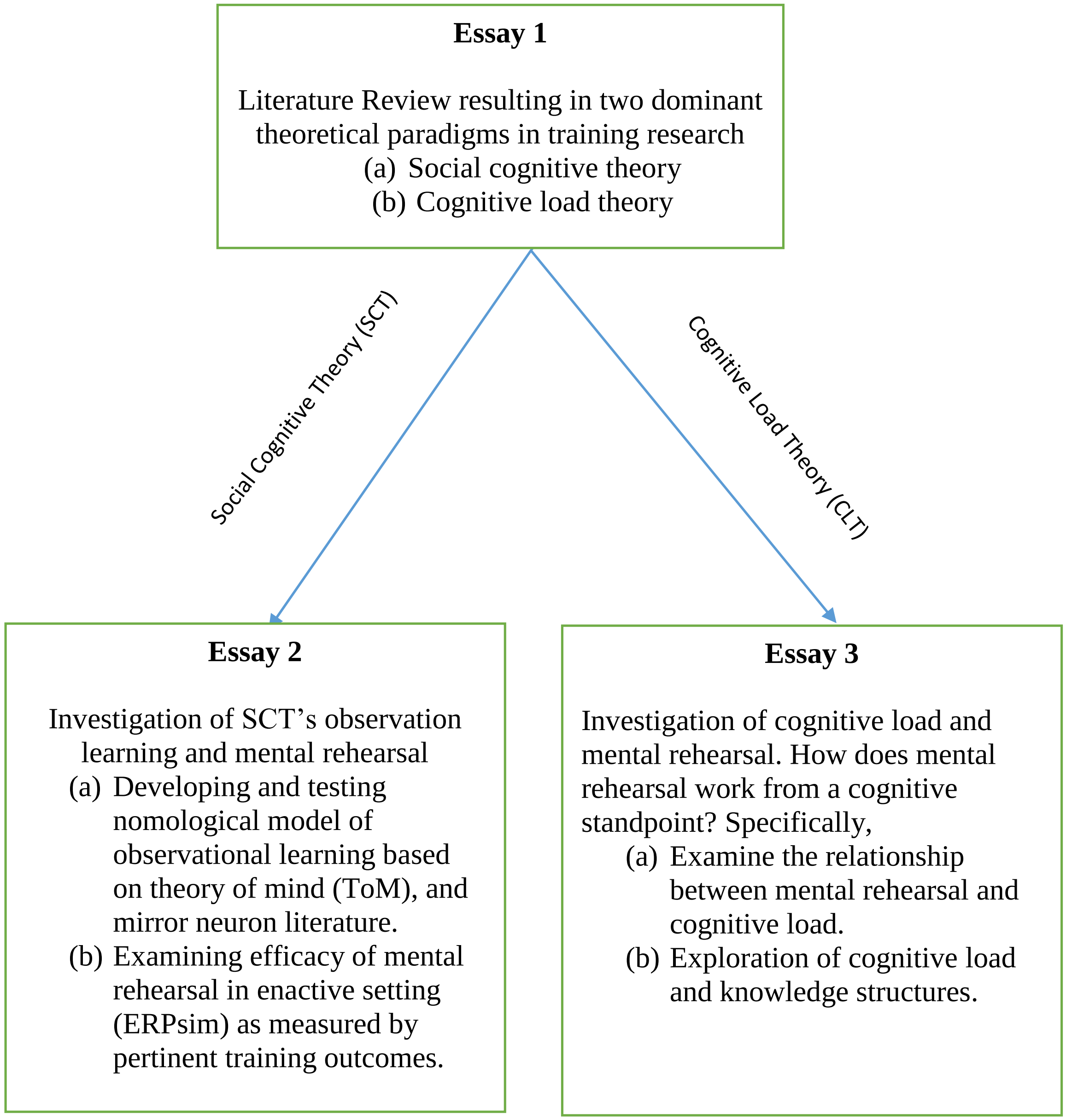

Figure 1. Summary of dissertation

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Chapter 2

ESSAY 1: Literature Review of Technology-Mediated Learning (TML)

Abstract

In today's competitive economy, organizations continue to invest in information technology (IT) based training. Given the pace and magnitude of these investments, IT-based training has become important research topic. In spite of rapid adoption and increase in popularity, information technology (IT) based training has not delivered expected returns. Scientific literature in this area has acknowledged this discrepancy and stressed the need to develop effective training interventions in a technology-mediated environment. The focal research domain of technology-mediated learning (TML) should be situated in a manner that makes various ways of investigating the domain clear and feasible. To this end, this essay established the need for TML research, its relevance to stakeholders, as well as the suitability of information systems (IS) research tradition to investigate TML. Prior studies on information technology/computer-based training have referred to it as e-Learning, technology-mediated learning (TML), virtual learning, and technology-based training (TBT). The variety of terms used in this field that refer to IT-assisted training has the potential to create confusion for an interested researcher. This study clarifies the nomenclature used in IT-assisted training, so future researchers have a clear understanding of the terms used in this domain. A literature review is conducted to find out theoretical frameworks that can help IS researchers in investigating TML. As a result, social cognitive theory (SCT) and cognitive load theory (CLT) are discovered as the most prominently used paradigms in training. Behavior modeling (BMT) emerged as a highly used training technique. Mental rehearsal was chosen as a candidate intervention, given its prevalence in IS research and applicability across a variety of research fields.

Introduction

Organizations continue to invest in technology training (Agarwal & Ferratt, 2001; Piccoli, Ahmad, & Ives, 2001). US corporations spent $171 billion on training in 2010, and about 40% of the spending was on training supported by information technology (ASTD, 2011). Investment in information technology (IT) based training makes a sound economic case, as it was recently found that ROI on IT-assisted training can be 60% higher than traditional training (SyberWorks, 2010).

Given the scale of the investments and potential benefits, there have been many efforts to understand training processes, and to identify the most effective training methods and strategies (Agarwal, Sambamurthy & Stair, 2000; Bostrom, Olfman & Sein, 1990, Compeau, Olfman, Sei & Webster, 1995; Compeau, & Higgins, 1995a; Johnson & Marakas, 2000; Lim, Ward, & Benbasat, 1997; Olfman, & Mandviwalla, 1994; Santhanam, & Sein, 1994; Venkatesh, 1999; Yi & Davis, 2001; Yi & Davis, 2003). In recent years, the manner in which training is delivered has undergone tremendous shift due to advances in information technology and infrastructure (Gupta & Bostrom, 2013). Training has shifted from traditional classroom settings to the technology-mediated environment. IT is now seen as a viable vehicle to deliver technology and business skills that knowledge workers require for performing their job effectively. Cost effectiveness, convenience and ubiquity of innovative training tools, and the Internet has fueled this growth (Santhanam, Sasidharan & Webster, 2008). Technology-mediated training promises to reach previously inaccessible remote audiences (Zhang, Zhao, Zhou & Nunamaker, 2004). The training delivery format is changing as well. For example, Sloan Consortium reported that 93.4% of public educational institutions and 63.7% of private educational institute use some form of technology-mediated courseware and support distance education in 2013. Student enrollment in online classes has increased by 7.2% at public institutions and by 12.7% at private institutions in 2013 compared to 2012. 70% of the sample indicated that online education is a long-term strategy for their institutions (Allen & Seaman, 2015).

As described in the previous section, many terms are used to describe information technology (IT)-assisted training such as e-Learning, technology-mediated learning (TML), virtual learning, and technology-based training (TBT). Later, I explain how these terms are used in IS and education literature. This dissertation refers to the scenarios where training is delivered via IT and are labeled as technology-mediated learning (TML).

In spite of gaining popularity and rapid increase in adoption, TML has not delivered the benefits that corporations and educational institutes had imagined (Alavi & Leidner, 2001; Gupta & Bostrom, 2005; Olfman, Bostrom & Sein, 2014; Sasidharan & Santhanam, 2006). The search for methods to deliver effective technology-mediated training is ongoing and urgent (Gupta & Bostrom, 2013; Santhanam et al., 2008). Thus, there are important reasons to consider and study technology-based training in greater detail.

One of the foremost considerations in choosing research topics should be the relevance (Benbasat & Zmud, 1999) and interest of the key stakeholders in the focal research topic. TML involves educators, universities, students, training institutes, corporations, and employees. The importance of TML research is evident, obvious and immediate (Alavi & Leidner, 2001) from the stakeholder point of view. The education and training sectors in the United State amounts approximately to $1.3 trillion, and worldwide they amount to $3.9 trillion. About 4.5% of the total training constitutes E-learning/technology-mediated sector in the US; worldwide this share is 1.6%. These numbers indicate substantial investments and prospects for TML (Advisers, 2011). Please refer to Table 1 below for more detailed information, as well as a granular breakdown of the market.

Table 1
U.S. and Global Education and Training Market

Geography	Market Size ($ billion)	IT-related expenditure to deliver training ($ billion)	As a % of market size
US	1,332	59.8	4.50%
Global	3,935	62.5	1.60%

In addition to organizations investing in their training programs, higher education demand is at an all-time high. According to Georgetown University's Center on Education and the Workforce, it is estimated that 65% of the jobs in 2020 will require, some form of college degree as the US economy recovers (Gabaree, 2013).

To meet this surge in demand, E-learning or TML/technology-based training is likely to play a critical role. Organizations also face a shortage of knowledge workers at an alarming rate (Alavi & Leidner, 2001), and many employees require continuous learning and updating of business and technical skills. It is evident that quality and quantity of training/learning demands from traditional student populations as well as working adults is on the rise. Information technology with its deep reach has the potential to transform training and learning practices. A myriad of colleges, universities, corporations and institutes are embracing information technology to develop and deliver innovative training programs. Research in this domain will eventually lead to the formation of best practices for corporations and universities who are trying to develop effective training program using IT tools at their disposal.

So far training research in IS on TML has been limited (Alavi & Leidner, 2001; Sasidharan & Santhanam, 2006), and researchers have called for an examination of the learning processes (Alavi & Leidner, 2001; Gupta, Bostrom & Huber, 2010) to understand technology-mediated training in greater detail. IS scholars can enrich TML research in the following manner.

First, IS research has a rich tradition of connecting information technologies and system user's cognitive states. This research stream may help in the exploration of TML because in the case of TML, cognitive/psychological states that arise as a result of the interaction of a user/trainee with information technology are essential. IS research in decision support system and decision making (Vandenbosch & Higgins, 1996) represents this line of work, and can be explored further in the context of TML.

Second, IS research is well positioned to draw on the literature of the information system success (Fiedler, Grover, & Teng, 1996; Robey & Sahay, 1996) to develop guidelines for effectively implementing TML initiatives.

Third, it is possible for IS researchers to tap into their knowledge of information technologies to design effective training techniques. This line of work has its roots in the design science approach. As a research discipline, IS can design and implement technology features as well as build prototypes of the IT systems that aid in training.

One must note that any theoretically grounded research on TML is likely to cover more than one of the research niches mentioned above. Approaching TML research from different viewpoint will not only contribute to our understanding of whether training interventions with the aid of information technology are effective (Gupta & Bostrom, 2005; Olfman et al., 2014) but also will help to reevaluate mixed results. Some early research suggests that TML does not enhance learning (Russell, 1999), while some research suggests a significant difference in outcomes when TML is used (Orr, 1997). Recent IS research has produced similar mixed results (Gupta et al., 2010; Lehtinen, 2003). This calls for more research, specifically focused on understanding the learning processes of the user/trainee (Alavi & Leidner, 2001; Gupta et al., 2010).

Finally, TML as a research topic has been increasingly attracting attention and gaining relevance as evidenced by a number of articles and Special Interest Groups (SIGs) on technology training (Hardaway & Scamell, 2005). Research on the interactions of information technology, instructional strategies, and the psychological processes of learners is scarce. Thus, there is a need to study the role of TML as an effective training vehicle.

So far, I have established the need for TML research, its relevance to stakeholders, as well as the suitability of IS field to provide an in-depth understanding of this phenomenon; next natural step is to introduce theoretical frameworks that will make this investigation possible. IS has a rich tradition of building on the Technology Acceptance Model (TAM). In fact, there have been numerous studies on adoption of TML/e-Learning in conjunction with TAM (Lee, 2006; Liu, Liao, & Pratt, 2009; Ong, Lai, & Wang, 2004; Park, 2009). However, there are a few limitations to this approach. TAM focuses on user's perceptions of the target system's characteristics, and intention resulting from these perceptions. The cognitive learning processes that beget as a result of user's interactions with the technology environment are not included in the model, but these processes can play a significant role in understanding TML. Thus, the research on TML/e-Learning needs to go beyond the variables included in the TAM framework. Theoretical frameworks that are suited to explain human learning process, as well as cognitive tendencies need to be explored while controlling for TAM variables. The question then is to understand which theoretical frameworks and paradigms can help IS researchers. Based on the literature review, I briefly describe two theories that IS researchers can use as anchors for TML research.

Social Cognitive Theory (SCT)

Humans learn relatively effortlessly through observation of the social context (Badura, 1969). Researchers can take advantage of this fact, and design training based on observational learning to create a more natural experience for learners/trainees. Behavior Modeling Training (BMT) is based on Bandura's SCT and places a heavy emphasis on learning through observation.

Cognitive Load Theory (CLT)

Learning is also dependent on bottlenecks of the human brain. To this end, Cognitive Load Theory (CLT) (Sweller, 1988) can help IS training researchers design training in keeping with the human cognitive architecture.

Theoretical Background

In this section, I present an overview of "Technology-mediated Learning (TML). There are many other terms that refer to this context such as *virtual learning, technology-based learning, distance learning, E-learning* (Santhanam et al., 2008). Such varied vocabulary can confuse the reader. Before proceeding, it would be worthwhile to explain the term "Technology-mediated Learning" (TML) as it is used in the relevant literature.

TML is defined as "an environment in which the learner's interactions with learning materials, peers, and/or instructor are mediated through advanced information technology" (Alavi & Leidner 2001, p.2). TML commonly refers to situations and environments where training and delivery are technologically supported. Learners may have a different level of control over the material (Benbunan-Fich, 2002; Jonassen, 2004). In situations where teaching material is self-paced, TML is often referred to as E-learning (Zhang et al., 2004).

Virtual learning is used as an encompassing term which refers to learning situation where trainees have access to a wide range of computer-based environments (Anohina, 2005; Piccoli et al., 2001) and learning resources.

One has to note that materials that are used in TML can be taught via other settings, such as face-to-face classroom settings. For example, training for fundamental business processes using various simulation technologies can well be taught without them. However, the simulation (or the IT component) is thought to materials in a more effective manner. Another example is fundamental concepts in computing or programming such as variables, strings, arrays, etc. Basic computer programming can be taught without employing technology or a computer. However, including information technology (IT) based delivery environments is thought to enhance the delivery, receipt and retention of the material. Depending on the role played by pedagogical information technologies, the nomenclature describing specific classes of training changes.

Technology-based training (TBT) is a subset of TML where a trainee receives the training using computer and information technology. Here, a user/trainee "learns from computers" instead of "learning with computers." For example, consider the case of computer game development training. It is nearly impossible to impart the knowledge required to develop the computer game without the tool i.e. the software/game engine is required in order to deliver this training.

There are other types of training called distance learning or E-learning. In distance learning, the instructor and students are separated by space and time. Also, there is a possibility of synchronous two-way communication, and it may also involve partial classroom instruction. In the case of E-learning, training is often self-paced. Figure 1 and Table 2 illustrates this point. As the role played by information technology changes, the label describing a specific class of training also changes. Often, multiple researchers refer to similar situations using various names. To ameliorate this situation, I have attempted to separate and group the keywords used in prior research and associate them with the "labels" used to describe that specific type of training situation. Training situations and scenarios considered in this dissertation are referred to as TML as it most closely relates to its definition.

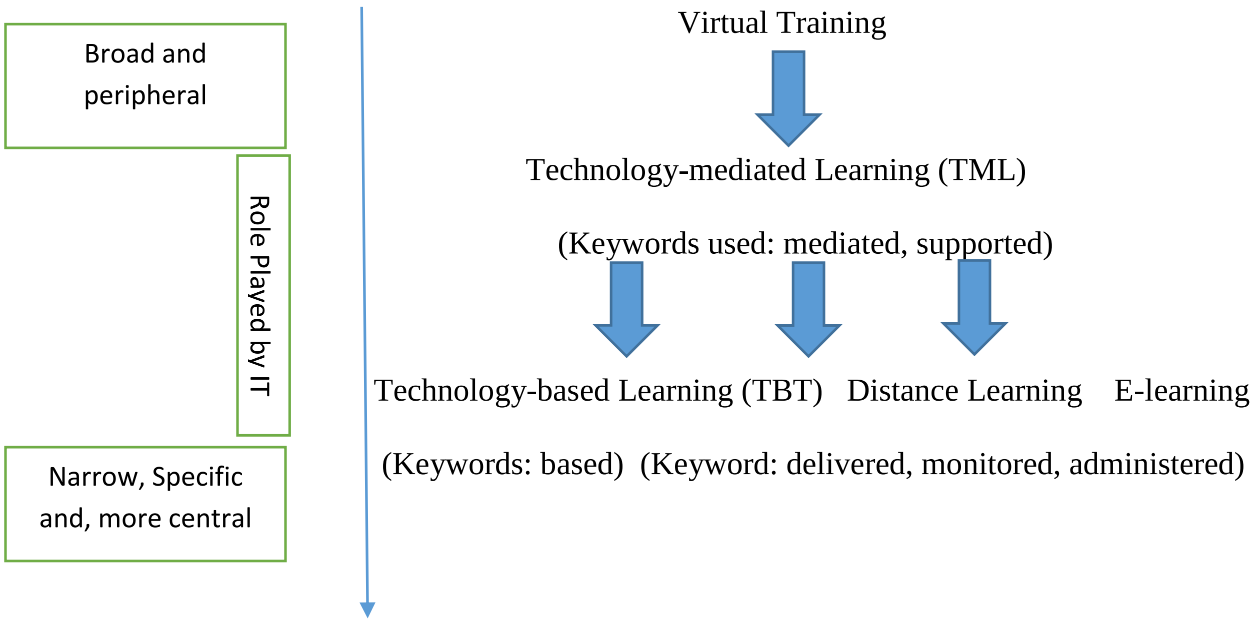

Figure 1. The terminology used in information technology (IT)-assisted training research.

Table 2
The Nomenclature used in technology-assisted training.

Label	Characteristics
Virtual Learning	It is an umbrella term used to refer to user's access to computer-based training environments and learning resources.
Technology-mediated Learning	IT is seen as an enabler or a delivery vehicle. Keywords such as "delivered", "mediated" etc. are used to describe this class of training. Training material can be imparted to the user without the use of IT, but its use is thought to enhance the delivery as well as retention. User's or trainee's Interaction with training material is facilitated by IT. In this sense, it can be understood as "learning with computers.".
Technology - based Training	This is further a subset of TML where the training itself is based on IT i.e. the separation between training material and the delivery vehicle is no longer possible. For example, 3-dimensional game development training. Unlike traditional computer science concepts or business processes concepts, untangling the 3-D engine and the concepts it teaches is very difficult. In this sense, this is "learning from computers".
Distance Learning	Training in which instructors and trainees are separated in time and space. There may be the possibility of two-way synchronous or asynchronous communication.
E-learning	It is similar to distance learning but is often self-paced.

Further, each of training method can be employed in a group context or an individual context. As we can see, there are many shades of what one might call, "Technology-mediated Learning" (TML). It is entirely possible, and often the case that a specific training technique does not fit in a particular category but spans over multiple categories described above. The above classification scheme is not rigid but rather a way to understand how various terms are used in the relevant training literature. Notwithstanding the variety of the terms used, one consistent observation is that IT is used extensively to impart training, and this opens up many opportunities for IS/IT researchers, particularly for scientific advancement in this area. In this dissertation, the focus is on the training techniques in which IT used as a delivery vehicle. The purpose of this dissertation is to explore such training methods in light of existing theoretical lens. In keeping with prior research, I refer to training situations considered in this dissertation as Technology-mediated Learning (TML).

Research Framework

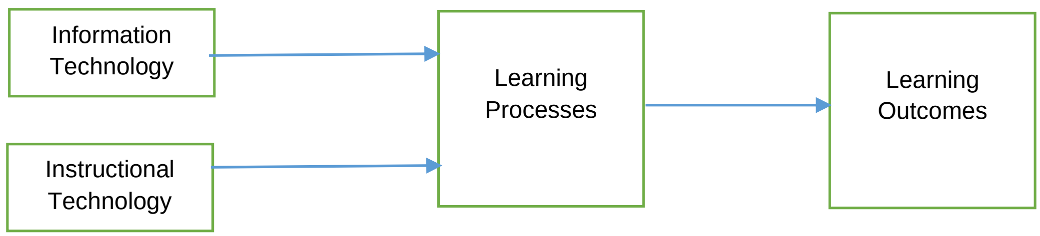

Figure 2. Research Framework

Figure 2 shows the framework on which TML research hinges, and is adapted from prior TML research (Alavi & Leidner, 2001). TML should not be restricted to mimicking or imitating traditional training/learning but should leverage relationships among technology and relevant instructional, psychological, and environmental factors to enhance training. Each component of the framework is described briefly.

Instructional Strategy. It refers to methods for sequencing, presenting and synthesizing the training content. Instructional strategies espoused by theories of learning and human cognition will likely make a TML intervention efficacious. Depending on the type of learning or training, instructional strategies can vary. Models such as Gagne and Briggs' (1979) can be employed. There are other theories which suggests how training materials should be designed, with one of the most prominent theory being Cognitive Load Theory (Sweller, 1988). Based on this theory, training interventions that are in congruence with human cognitive structure are likely to be more effective.

Information Technology. IT provides enhancement and delivery capabilities. The role of IT can be *peripheral and broad* or *central and specific* in a training intervention. Judiciously using IT can engage trainees and invoke psychological processes relevant to the learning. IT can also directly influence the quality of training. One such example is providing the trainees with an immediate enviornment to practice the training being delivered. It may take many forms such as engaging trainees in an interactive simulation and providing them with an immediate environment where they can practice their skills. For example, if training is targeted towards computer programming, then providing an in-browser code editor where students can practice may help learners. Following, I will discuss how TML has helped instantiate a specific pedagogy called problem-based learning (PBL). In the following section, the problem-based learning (PBL) is described shortly. Thereafter two instances where PBL is enabled by information technology are described.

1. Business process training using Enterprise Resource Planning (ERP) systems.
2. Basic computer programming in Python.

Problem-based learning. It is an approach to learning where students or trainees work a problem either individually or in groups rather than or in addition to attending/listening to lecture. The following guiding principles are borrowed from prior work on PBL (Savery & Duffy, 2001).

Anchoring learning activities to a relevant problem. The learning must have a purpose, beyond the assignment or homework exercise. Problems can be of any type, but the most important factor is that the learner should perceive the relevance of the problem as it relates to them (CTGV, 1992; Honebein, Duffy, & Fishman, 1993). It must be noted that in order to afford exploration, the overall problem is relatively vaguely defined. For example, in a business process simulation game, the problem would be to achieve maximum profit, or in an online computer science training the goal may be learning to extract strings.

Supporting the learner in developing ownership of the overall problem: This point refers to the alignment between instructional objectives and learner objectives. Often, participants do not understand the real-world use of the exercise and simply focus on passing the test or putting in their time. It is important to establish the problem in a way that the learners will readily adopt the problem as their own.

Operating authentic context: Authentic context refers to cognitive continuity i.e. the activities in training should be similar, in the sense that it should present the same “type” of cognitive challenges. Difficulty level must not increase or decrease suddenly. Training should aim at generating cognitive demands that are in line with the cognitive requirements of the future work environment of the learner (Honebein, et.al. 1993).

Realistic learning environment: PBL training environments or contexts aim to reflect the complexity of the environment in which the trainee should be able to function after completion of the training. Instead of oversimplifying the environment, it is suggested that the training should reflect the real-world environment. This idea is supported in cognitive apprenticeship (Collins, Brown, & Newman, 1989) and cognitive flexibility theories (Spiro & Jheng, 1990).

Give the learner ownership of the process: The process of arriving at a solution must not be completely laid out or dictated. This aspect is not always possible if we want trainees to develop specific skills. However, with the help of information technology, trainees can regulate the pace of delivery, replay the content, and have more ownership of the learning process. One must note that this may not always be possible, especially in timed training sessions. However, IT does facilitate aspect of self-learning.

Design the learning context to support and challenge the learner's thinking: This is in contrast to the widely used Socratic lecture method where the “right” answer is held by the teacher and pupils arrive at it via logical deduction. Instead, the emphasis is on learning the scaffolding of the knowledge domain (Vygotsky, 1978) by prevalent modeling techniques, and simultaneously applying it to the problem at hand.

Encouraging testing of ideas and applying it in alternative contexts: Skills training is aimed at increasing individual's ability to solve problems in a particular domain; knowledge and skills learned are seldom applied individually. Often, the skill application happens in a social environment. It means that users have to understand and accommodate issues and views of others. Information technology can serve a powerful tool to generate these social communities and promote collaboration. This dissertation does not deal with the aspects of learning communities and collaboration given the data collection constraints.

Learning environment should support reflective mindset: PBL aims to model reflective thinking in the learning process i.e. activities should build-up on a sequential chain and encourage the learner to think in a logical way instead of rote memorization. Note that this must be done in keeping with cognitive continuity.

Principles of problem-based learning (PBL) can be realized in technology-mediated learning (TML). Depending on the extent to which IT is employed some or all of the instructional principles of PBL will be realized in a specific training intervention. Further, training can be designed to combine elements of PBL with existing training mechanisms such as BMT. This is the main thrust of training methods explored in this dissertation.

The two training contexts examined in this dissertation are (1) Enterprise Resource Planning (ERP) simulation known as ERPsim, and (2) Video training for teaching computer science fundamentals based on a Massively Open Online Course (MOOC). Both of these scenarios anchor the problems in the real-world, establish the relevance of the problem, and are comprised of authentic tasks that present the same "type" of cognitive challenge (i.e., difficulty does not increase or decrease suddenly). Further, they encourage a reflective mindset by encouraging participants to try possible solutions rather than relying on rote memorization. Both contexts are designed to reflect the environment in which trainees are likely to operate after training. In the following sections, I describe these two learning contexts.

Training Context 1: Enterprise Resource Planning (ERP) simulation. In response to increasing competitive pressures, rapid changes in the business environment, and dynamic and unpredictable economic conditions, most large organizations are seeking to optimize their operations. One way to optimize operations is by streamlining business processes such as sales, marketing, and procurement is the implementation of ERP systems. ERP promises to be a vehicle for achieving such functional efficiencies. Thus, there has been an uptick in ERP implementation (Cronan & Douglas, 2012). ERP implementation causes a firm business processes to undergo re-engineering, and consolidation (Gattiker & Goodhue, 2005), and due to that work spans across cross-functional systems. As a result of this uptick in ERP implementation, the need to adequately train employees has increased considerably (Wang, Hsieh, Butler, & Hsu, 2008). Traditionally, colleges have delivered education in specific functions (Cannon, Klein, Koste, & Magal, 2004) such as marketing, operations, and accounting. This type of approach has been criticized, as it does not adequately prepare students for careers that increasingly span across functional systems (Malekzadeh, 1998), and corporations struggle to find adequately trained talent (Downe, Loke, Ho & Taiwo, 2012). Given this backdrop, it becomes imperative that students are accustomed to basic business process integration (Coulson, Shayo, Olfman, & Rohm, 2003; Kang and Santhanam, 2003). Teaching ERP concepts of process integration poses a challenge as they are often hard to grasp and have been difficult to teach to new trainees or students (Leger, Charland, Feldstein, Robert, Babin, & Lyle, 2011). PBL holds the promise to improve this training situation. Starting with the idea of PBL, enactive and hands-on learning, researchers at HEC Montreal created and ERP simulation game called ERPsim (Léger, 2006).

ERPsim can act as an IT tool to train future and current employees in business process training. As business processes change rapidly, its training requires methods that will help learners develop needed cognitive skills (Clarke & Clarke, 2009). ERPsim achieves this by implementing many of the principles of problem-based learning. Many Fortune 1000 organizations also use ERPsim to train their employees. Commercially, it is made available by Baton simulations. Many academic intuitions use ERPsim for student training and research purposes (Cronan, Douglas, Schmidt, & Aluaimi, 2009a; Cronan, Douglas, Schmidt, & Aluaime, 2009b; Cronan, Douglas, Aluaimi, & Schmidt, 2011; Léger et al., 2011). In an ERPsim game, participants run business transactions using a real-life enterprise system (SAP). ERPsim gives participants hands-on exposure to the kind of ERP systems used at the world's largest companies. Participants simulate and transact against a simulated market using SAP interface. Their decisions result in a set of the business transaction(s), and should be entered in the ERP-SAP interface. Information about states of market, sales, inventory and finances can be accessed using built-in reports. HEC researchers describe ERPsim as *"similar to using a flight simulator, but in a real plane cockpit"* (Leger, Robert, Babin, Lyle, Cronan, & Charland, 2014, p. 330) as the participant can learn about integrated business processes in hands-on exercises. ERPsim provides three functions:

*Simulation of real-time market***.** Realistic demand is simulated by creating a large population of customers each with their tastes and preferences. The market simulation does not depend on an aggregated demand function and hence cannot be easily pinned down, mimicking the real-world. Each customer's utility is indirectly based on his/her preferences, and customers make purchases that will maximize their utility. Simulated customers can compare prices and products offered by different ERPsim participants. Such an approach generates rich, high volume, and transaction-based demand side.

Automation of routine tasks. To receive and fulfill orders from customers, manufacturers would have to undergo routine business processes such as receiving a sales order, and sending products and invoices to customers. Since these tasks do not depend on critical business decisions, ERPsim automates them so that the trainee/students can run the business, focusing on executive decisions such as sales, marketing, procurement, and production. For example, once a trainee releases the purchase order, ERPsim automates the goods receipt and invoice receipt from vendors, as well as sending them payment.

Time management. Time is compressed into a short space but gives a sense of evolution like in the real-world. ERPsim is typically played over three rounds (and over 90 virtual days), with each round lasting 30 minutes, and each minute represents the passing of a virtual day. Participants learn to adjust their actions to make better business decisions over time as they learn to play the game. ERPsim uses Java to connect it to the real-world ERP-SAP systems.

Depending on the training requirement, different versions of ERPsim can be used. As of this writing, there are three major versions of the game: *logistics game*, *distribution game*, *manufacturing game.* I will describe the *manufacturing ERPsim game*, as it is the most comprehensive of three in terms of business transactions, and it is used in this dissertation. In the manufacturing game, the participants are responsible for selling six varieties of muesli in three regions of a simulated German market (North, South, and West) through three different channels (large retailers, small retailers, and independent grocers). It is possible to sell muesli in either a small box or in a large box. The aim of ERPsim is to expose students to skills required to optimize and synchronize the planning, procuring, manufacturing, and sales business processes. In the ERPsim manufacturing game, transactions that trainees/students will engage in are described in Table 3.

Table 3.
Details of Transactions in an ERPsim game

Transactions area	**What it entails?**	**Transactions Code in ERPsim**
Forecasting and production planning	Creation of sales forecast	MD61
Material requirement planning/Materials Management	Purchasing the production requirements based on the sale forecasting, and on-hand inventory	MD01, ZME2N
Production scheduling	Specification of order in which production order are released on the assembly line	C041, ZCOOIS, ME59N
Sales and marketing management	Sales orders are automated, but trainee need to manage sales in such way to enhance profit but keep the optimal safety stocks	VK32, ZADS, ZVA05, ZCV2, ZMARKET
Accounting and treasury management	Keeping up with current balance sheet and P/L of the company	F.01, ZCK11
Stock management	Managing inventory to and ensuring continuous supply	MB52

Appendix A displays the "Job aid" provided to the participants which detail the transactions possible in ERPsim. ERPsim has been shown to be an effective training tool, and it also provides "enactive" learning as users are able to observe the impact of their actions in real-time. Previous research has shown that enactive learning improves learning significantly (Gupta & Bostrom, 2013). Given the effectiveness of enactive problem-based learning such as business simulation, more research is needed to see if this approach can be used in conjunction with well-established training techniques such as behavior modeling.

Training Context 2: Computer Programming Videos Based on a Massively Online Open Course (MOOC). Massively Online Open Courses (MOOC), are heralded as information technology's incredible feat. The introduction of MOOC to higher education has been very swift and unprecedented (Breslow Pritchard, DeBoer, Stump, Ho, & Seaton, 2013). MOOCs have the pppotential to ameliorate STEM and IT worker shortages (Johnson-Bey, Girma, Udofa, & Parker, 2013; Schelmetic, 2013; Waßmann, Schönfeldt, & Tavangarian, 2014; Wilner, 2014). In fact, 2012 was called the year of the MOOC by time magazine. A MOOC generally does not require fees or prerequisites apart from the Internet access. Also, most MOOCs have no expectation in terms of participation, and offer no formal accreditation (McAuley, Stewart, Cormier, Siemens, 2010), while some MOOC's do provide a certificate of participation.

Primary training materials for a MOOC is a series of well-designed instructional videos presented in an interactive learning context. It is done in the hopes of motivating students and increasing their participation in learning. Additionally, there is usually an online community built around the MOOC offering. The ability to create and apply knowledge to solve problems is critical to the current digital economy. IT innovations such as MOOCs have the potential to radically increase the rate at which knowledge is created and distributed, and it also promises to reduce barriers to knowledge creation and consumption. Innovations such as MOOCs alter the traditional hierarchy of the pedagogical relationships in a learning organization (Cope & Kalantzis, 2000). MOOCs may serve as an ecosystem to gain knowledge, skills and attitudes individuals need to thrive in the current digital economy. MOOCs are open, and no one is excluded based on prior academic experience, so it has tremendous potential to educate masses. This inclusive approach promises to from a "long tail" of participants and has induced a participatory scenario called "legitimate peripheral participation" (McAuley et al., 2010). The emergent, self-defined nature of MOOCs makes it possible to build knowledge, skills and abilities of individual participants required in the information economy.

MOOCs are used for a myriad of subjects including, history, medicine, computer science and economics. However, they are particularly useful in delivering classes with heavy "learning by doing" and enactive components. For this reason, teaching computer programming using MOOC has been on the rise. The most recent example of this can be seen in the rise of well-financed MOOC providers such as edX, Coursera (Carr, 2012), and Udacity (Klawe, 2015).

MOOCs use well-designed videos as a primary tool to impart training. Lectures are video-recorded and distributed to students, in addition, they provide other features such as online forums where participants can interact. MOOCs have all the components of the traditional classroom as far as assignment and quizzes are concerned. MOOC videos are designed meticulously, and embody principles of PBL such as *authentic learning, learning by doing, and providing a practice environment* so that participants can interact with teaching material (Billsberry, 2013; Chen, Barnett & Stephens, 2013; de Waard, Koutropoulos, Keskin, Abajian, Hogue, Rodriguez, & Gallagher, 2011; Mackness, Mak, & Williams, 2010; Taradi, Taradi, Radić & Pokrajac, 2005).

There are two divergent views on the impact of MOOC on higher education and training. Some universities see MOOCs as a panacea to democratize education while other see them as substantial investments which may not yield adequate returns (Chen et al., 2013). MOOCs are free or very low cost for participants, but it requires substantial investment to produce a MOOC class. A MOOC course offering on edX.org (run by MIT, Harvard, and Berkeley), can cost the focal school offering the course upwards of $300,000 per course (Kolowich, 2013). Some university administrators have expressed strong doubts about the future of MOOCs as can be seen from following the quote. "MOOCs are a perfect storm of hype, hyperbole, and hysteria and yet many have plunged headlong into them without a real clear sense of why or how

MOOCs can help more students succeed" (Greenstein, 2013, p. 5). Current ventures in MOOC space (e.g. Coursera and Udacity) are well-funded, but a repeatable revenue generation model has yet to be established. Also, there is the looming problem of completion rates (Mackness et al., 2010), at the most 8 to 10% of MOOC participants complete the course (Reilly, 2013).

Given the attention, funding and controversies that MOOC providers are garnering, it is worthwhile to explore more fundamental questions related to learning before reaching any verdict on MOOCs. One such fundamental question would be to measure the effectiveness of the training methods used by MOOCs. MOOCs heavily rely on well-designed, recorded videos to demonstrate the subject matter and motivate the trainee/user/ to "actively take part" in the learning process. Educational technologist, administrators, teachers, and researchers must examine the effectiveness of these training videos, and explore ways to enhance them further using known instructional strategies. Does the delivery of educational contents via a well-designed video lecture espouse learning? Is there any existing educational strategy that can enhance it? Are there any existing theoretical frameworks that will help academics and practitioners in conducting research on this issue?

In previous two contexts, I described how IT can be used to deliver and enhance training. Following, I describe other two blocks of the training research framework.

Learning Process. The objective of TML is to positively influence learning. Prior research has focused on design and examination of technology features relevant to learning. IS research focused on psychological processes associated with learning (Gupta & Bostrom, 2013; Yi & Davis, 2004) is scant. The term psychological process is used as an umbrella term used to describe various mental states of the learner. It may include motivation, information processing stages, cognitive structures or memory. Information processing refers to a range of processes to select, encode, and comprehend the information presented to the learner. Based on this researchers have called for TML research that links technology and relevant instructional and psychological factors (Alavi and Leidner, 2001).

Outcomes. Depending on the target skills, training outcomes vary**.** For example, Gange (1977) identified five different types of skills that any specific training intervention can target. They are intellectual skills, motor skills, verbal or declarative information, cognitive strategy, and attitude. In addition to these, it may be possible to measure affective outcomes such as satisfaction as well as cost-related outcomes such as efficiency. Depending on the context of training, relevant outcomes should be chosen and measured.

Up until this point, I have summarized the state of TML research and described a broad framework that can be used to conduct TML research. As indicated earlier, more TML research needs to be aware of the human cognitive structure, and should include human learning processes. To find out if existing theoretical paradigms can be used to examine TML in the previously mentioned two contexts, I conducted a literature review of technology training.

Literature Review

To find suitable theoretical frameworks that can be applied to above the above contexts; I extended a recent IS training review (Santhanam, Yi, Sasidharan, & Park, 2013). Four more journals (Computers & Education, Computers & Human Behavior, Journal of Information Systems Education, and Journal of Information Technology Education) were added to the review. To extend the literature survey, I used the same criteria used in prior research (Santhanam et al., 2013) i.e. articles quantitative studies on training in IS and HCI literature were included. Qualitative articles were not included. It resulted in 164 articles being included. Including four more journals in the literature survey ensures that the relevant literature into account. The list of articles can be found in Appendix B. Table 4 shows the list of journals and corresponding article count. The goal was to find out the most widely used theoretical framework in IS and HCI training literature. Table 5 shows the various theoretical lenses employed in the selected articles. Note that many articles use more than one theoretical paradigm.

Table 4
List of journals and count of articles

List of journals	Count
International Journal of Human-Computer Studies	10
Behavior & Information Technology	9
Computers & Education	13
Computers & Human Behavior	38
Human-Computer Interaction	8
Information Systems Research	8
MIS Quarterly	6
SIGCHI Bulletin (ACM SIGCHI)	5
International Journal of Human-Computer Interaction	4
Decision Sciences Journal of Innovative education	10
Interacting with Computers (BCS-HCI)	3
Journal of Management	3
Journal of Management Information Systems	2
Communications of the ACM	1
IEEE Transactions on Professional Communication	1
Information Systems Journal	1
Journal of Information Systems	1
Journal of Organizational and End User Computing	1
TOCHI – ACM Transactions on Computer-Human Interaction	1
Journal of Information Systems Education	18
Journal of Information Technology Education	21

Table 5
List of theories used

Theory	Frequency	Examples
Social Cognitive Theory(SCT)	32	Koh, 2011 Wu, Tennyson, & Hsia, 2010 Niederhauser & Perkmen, 2010 Liaw, 2009 De Grez, Valcke, & Roozen, 2009
Field Independence – dependence Theory	1	Chou, 2001

Elaboration Theory	1	Salden, Paas, & van Merrienboer 2006
Mental Model Theory	30	Emurian, Hu, Wang, & Durham, 2000 Amadieu, Tricot, & Mariné, 2009 Arguel & Jamet, 2009 Casterella & Vijayasarathy, 2013 Gill, 2006
Cognitive Flexibility Theory	1	Schellens & Valcke, 2005
Kolb's /Huber's Model	1	Kamis & Kahn, 2009
Learning Theory Felder-Silverman Learning Model Constructivist Learning Theory Bloom's Cognitive Theory Generative Learning Theory Vygotsky's Collaborative Learning Theory	7	Akbulut & Looney, 2009 Moor & Deek, 2006 Roussev, 2003 Palvia & Palvia, 2007 Wong & Fong, 2014 Cheong, Bruno, & Cheong, 2012
Relational frame	1	Emurian, 2005
Assimilation	7	Davis & Wiedenbeck, 2001 Wiedenbeck, 1999
Information Processing Theory	7	Moos, 2009 Coppola & Myre, 2002 Webster & Martocchio, 1993
Cognitive Load Theory	32	Tasir & Pin, 2012 Kühl, Scheiter, Gerjets, & Gemballa, 2011 De Koning, Tabbers, Rikers, & Paas, 2011 Williams, D. J., & Noyes, 2007 Zumbach, 2009 Sung & Mayer, 2012 Darabi, Nelson, & Palanki, 2007
Simulation	1	Fiorella, Vogel-Walcutt, & Fiore, 2012
Situational Method Engineering/Process Engineering	1	Tan & Tan, 2010
Four-component Instructional Design System (4C/ID-model)	1	van Merriënboer, Clark, & de Croock, 2002
Cognitive Theory of Multimedia Learning (CTML)	4	Kühl, Scheiter, Gerjets, & Gemballa, 2011 Gerjets, Scheiter, Opfermann, Hesse, & Eysink, 2009
Gibson's Theory of Affordances	1	Andres & Shipps, 2010
Self-determination Theory	2	Shroff, Vogel, & Coombes, 2008 Roca & Gagné, 2008
Constructive Cognitivist Theory	1	Levy & Hadar, 2010
SCCT	2	Akbulut & Looney, 2009 Niederhauser & Perkmen, 2010
TAM/TRA	11	Liaw, 2009 Manochehri, & Sharif, 2010

		Kusano, K., Frederiksen, S., Jones, L., Kobayashi, Mukoyama, Yamagishi, & Ishizuka, 2013
UTAUT	1	Ball & Levy, 2008
Task Technology Fit	1	Dishaw, Eierman, Iversen, & Philip, 2013
Transactional Distance Theory	1	Hauser, Paul, & Bradley, 2012
Media Richness Theory	1	Liu & Burn, 2007
Concerns Based Adoption Model (CBAM)	1	Yang & Huang, 2008
Dual Coding	2	Byrne, Catrambone, & Stasko, 1999 Nicholson, Nicholson, & Valacich, 2008
Self-regulation	4	Chang, Tseng, Liang, & Liao, 2013 Delen, Liew, & Willson, 2014 Greene, Moos, Azevedo, & Winters, 2008 Wong & Fong, 2014

Social cognitive theory (SCT) (Bandura, 1986) emerged as a dominant theoretical lens, closely followed by mental models (Craik, 1943; Johnson-Laird, 1983) and cognitive load theory (Sweller, 1988) based on Table 5. The mental model theory is based on human associative memory (HAM), where human learns through association of concepts (Anderson, 1973). It prescribes that behavior of an organism originates from his/her mental models. In order, to facilitate the formation of these mental models, training interventions should be designed in keeping with the human cognitive architecture. However, the mental model theory is of limited use in developing a training intervention but can be used to test whether a specific training method is successful in forming appropriate knowledge structures. Other two leading theories i.e. Social Cognitive Theory (SCT), and Cognitive Load Theory (CLT) can be leveraged to study the effectiveness of a training intervention. Mental models are intricately related to SCT (Bandura, 1986) and CLT (Sweller, 1988), and can be used as a measure of the effectiveness of a training intervention. Next, these two theories are briefly described.

Social Cognitive Theory (SCT)

Social cognitive theory (Bandura, 1969; 1986) postulates that humans can learn from their environment effortlessly. This is facilitated by behavior modeling technique (BMT). It refers to a condition when a person receiving training can learn from the model as a function of exposure to the cues disseminated by the model. These cues then could form knowledge structures as the basis for future actions even when stimulus provided by the model is not present. BMT is one of the most widely used training techniques in IS as evident from Table 6.

Table 6
Significant training studies in IS

Paper/Study	**Training method**
Gist et al. (1989)	BMT vs. computer aided instruction
Compeau et al. (1995)	BMT vs. non-modeling training
Desai (2000)	BMT vs lecture based instruction
Johnson et al. (2000)	BMT vs. non-modeling training
Bolt et al. (2001)	BMT vs. non-modeling training
Yi & Davis (2003)	BMT vs. BMT with Symbolic Mental Rehearsal (SMR)
Davis & Yi (2004)	BMT vs. BMT with Symbolic Mental Rehearsal (SMR)
Gupta & Bostrom (2013)	BMT vs. BMT with Enactive learning

SCT posits that BMT is rooted in four observational learning (OL) processes, (1) Attention (2) Retention (3) Production and (4) Motivation. These processes are explained briefly.

Attention. It regulates exploration and perception of modeled activities. One cannot learn without paying attention.

Retention. In this stage trainees, cognitively register modeled actions as symbolic representations in memory to regulate future behavior.

Production. Based on the strength of the retention, trainees can reproduce the modeled behavior.

Motivation. This process determines whether or not observationally acquired skills are enacted in the future.

OL operates through vicarious and enactive learning. Vicarious learning occurs via observation of a model while enactive learning occurs by practice and observation of self-actions and its consequences.

The goal of Essay 2 is to explore interrelationships between these OL processes. Also, OL processes are posited to result in schemas or knowledge structures. The similarity of trainees' knowledge structures to the expert reference is likely to be different across the two groups in Essay 2. The group which performs mental rehearsal is hypothesized to have greater knowledge structure similarity (KSS) to the expert reference compared to the group that did not engage in mental rehearsal.

Cognitive Load Theory (CLT)

Cognitive load theory (Sweller, 1988) is best applied in cognitively complex situation Cognitive load refers to the total amount of mental activity imposed on working memory at an instance in time. Human memory is divided into *working memory* and *long-term memory.* Humans have limited working memory, and instructions should be designed in such a manner that it reduces the strain placed on working memory and not exceed its holding capacity. CLT provides recommendations on how to develop training intervention that minimize loads placed on working memory. According to CLT there are three types of mental loads that any instructive material has:

Intrinsic Load. Load that is inherent to the material and is based on the complexity of the material.

Extraneous Load. This type of load depends on the training delivery technique. A good training technique would reduce the extrinsic load. This type of load is also called *irrelevant* load.

Germane Load. This type of load relates to the effort involved in the processing and construction of mental schemas. This type of load is also called *relevant* load.

The goal an effective instruction mechanism is to reduce extrinsic load and to increase the germane load. As germane load increases, there is greater probability that training imparted will actually translate into mental schemas. Essay 3 explores this topic in greater detail. Essay 3 investigates the impact of behavior modeling and mental rehearsal on cognitive load. To investigate this impact, the context of basic a computer science course was chosen. Trainees were taught basic Python language using MOOC videos and an interactive environment. An example of this environment can be found in Appendix C.

Intervention

Above two theories guide IS training research. However, what kind of enhancement or intervention can improve the effectiveness of such training? Based on the literature review, mental rehearsal consistently emerges an add-on/enhancement/intervention that has proven to be effective in various fields ranging from sports, music, neurology, to technology training (Bernardi, Schories, Jabusch, Colombo, & Altenmueller, 2013; Clowes, & Knowles, 2013; Marcus, Vakharia, Kirkman, Murphy, & Nandi, 2013). Thus, it is examined in detail in essay 2, and essay 3.

Conclusion

In this literature review, I classified the terms used information technology (IT)-assisted training. It was found that the previous literature on IT-assisted training used a variety of terms often referring to the same concepts, this causing confusion. A nomenclature of terms used in the field was developed. Finally, I examined 164 articles on training in IS literature from 21 journals. These articles were examined for the theoretical lens used. Results indicate that social cognitive theory (SCT) and cognitive load theory (CLT) are suitable candidates to examine mental rehearsal training intervention.

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Appendix A- ERPsim Job Aid

Change Product Design
Modify BOM (ZCS02)

1	In *Material*, enter the product to redesign : $$-F##
2	✔
3	Modify, delete or add component, change quantities
4	💾
5	✔

Forecast Sales
Create Planned Indep. Req. (MD61)

1	Select *Product group*, then enter: $$-F
2	✔
3	Enter new forecasted quantities in *next month*
?	The quantity corresponds to the replenishment level
5	💾

Calculate Requirements
MRP Run (MD01)

1	✔
2	Click another time on continue ✔
3	In the pop-up window, click ✔
4	Creates new documents

Purchasing
Automatic Gen. of POs (ME59N)

1	⊕
2	Purchase orders are created
?	If no open requisitions : *No suitable requisitions found.*

Release Production
Coll. Conversion of Pld Orders (CO41)

1	⊕
2	Select orders
3	Click on *Convert*. Message confirms the conversion.
4	If no planned order: *Planned order could not be selected*
5	If conversion fails, click on ✖ to see log

Change Price
Condition Maintenace: Change (VK32)

1	Open *prices* folder and dbl click on *Price list*
2	In *Distribution channel*, enter DC **10** to **14** (optional)
3	In *Material*, enter product code (optional)
4	⊕
5	Enter your prices
6	💾

Purchase Orders
Purchase Order Tracking (ZME2N)

Shows purchase orders. For each order, it shows the issue date, the expected arrival of the products (Qtr and Day) and when the vendor payment will be made (Qtr and Day).

Stock Levels
Current Material Overview (MD07)

1	✔
2	Stock level is displayed in the Plant stock column
?	*For more details, select Material and click on stock requirement list*

Inventory report (ZMB52)

Shows all stock levels

Production Schedule
Production Schedule (ZCOOIS)

Shows released production orders, past and future. For each order the time released, started and finished (or to start and finish if incomplete). Target Qty > Conf Qty means still pending

Production Cost
Product Cost Analysis(ZCK11)

1	⊕
2	For each product it shows: two product costs (variable cost and cost including fixed costs) and the price for each DC.

RM cost per Prod. Order (ZKSB1)

Shows raw material cost per production orde

Sales and Market Data
Sales Order Report (ZVA05)

Shows sales transactions: time, sales revenues, boxes sold and price per box.

Summary sales report (ZVC2)

Shows daily sales activity

Price Market report (ZMARKET)

Shows market sales for lagging 5 days - revenues, units, and average price

Financial Statement
Financial Statements (F.01)

1	In *company code*, enter your company number ($$)
2	Select ALV Tree control (optional)
3	⊕
4	Net income corresponds to the profit

Loan Repayment
Enter G/L account (FB50)

1	Enter current date (F4)	
2	1st Line	2nd Line
Account	113101	113300
D/C	Debit	Credit
Amount	???	???
3	✔	
4	💾	

Marketing Expense
Marketing Expense Planning (ZADS)

Enter the daily amount of marketing for each product and each area.

💾

Setup Time Reduction
Enter G/L account (FB50)

1	Enter current date (F4)	
2	1st Line	2nd Line
Account	478 000	113300
D/C	Debit	Credit
Amount	???	???
Cost Center	$$	
3	✔	
4	💾	

Increase Capacity
Enter G/L account (FB50)

1	Enter current date (F4)	
2	1st Line	2nd Line
Account	11000	113300
D/C	Debit	Credit
Amount	???	???
	✔	
	💾	

EXTENDED GAME

HEC MONTRĒAL
ERP SIMULATION GAME
Manufacturing Muesli Game
powered by ERPsim

Login	$1	to	$9
Password	ERPSIM		

Operational transactions (blue) · Reporting transactions (green) · Decision transactions (purple) · Accounting transactions (red)

Nut - 1 kg	$$-F01
Wheat	40%
Oat	40%
Nuts	20%
Box	1
Bag	1

Blueberry - 1 kg	$$-F02
Wheat	40%
Oat	40%
Blueberries	20%
Box	1
Bag	1

Strawberry - 1 kg	$$-F03
Wheat	40%
Oat	40%
Strawberries	20%
Box	1
Bag	1

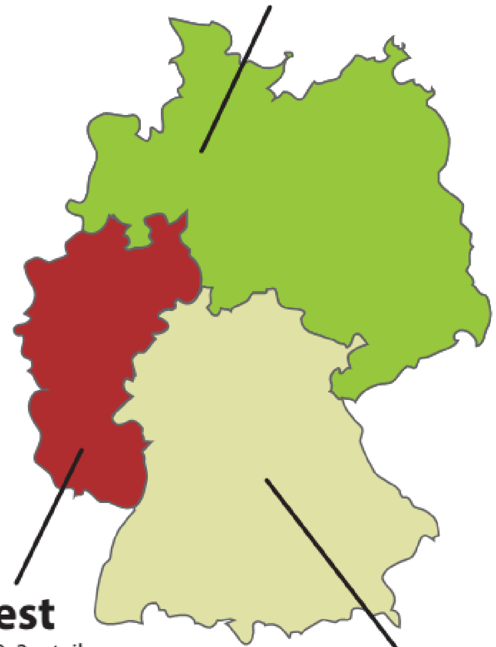
Raisin - 1 kg	$$-F04
Wheat	40%
Oat	40%
Raisins	20%
Box	1
Bag	1

Original - 1 kg	$$-F05
Wheat	50%
Oat	50%
Box	1
Bag	1

Mixed - 1 kg	$$-F06
Wheat	35%
Oat	35%
Fruits and nuts*	30%
Box	1
Bag	1

*10% nuts, 5% blueberries, 5% strawberries, 10% raisins

North
DC10: 2 retailers
DC12: 19 retailers



West
DC10: 3 retailers
DC12: 17 retailers

South
DC10: 7 retailers
DC12: 23 retailers

Legend
DC10: Hypermarkets
DC12: Grocery Stores

General information

Customers	DC10	DC12
Lead time (days)	0	0
Payment time (days)	20	10-15

Suppliers	
Lead time (days)	3-5
Payment time (days)	15

Days / Round
30

Total Market Size
Approx. €80,000 per team per day

Production Capacity
25,000 / day

Appendix B – List of Articles

Agarwal, R., Prasad, J., & Zanino, M. C. (1996). Training experiences and usage intentions: a field study of a graphical user interface. *International Journal of Human-Computer Studies*, *45*, 215-241.

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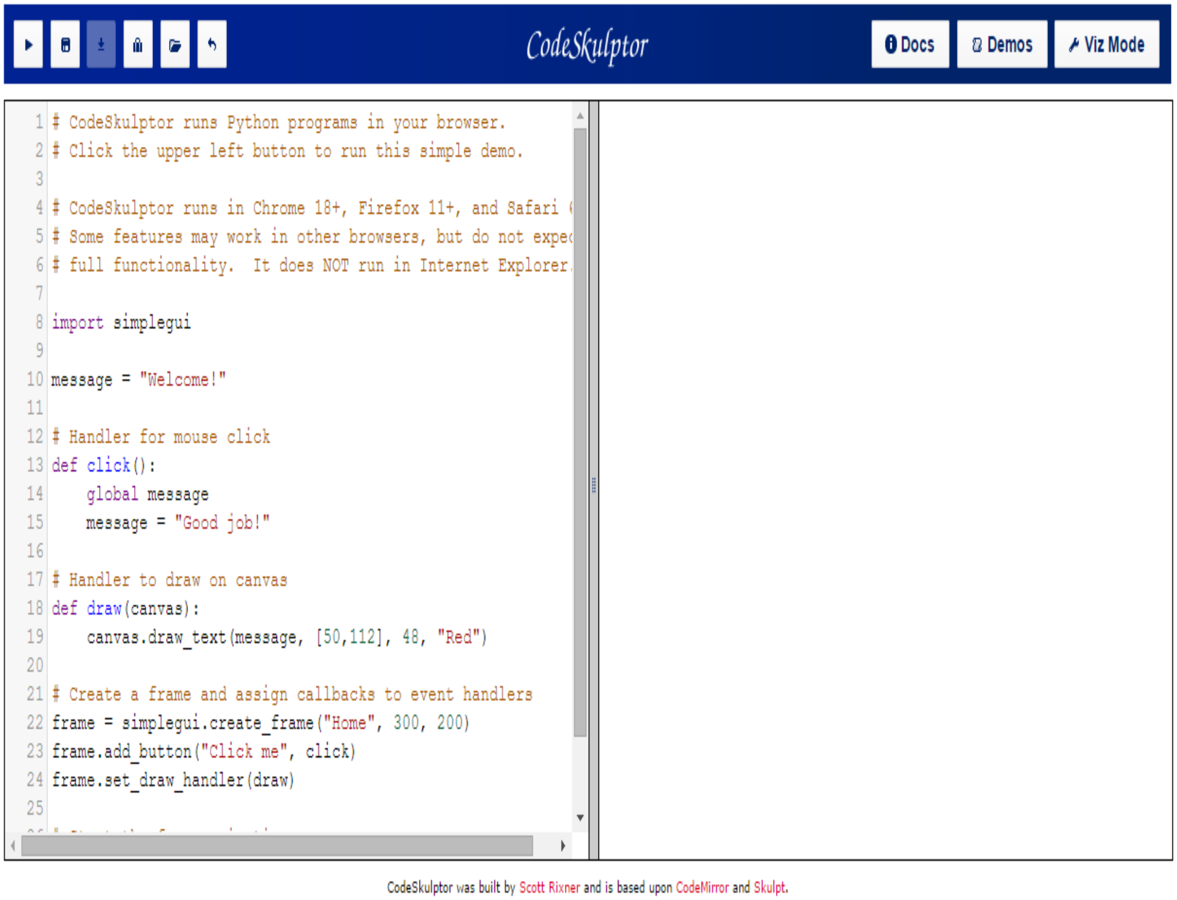
Appendix C – In-browser Coding Environment



Link: http://www.codeskulptor.org/#user40_XzS3p71lOW_0.py

Chapter 3

ESSAY 2: Examining Mental Rehearsal in conjunction with Enactive Learning: An Enterprise Resource Planning Study

Abstract

Information systems (IS) training literature draws heavily from Bandura's social cognitive theory (SCT). Social cognitive theory places heavy emphasis on observation learning (OL) processes. Observational learning can occur through: (1) Observation of other's actions, referred to as vicarious learning; and (2) Observation of self-actions in practice or enactive learning. According to Bandura, humans learn and acquire new skills through four processes of observational learning (*attention, retention, production and motivation*). There has been recent work on SCT in IS. However, interrelationships between OL processes as predicted by Bandura (1969) have not been explored empirically. Also, the prevalent training interventions such as mental rehearsal in a technology-mediated environment are under-researched. This study filled this gap by focusing on following two objectives: (1) Examining relationships between OL processes; and (2) Examining the effectiveness of training intervention which combines vicarious learning, enactive learning, and mental rehearsal in a technology-mediated context of Enterprise resource planning (ERP) simulation. To achieve these objectives, a between-subjects two-group quasi-experiment with n = 150 was conducted, where the control group received training which formed the baseline. The treatment group was exposed to additional mental rehearsal. The results indicated that mental rehearsal enhances the effectiveness of the training based on the similarity of knowledge structures with respect to the expert reference. The treatment group also scored higher in terms of business process knowledge and integration knowledge compared to the baseline.

Introduction

Training is very important for workplace performance (Barrett & O'Connell, 2000; Gupta & Bostrom, 2013; Park & Jacobs, 2011). In 2012, US corporations spent $164.2 billion on learning and development (ASTD, 2013). Only 13% of the employees were able to perform the newly learned skills while on the job, and only 3% of the employees were able to translate the training provided to reduce cost and improved quality (ASTD, 2005). Corporations need human capital to gain competitive advantage. Failure to maintain an adequately trained workforce can erode a firm's competitive advantage. This is especially true in the current digital economy. In fact, training is deemed as a critical component for IS success (Medsker & Medsker, 1987; Nelson & Cheney, 1987; Cronan & Douglas, 1990; Yaverbaum & Nosek, 1992).

In this essay, enterprise resource planning (ERP) is chosen as the context to study the effectiveness of training interventions. Developing an effective ERP training intervention makes strong business sense due to the following characteristics of ERP systems:

(1) ERP systems have been plagued by high failure rates (Aladwani, 2001). As many as 60% of ERP implementations fail (May, Dhillon, & Caldeira, 2013). This has led researchers to list Critical Success Factors (CSFs) related to ERP implementation success, and nearly 22 CSF are listed (Colmenares & Otieno, 2005). Although CSFs have provided invaluable guidance in ERP implementation, ERP failure rates continue to be high.

(2) ERP implementation often changes the focal organization's business processes. It has been empirically shown that ERP implementation changes employees' perceptions about the nature of their jobs (Morris & Venkatesh, 2010; Sykes, Venkatesh & Johnson, 2014). These changes can lead the users to resist the ERP system (Lim, Pan, & Tan, 2005; Klaus & Blanton, 2010). Previous research has investigated the factors responsible for user

resistance to ERP systems (Mahdavian, Wattanapongsakorn, Azadeh, Ayati, Mahdavian, Jabbari, & Bahadory, 2012; Robey, Ross & Boudreau, 2002). It has been found that in addition to the job/task design changes espousing ERP resistance, many users genuinely do not know to perform their task in the face of process changes implemented by ERP systems (Kwahk & Lee, 2008; Robey, Ross & Boudreau, 2002). The following quote (Robey et al. 2002) illustrates this point, "For example, a PlastiCo respondent noted that practicing on sample data did not prepare employees for live implementation: It's like turning out the lights; people didn't know where they were going" (p. 28). More recent research ERP system use has shown that users with lack of tacit knowledge about ERP business processes have difficulty in using the system (Freeze & Schmidt, 2015).

(3) In the wake of competitive pressures, rapid changes in the business environment, and dynamic and unpredictable economic conditions, most large organizations are seeking to optimize their operations (Cronan & Douglas, 2012). One way to optimize operations is to streamline business processes such as sales, marketing, and procurement (Cronan & Douglas, 2012) to achieve functional efficiencies. ERP systems promise to be the vehicle for achieving such functional efficiencies. As a result, ERP implementations across large corporations are on the rise. ERP implementation causes a focal firm's business processes to undergo re-engineering and consolidation (Gattiker & Goodhue, 2005), leading to workflows that span across cross-functional systems. Thus, the need for adequately trained employees has increased considerably. Traditionally, colleges have delivered education in specific functions (Cannon, Klein, Koste, & Magal, 2004) such as marketing, operations, and accounting. This type of approach has been criticized, as it does not adequately prepare students for careers that increasingly span cross-functional

systems (Malekzadeh, 1998). Against this backdrop, it becomes imperative that students are accustomed to basic business process integration (Boudreau, 2003; Coulson, Shayo, Olfman, & Rohm, 2003; Downe, Loke, Ho, & Taiwo, 2012; Kang & Santhanam, 2003).

Given the rapid adoption of ERP systems, the need for an adequately prepared workforce, and high failure rates of ERP systems, end-user training presents itself as a possible solution to improve the situation. In fact, training has been recognized as one of most important critical success factors (CSFs) and is ranked third most important factor for ERP success. (Carton, Adam, & Sammon, 2008; Ferratt, Ahire & De, 2006; Scorţa, 2006; Wang, Klein, & Jiang, 2006). The importance of training was recognized shortly after ERP systems were developed (Aristomenis, 2006; Noudoostbeni, Ismail, Jenatabadi, & Yasin, 2010; Norton, Coulson-Thomas, Coulson-Thomas, & Ashurst, 2012; Tsai, Chen, Hwang, & Hsu 2008; Wu, Liu, Li, Gao, & Tian, 2006).

In spite of recognizing the importance of user training, theoretically grounded research on ERP training interventions is rare (Dorobăţ, & Năstase, 2012). There are few empirical studies on ERP systems (Morris & Venkatesh 2010; Sykes et al. 2014) while the majority is in the form of case studies. Empirical ERP studies (Morris & Venkatesh 2010; Sykes et al. 2014) have explored issues of job satisfaction and job performance, but empirical investigation on ERP training intervention is scarce. Recent studies (Cronan & Douglas, 2012; Cronan, Léger, Robert, Babin, & Charland, 2012; Léger, Cronan, Charland, Pellerin, Babin, & Robert, 2012) have explored an ERP simulation called ERPsim for training purposes. The promise of the ERP simulation to work effectively as a training tool, coupled with the fact that the research on effective ERP training interventions is scarce (King & Burgess, 2008; Umble, Haft, & Umble, 2003), and presents IS researchers an appropriate and timely opportunity to develop theory-based

ERP training interventions. As explained earlier, in order to achieve the benefits of an ERP system, the users/employees need to be adequately trained in business processes and technical skills associated with ERP system (Dorobăt, & Năstase, 2010). This study addresses this issue by examining the effectiveness of an ERP training intervention using the enactive context of the simulation. Theoretically, it is focused on the following objectives:

(1) Examine relationships between observational learning processes as the training is based on SCT (Bandura, 1977). According to SCT, humans learn and acquire new skills through four processes of observational learning (attention, retention, production, and motivation).

(2) Examine the effectiveness of the training intervention which combines vicarious learning, enactive learning, and mental rehearsal in a technology-mediated context of an ERP simulation. Contingent on the effectiveness of the training intervention, further conduct posthoc analyses to understand the difference between the intervention and the control group.

Theoretical Background

ERP training using innovative methods such as simulations holds the potential to equip current and potential ERP users with adequate business processes as well as technical knowledge. In order to study this context, I employ social cognitive theory (Bandura 1977; Bandura 1986; Bandura 2001) as it has been one of most dominant and successful theoretical paradigms in technology training research.

Social Cognitive Theory (SCT)

The stance SCT takes on human learning as evident from the following quote (Bandura 1986), "Learning is largely an information processing activity in which information about the structure of behavior and about environment events is transformed into symbolic representations that serve as guides for action" (pg. 51). It is the main reason for SCT's prevalence in training studies.

SCT neither places exclusive emphasis on the environment nor on the organism; which is to say that learning does not happen automatically due to environmental stimuli nor is it exclusively driven by inner forces of the organism. SCT views human learning in terms of a model of three-way reciprocity in which behavior, cognitive/psychological, and other personal factors interact. According to SCT, training/learning interventions work through what is called observational learning (OL). Observation learning is the basis of the behavior modeling technique (BMT). BMT variants of observational learning maintain that at the root of BMT's effectiveness lies a method called *vicarious learning*. As the name suggests, in vicarious learning trainees learn by observing the desired behavior. The importance of observation is evident in the following quotes (Bandura, 1977):

> Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action. (p. 22)

BMT is widely used in education and in IS literature. It has been used in supervisory (Latham & Saari, 1979) and technology/computer training (Davis & Yi, 2004) settings. BMT has proved more effective than lecture based training (Compeau & Higgins, 1995), and self-study (Simon & Werner, 1996). The model in BMT does not specifically refer to a human teacher (Renkl, 2014). The desired behavior can be displayed to the trainees via programmed steps captured in videos.

Given the prevalence of BMT; understanding theoretical underpinnings of observational learning becomes important. It will allow us to enhance the effectiveness of training interventions.

Mental Rehearsal was added to BMT based on operant conditioning (Skinner, 1953). According to operant conditioning theory, people learn from doing/performing the desired behavior. The role of mental rehearsal was to reinforce the observed behavior so trainees could perform it better. According to SCT, observational learning also has another mechanism in addition to *vicarious learning,* called *enactive learning.* Enactive learning operates through practice and observation of self-actions (Schunk, 1996). Some literature suggests that learning from behavioral consequences is an automatic and unconscious process (Chen & Bargh, 1997). Often, it is seen as a mechanistic process instead of reflective (Bargh & Chartrand, 1999). SCT, on the other hand, suggests that in addition to non-conscious learning, a person can learn from behavioral consequences (Bandura, 1986) consciously due to the generative and reflective nature of human thought. Behavioral consequences can inform the trainee and function as a source of motivation (Rosenthal, & Zimmerman, 2014). Table 1 lists major studies utilizing BMT. It can be seen from Table 1 that the studies have focused on BMT, while only one study (i.e., Gupta & Bostrom, 2013) has examined the enactive context. Overall, the consistent finding is that BMT yields better results compared to instructor-based training or studying from a manual. Some studies (Yi & Davis, 2003; Davis and Yi, 2004) have examined a retention enhancement in addition to BMT. It has been sometimes referred to as rehearsal, retention enhancement or symbolic mental rehearsal (SMR). It was found that mental rehearsal had a positive impact on the effectiveness of training.

Table 1
Previous studies on observational learning

Paper/Study	Training method
Gist et al. (1989)	BMT vs. computer aided instruction
Compeau et al. (1995a)	BMT vs. non-modeling training
Desai (2000)	BMT vs lecture based instruction
Johnson et al. (2000)	BMT vs. non-modeling training
Bolt et al. (2001)	BMT vs. non-modeling training
Yi & Davis (2003)	BMT vs. BMT with Symbolic Mental Rehearsal (SMR)
Davis & Yi (2004)	BMT vs. BMT with Symbolic Mental Rehearsal (SMR)
Gupta & Bostrom (2013)	BMT vs. BMT with Enactive learning

In all of the above studies, training is directed to basic word processing software (i.e., word or excel) training. It remains to be seen if these training techniques can be enhanced as well as applied to more complex content such as ERP learning. An effective training intervention for complex domains should involve a combination of vicarious learning and enactive learning (Bandura 1986). Prior research (Compeau et al., 1995) suggests, when modeling is enhanced with enactive learning it can have beneficial impacts. So far, I have established that BMT has been successful in IS training research and retention enhancement has increased training effectiveness. Further, the need for inclusion of enactive learning (i.e., learning by doing) is also emphasized. How does one achieve enactive learning in a complex setting such as ERP? ERP simulation could be helpful in this regard. In the following section, the status of ERP training in the industry described. Current ERP training practices further supports the idea of introducing ERP simulation as a training tool.

State of ERP Training in the Industry.

ERP training has been recognized as one of the most important factors in ERP implementation success. Academic researchers have listed end user training as third most important CSF (Carton, Adam, & Sammon, 2008; Ferratt, Ahire & De, 2006; Scorţa, 2006;

Wang, Klein, & Jiang, 2006). In spite of this recognition, training seems to be an afterthought, leading to ERP project failures (Dockery, 2014).

Often in training, companies use what is called “cascade approach.” In this approach, there are few “superusers” who train the rest of the firm’s employees. Superusers are employees across the company who have in-depth knowledge of the ERP system and function as trainers. However, there are some limitations of this approach.

(a) Communication barrier: Traditionally, superusers are exceptionally good at understanding the system but may not have the communication skills to train other users. Since superusers are detailed and technical, training designed by them is likely to be system-driven and not catering to the employee’s role.

(b) Information overload: Since there are few superusers in a firm relative to the total number of workers, employing them to impart training adds to their already heavy workload. This approach hampers the training program.

(c) Heavy customization: Employing superusers for training leads to very specific ERP training as they are highly technical about the ERP system. Quite often, such technically savvy users/trainers lack the context in which ERP is employed. This approach over-customizes training, and other employees may not receive it enthusiastically. Role-based customization is needed, but training should be kept as generic as possible while introducing the user to various business processes.

Training professionals and firms (Profitt, 2013; Phelan, 2012) recommend the following ways to overcome the above problems:

(a) Utilization of boot camps – short and intensive training in multiple sessions

(b) Employing adult/hands-on learning methodology

(c) Delivering process-based training

(d) Tailoring training towards focal organization's business: For example, depending on the firm's focus (distribution, manufacturing, or logistics), selective modules of an ERP system become applicable for training.

Given tighter training budgets, the current state of ERP training in the industry, and the need for adequate ERP training; training professionals recommend short, economical, repeatable ERP training methodology. ERP simulation called ERPsim can achieve this goal can achieve this. It is described in the next section.

Role of ERP Simulation

Concepts related to ERP are often hard to grasp and have been difficult to teach to new trainees or students (Leger, Charland, Feldstein, Robert, Babin, & Lyle, 2011). New generations of students and employees have not been exposed to the non-integrated software packages that ERP systems replace. These stand-alone software packages were specific to various business functions such as purchasing, accounting, or production. As they do not have prior background in these business processes, it becomes difficult to teach them the value of horizontal integration provided by ERP systems.

Problem-based learning (PBL) holds promise to improve this training situation. Starting with the idea of PBL and hands-on learning, researchers at HEC Montreal created an ERP simulation game called ERPsim. ERPsim can act as an IT tool to train future and current employees in business process training. As business processes change rapidly, training requires methods that will help learners develop needed cognitive skills (Clarke & Clarke, 2009). ERPsim achieves this by implementing many of the principles of PBL.

Many Fortune 1000 organizations also use ERPsim to train their employees. Commercially, it is made available by Baton Simulations. Many academic intuitions use ERPsim for student training and research purposes (Cronan, Douglas, Schmidt, & Aluaime, 2009a; Cronan, Douglas, Schmidt, & Aluaime, 2009b; Léger, 2006; Léger et al., 2011).

In an ERPsim game, participants run business transactions using a real-life enterprise system (SAP). It gives them hands-on exposure to the kind of ERP systems used at the world's largest companies. Participants simulate and transact against a simulated market using SAP interface. All decisions result in a set of particular business transactions and are entered in the ERP-SAP interface. Information about the state of market, sales, inventory, and finances can be accessed using built-in reports. HEC researchers describe ERPsim as "similar to using a flight simulator, but in a real plane cockpit" (Leger, Robert, Babin, Lyle, Cronan, & Charland, 2014, p. 330). Participants can learn about integrated business processes through enactive and hands-on exercises. ERPsim provides three functions as detailed.

Simulation of the real-time market. Realistic demand is simulated by creating a large population of customers, each with their tastes and preferences. The market simulation does not depend on an aggregated demand function and hence cannot be easily pinned down, mimicking the real world. Each customer's utility is based on his/her preferences, and customers make purchases that will maximize utility. Simulated customers can compare prices and products offered by different ERPsim participants. Such an approach generates rich, and high volume demand.

Automation of routine tasks. To receive and fulfill orders from customers, manufacturers would have to undergo routine business processes such as receiving a sales order, shipping products, and sending an invoice to customers. Since these tasks do not depend on critical business decisions, ERPsim automates them. Trainee/students can run the business, focusing on executive decision making related to sales, marketing, procurement, and production. For example, once a trainee releases the purchase order, ERPsim automates the goods receipt, and invoice, sending payment to vendors.

Time management. Time is compressed but gives a sense of evolution like in the real-world. ERPsim is typically played over three rounds (and over 90 virtual days). Each round lasts 30 minutes. Each minute represents the passing of a virtual day. Participants learn to adjust their actions to make better business decisions over time, as they learn to play the game connected to the real-world ERP-SAP system.

As of this writing, there are three major types of game: *logistics game, distribution game, and manufacturing game.* The manufacturing ERPsim game was used in this dissertation due to its comprehensive coverage of business transactions. In the manufacturing game, participants are responsible for selling six varieties of muesli in three regions of German market (North, South, and West) through three different channels (large retailers, small retailers, and independent grocers). In ERPsim, muesli in can be sold in either a small box or in a large box. The simulation aims to expose students to the skills required to run business processes using an ERP systems. In the ERPsim manufacturing game, transactions that trainees/students are engaged in the transactions described in Table 2.

Table 2
Details of Transactions in an ERPsim game

Transactions area	**What it entails**	**Transactions Code in ERPsim**
Forecasting and production planning	Creation of sales forecast	MD61
Material requirement planning/Materials Management	Purchasing the production requirements based on sales forecasting, and on-hand inventory	MD01, ZME2N
Production scheduling	Specification of the schedule in which a set of production orders is released on the assembly line	C041, ZCOOIS, ME59N

Sales and marketing management	Sales orders are automated. A trainee needs to manage sales in such way to enhance profit as well as keep the optimal safety stocks	VK32, ZADS, ZVA05,ZCV2,ZMARKET
Accounting and treasury management	Keeping up with current balance sheet and P/L of the company	F.01, ZCK11
Stock management	Managing inventory to ensure continuous supply	MB52

Appendix A shows the "Job aid" provided to the participants which provide the details the transaction possible in ERPsim. ERPsim has been shown to be an effective training tool. ERPsim provides enactive learning as users/trainees can understand the impact of their actions in real-time. Previous research has shown that enactive learning improves learning significantly (Gupta & Bostrom, 2013). In this study, the technological component in the training i.e. ERPsim affords enactive learning.

In previous paragraphs, I described how SCT explains human learning in vicarious and enactive ways. According to SCT, four processes responsible for learning: (1) Attention, (2) Retention, (3) Production, and (4) Motivation. These processes are explained briefly below.

Attention. It regulates exploration and perception of modeled activities. One cannot learn without paying attention.

Retention. In this stage trainees cognitively register modeled actions as symbolic representations in memory in order to regulate future behavior.

Production. Based on the strength of the retention, a trainee can reproduce the modeled behavior. Also, if the structured environment is provided for self-exploration, this phase can afford enactive learning.

Motivation. This process determines whether or not observationally acquired (from either observation of a model or self-actions) skills are enacted in the future.

There has been recent work on observational learning (OL) in IS (Davis & Yi 2004; Gupta & Bostrom, 2013; Yi & Davis, 2003). However, interrelationships between OL processes as predicted by Bandura (1969) have not been explored empirically. The investigation of the prevalent training interventions such as mental rehearsal in a technology-mediated environment is an under-researched area (Gupta & Bostrom, 2013). This study aims to fill this gap. Objectives of this essay are summarized in the following points.

(1) *Examine the interplay between OL processes*. A nomological model hypothesizing relationships between various OL processes was proposed and tested to do so. The training intervention contained both vicarious aspects and enactive aspects.

(2) *Examine the effectiveness of a training intervention which combines vicarious learning, enactive learning, and mental rehearsal*.

To achieve these objectives, a between-subjects quasi-experiment was conducted where the control group received training which espoused vicarious learning as well as enactive to form the baseline. The treatment group was exposed to additional mental rehearsal. Contingent on the effectiveness of the training intervention, further posthoc analyses was conducted to understand the difference between the intervention and the control group.

Theory and Hypotheses Development

In this section, I develop the hypotheses for this study. Figure 1 presents the proposed research model. The rationale for the proposed relations and the hypothesis are presented in the following pages.

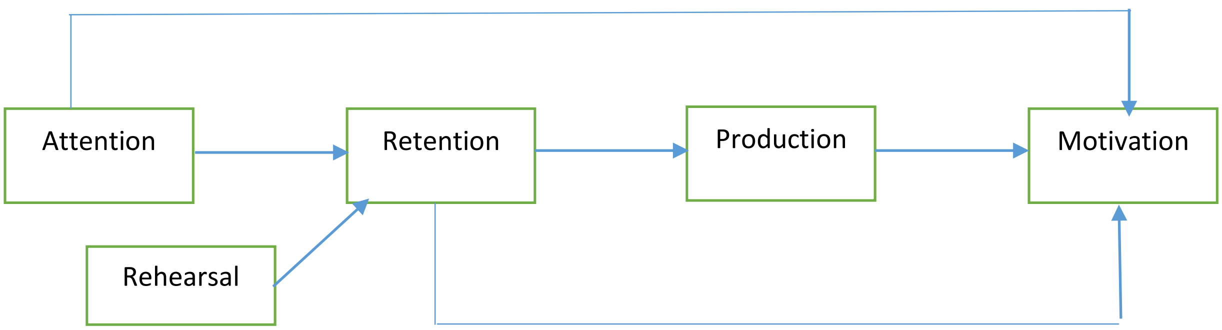


Figure 1. Hypothesized model

As discussed earlier, OL operates by four processes: *Attention, retention, production, and motivation.* These processes are interrelated, and the purpose of the following discussion is to develop a rationale for the relationships among them and test them.

Attention

It is unlikely that a trainee could reproduce desired behavior if he/she is not able to attend, recognize and distinguish various aspects of the training. Also, simply exposing a person to the stimuli is no guarantee that he/she will pay attention to the model's behavior. It is important to set an adequate environment for learning.

Retention

This process of OL is credited with the development of symbolic codes of the training. These codes act as cues to actions in the future. Participants who are able to develop symbolic codes can use them as scaffolding for future action. Being attentive to the model's behavior is likely to strengthen the formation of symbolic codes. Another way to enhance symbolic coding is through mental rehearsal (Davis & Yi, 2004; Margolius & Sheffild, 1961; Michael & Maccoby, 1961). During mental rehearsal, participants are encouraged to code the behavior into more easily remembered schemes. While there is no one way to symbolically code and/or cognitively rehearse the model's behavior, participants in this study were instructed to put themselves in the model's shoes and imagine the behavior performed by the model. Additionally, participants could code model's behavior in any other way they wanted (i.e., take additional notes if they need it). The impact of mental rehearsal on OL is explained in detail later in this section.

In this study, participants were part of undergraduate ERP classes, and the training was administered as part of their curriculum. Also, they were awarded extra credit for participating in the study. Given this situation, they were likely to be attentive to the training imparted.
Given this argument, I hypothesize:

H1: Attention will a positively impact the retention process.

H2: Mental rehearsal will have a positive impact on the retention process.

Production

Reference to production was made earlier in the discussion about symbolic codes. In this study, the desired behavior was shown to trainees using well-crafted videos. When participants practiced the desired behavior, the video was not present so they had to rely on the symbolic codes that they developed in the retention phase (Bandura, 1969; Bandura, 1986). Felicity of the practice, (i.e., production stage) would depend on the degree of retention.

H3: Retention will positively impact the production process.

Also, note that merely paying attention to a model's behavior does not aid in production. This is because if a participant has not developed symbolic codes of model's behavior then he/she will not have cues to the actions that would be needed in the production process. In other words, attention has no direct impact on production, but it is "indirect" or through the retentive process and the production process. Without the retentive process being attentive does not aid in reproduction of the model's behavior. In the production process, in addition to producing the observed behavior of the model, the enactive component of the observational learning also comes into play. Participants are able to observe the impact of their own actions in real-time due to the use of ERP simulation.

Motivation

Participants may acquire skills through the previously mentioned processes (i.e., attention, retention, and production), but if they do not have favorable views of the value of the training or are operating in unfavorable conditions, they will not be motivated to perform the behavior (Bandura, 1977). Production of the modeled training behavior, as well as self-exploration afforded by enactive practice, would prompt users to see the value in the ERP training. As participants practice, the value of integrated training provided by the simulation becomes evident and could lead to favorable dispositions of the training. Production of the behavior can favorably modify the outcome expectations (Manz & Sims, 1981) of the trainee.

H4: Production will positively impact motivation.

Observational learning processes require favorable conditions (i.e., participants may not automatically pay attention to the models' behavior, neither they may be motivated to learn or perform the skills learned). In order to facilitate favorable learning conditions, the learning setting must be favorable, and should provide incentives for learning. To this end, this study was conducted as a quasi-experiment and as part of undergraduate ERP classes. Students had interest and predisposition towards learning ERP, assuring that initial conditions for observational learning were met.

Other than the effects discussed above, other direct and mediated impacts are possible. I have argued that merely paying attention does not facilitate production if the focal participant did not have the opportunity to form symbolic codes through the retentive process. However, attention and retention processes can possibly impact the motivation process of OL. This has been a consistent finding in neuroscience and psychology as explained below with the help of the theory of mind and mirror neurons.

Theory of Mind

Theory of mind (ToM) deals with the ability of a person to impute mental states to self and others and to predict behavior on the basis of such states (Premack & Woodruff, 1978). ToM involves placing oneself in someone else's shoes, imagining their intentions, and thoughts and (Baron-Cohen, 2009). In understanding other people's intentions, there are two sub-aspects involved: *mirroring and mentalizing* (Chiavarino, Apperly, & Humphreys, 2012). Mirroring has been shown to correspond to the affective neural circuits and metalizing has been shown to map to cognitive neural circuits (Abu-Akel & Shamay-Tsoory, 2011; Lieberman, 2007; Sabbagh, Moulson, M, & Harkness, 2004; Saxe, Moran, Scholz, & Gabrieli 2006). Brain areas related to cognitive and affective aspects of ToM have been shown to map to explicit and implicit mental states respectively (Wolf, Brüne, & Assion, 2010).

The cognitive (i.e., explicit) reasoning component of ToM is explained in neuroscience literature by the "rehearsal" point of view where one imagines/rehearses behavior performed by a model as if he/she was performing it (Goldman, 1992; Gallese & Goldman 1998; Ochsner, Knierim, Ludlow, Hanelin, Ramachandran, Glover, & Mackey, 2004). This step of imagining the model's behavior and rehearsing as if the focal trainee was performing the behavior himself/herself is a characteristic of the *retention* stage (specifically rehearsal intervention) in observational learning. This aspect of explicitly imputing observed behavior is termed *mentalizing.*

An aspect of ToM called *mirroring* is largely related to the implicit components of ToM and is recruited when a trainee is paying *attention* to the behavior of the model. It has been shown that whenever a trainee is paying attention, the human brain unconsciously primes the mirror neurons to mirror the observed action (Miall, 2003). Later, when he/she cognitively *rehearses,* the explicit components of ToM come into play in addition to the implicit part. Recent neuroscience evidence supports this view of observational learning (Iacoboni, 2009; Miall 2003; van Gog et al., 2009). In the next section, I explain how mirror neurons can lead to mirroring and *mentalizing* in observational learning.

Mirror Neurons

Mirror neurons were serendipitously discovered in Macaque monkeys, and they have been found to operate in humans as well (Rizzolatti & Craighero, 2004). They are cells with complex response characteristics closely linked to and activated by action observation and performance (Miall, 2003; Thill Caligiore, Borghi, Ziemke, & Baldassarre, 2013). Imitation learning is attributed to the mirror neurons system (MNS), and theory of mind (ToM) is seen as a result of having these specific types of neurons in the human brain (Iacoboni, 2009; Gallese & Goldman 1998).

Mirror neurons so far have been limited to "motor training" (i.e., learning where motor movements are involved). However, in this study BMT is employed to enhance cognitive skills. An obvious question arises: does the MNS finding extend to cognitive training? Recent evidence suggests that MNS extends to cognitive tasks such as technology training (van Gog et al., 2009; Keysers & Gazzola, 2007).

Unless one employs neuro-scientific methods, measuring activation on mirror neurons remains a difficult task. However, activation implicit and explicit components of ToM can be linked to MNS, and these implicit and explicit components are explained as the mechanism behind observational learning in this study. Neuroscience literature suggests that mirror neurons provide implicit and explicit encoding of the action to the observer (or in this case to the trainee) based on whether the observer can imagine the mental state of the model and learn the behavior.

Further, implicit and intuitive aspects constitute *mirroring*, which has been shown to inform the explicit aspect of ToM called *mentalizing* (Van Overwalle, & Baetens, 2009; Shamay-Tsoory 2011; Chiavarino et al. 2012). Mentalizing is the characteristic of the retention process in observational learning. This argument gives greater credence to H1.

Paying attention to the modeled behavior can automatically and implicitly lead the focal participants to mirror the mental state of the model. The ERPsim videos were borrowed from HEC Montreal. The videos were well-designed and professionally produced to motivate learning. Thus, I hypothesize that,

H5: Attention process will have a positive impact on the motivation process.

Retention and production processes are crucial in the generation of scaffolding and its utilization. Through the retention and production stage, the focal participant is able to learn the value of ERP training and be motivated to perform the behavior.

H6: Attention process will have an indirect positive effect on motivation operating through retention and production processes.

The act of rehearsing facilitates the formation of symbolic codes which is synonymous with *mentalizing* in ToM, and it has been shown to form a stable scaffolding of the learning material (Heyes, 1996; Perner, 1988; Wertz & German, 2013). Not only does such retention structures act as the basis of production, but it has also been shown to impact the motivation a person. Prior research on schemas in the psychological literature (Baumeister & Newman, 1994; Bluck & Habermas 2000) has shown that mental structures formed through learning and life experiences potentially dictates similar motivational outcomes from the focal person in the future. Essentially, mental structures are produced by training under certain motivation demands (Siegel, 1997) (those observed/extracted from the behavior model), and are likely to direct similar motivational demands in the future. In addition to the retention process, production of the observed behavior as well as self-exploration of the ERP system (afforded by enactive learning) also explicates the value of the training to the focal participant and motivates him/her to perform the behavior. Based on above arguments,

H7: Retention process will have a positive impact on the motivation process.

H8: Retention process will have an indirect positive effect on motivation operating through production.

Mental Rehearsal

Mental rehearsal intervention refers to two primary activities (Decker, 1980) on the part of a trainee: (1) reducing elements of modeled performance into easily stored symbols which can be easily stored and retrieved to guide behavior and; (2) cognitively rehearsing to visualize themselves performing the target behavior. According to Bandura (1986) during mental rehearsal, trainees must be encouraged to, "transform what they observe into succinct symbols to capture the essential features and structures of the modeled activities" (p. 56). These symbols act as a guide for future action. Such interventions have been used successfully in IS and other research (Davis & Yi, 2004; Yi & Davis, 2003). As previously discussed, symbolic codes lead to the formation of mental scaffolding. These cognitive representations drive subsequent production. Note that the subsequent process of production can further aid in the formation these knowledge structures/mental schemas. In the next section, knowledge structures are described.

Mental rehearsal is aimed at enhancing the mentalizing process (i.e., the explicit component) of ToM (Williams, 2004). Mentalizing results in the formation of stronger mental scaffolding. As a consequence, it is likely to boost production fidelity of the observed behavior as well as motivation to perform it. Prior research on mental rehearsal indicates that it can act as a bolstering mechanism and aid in the formation of trainees' knowledge structures (Clark & Herrelson, 2002). It has been shown to prompt trainees to segmentize the training materials and then integrate them (Clark, Nguyen, & Sweller, 2011).

H9: Mental rehearsal will have a positive indirect effect on the production process.

H10: Mental rehearsal will have an indirect positive effect on the motivation process.

Mental rehearsal's place in the nomological model

As detailed in the activity diagram (Figure 3), mental rehearsal was conducted after trainees had seen and practiced the material in the ERPsim videos. Final practice session followed the mental rehearsal step. Attention is the first OL process and is concerned with focusing on the visual and auditory stimuli of the anthropomorphic/computer model (in this case behavior in ERPsim videos). ERPsim practice occurred later in time, and participants had no access to the videos. Thus, mental rehearsal (i.e. retention enhancement) temporally lagged from the visual and auditory stimuli and should have no impact on the attention processes of OL. Mental rehearsal (i.e., retention enhancement) by itself cannot influence production and motivation processes, but only through the cognitive representations of training via the retentive process. If not for the retentive process, production and motivation processes would have the no scaffolding to depend on when a trainee practices the behavior. Thus, retention enhancement should not have any direct impact on the production and motivation processes.

As OL is impacted by individual traits and orientation, I control for age, gender, previous ERP experience, pre-training self-efficacy, pre-training motivation, TAM variables, computer playfulness, personal innovativeness, and conscientiousness.

Knowledge Structures

In the process of skill acquisition, individual chunks of information interconnect to form knowledge structures also called cognitive representations, mental models, cognitive maps, or schemata (Johnson-Laird, 1983). Social cognitive theory (Bandura, 1986, 1997), argues that observational learning is, "largely an information processing activity in which information about the structure of behavior and about environmental events is transformed into symbolic representations that serve as guides for action" (Bandura, 1986, p. 51). There has been previous research highlighting the importance of knowledge structures in observational learning (Bandura & Jeffrey, 1973; Carroll & Bandura, 1985; Carroll & Bandura, 1987). Observational learning places heavy emphasis on the formation of knowledge structures. The importance of retention and production processes in the formation of knowledge structures is clear from the explanation above. Also, the attention process can activate implicit coding of the model's behavior and aid in the formation of knowledge structures. Further, observational learning operates by modifying outcome expectations (Manz & Sims, 1981). To that extent, that a trainee can see the value in the training provided, as evidenced by prior processes (i.e., attention and retention), he/she will be motivated to perform the modeled behavior in the future. Given that this research employs a quasi-experimental design where participants view the model's behavior (through a series of well-designed videos) in multiple sessions, motivation gained from prior sessions of training can aid in the formation of knowledge structures in the current or future sessions. Thus, all four processes of OL can work towards building knowledge structures. Thus, it would be erroneous to place the knowledge structures in the nomological net of OL. Instead, it is seen as the end result of all four OL processes.

Knowledge structures of a trainee/participant by themselves are not interpretable unless their relative similarity to the expert referent is measured. For this reason, the same task that the trainee perform is performed by domain experts. After that, experts' knowledge structures are taken as a reference. The distance of a trainee's knowledge structures from the reference is called knowledge structure similarity (KSS). It is a similarity measure ranging from 0 to 1 and is based on well-established research in education and information systems. KSS was also used in Davis & Yi (2004). The goal of mental rehearsal intervention is to make trainee's knowledge structures analogous to the expert referent. The cohort receiving mental rehearsal intervention should theoretically result in greater post-training knowledge structure similarity to the expert referent.

H11: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on KSS.

H12: Mean KSS for the intervention cohort greater will be greater than the control cohort.

Training Outcomes

Following prior research on ERP and training, training outcomes were captured in the form of enterprise systems integration knowledge, business process knowledge, transaction knowledge, ERP quiz, and post-training self-efficacy (Cronan et al., 2012; Yi & Davis, 2003). Further, the affective outcome was captured in the form of the simulation experience. Objective training outcomes were also captured in the form of an ERP quiz. If the training intervention was effective, the mean of training outcomes in the treatment cohort would be higher than the control cohort. Thus,

H13: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on enterprise systems integration knowledge.

H14: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on business process knowledge.

H15: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on transaction knowledge.

H16: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on simulation experience.

H17: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on the ERP quiz score.

H18: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on post-training self-efficacy.

Hypotheses are summarized in Table 3. Hypotheses H1 to H10 captured various components of the OL process and interrelationships among them, addressing the first objective of developing a nomological model of OL. The rest of the hypotheses (H11 to H18) address the second objective. It examined the effectiveness of training intervention with respect to the baseline training.

Table 3
Summary of hypotheses

H1: Attention process will positively impact the retention process.
H2: Mental rehearsal will have a positive impact on the retention process.
H3: Retention process will positively impact the production process.
H4: Production process will positively impact motivation process.

H5: Attention process will have a positive impact on the motivation process.
H6: Attention process will have an indirect positive effect on motivation process operating through retention and production processes.
H7: Retention process will have a positive impact on the motivation process.
H8: Retention process will have an indirect positive effect on motivation process operating through the production process.
H9: Mental rehearsal will have an indirect positive effect on the production process.
H10: Mental rehearsal enhancement will have an indirect positive effect on the motivation process.
H11: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on KSS.
H12: Mean KSS for the intervention cohort greater will be greater than the control cohort.
H13: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on enterprise systems integration knowledge.
H14: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on business process knowledge.
H15: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on transaction knowledge.
H16: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on simulation experience.
H17: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on the ERP quiz score.
H18: Adding mental rehearsal to modeling-based (enactive and vicarious) training will have a positive impact on post-training self-efficacy.

Method

This section describes the experimental design, treatment, variables involved, and the subjects. The experimental approach employed by Yi & Davis (2003) was adopted, and a between-subjects quasi-experiment was conducted. The groups were designed to be equal through randomization, except for the treatment.

The quasi-experiment followed a between-subjects design. In order to control for pre-training individual differences, participants were given a pre-survey which collected variables which can impact training outcomes. Specifically, I controlled for age, gender, previous ERP experience, TAM variables (perceived ease of use and usefulness), computer playfulness, personal innovativeness, conscientiousness, pre-training self-efficacy, and pre-training motivation to learn. Data were collected from undergraduate ERP classes who played the ERPsim manufacturing game as part of the course. Students were awarded extra credit for participation.

Procedure

ERPsim was played in three rounds. Before each round, participants were instructed to watch the video detailing information about the game as well as showing the desired behavior. After that students played and practiced the round relevant to the video they watched. Details on the ERPsim videos can be found in Appendix B. Students were instructed to closely mirror the behaviors observed as well as explore the ERPsim system on their own. Flowchart (Figure 2) displays the process[1].

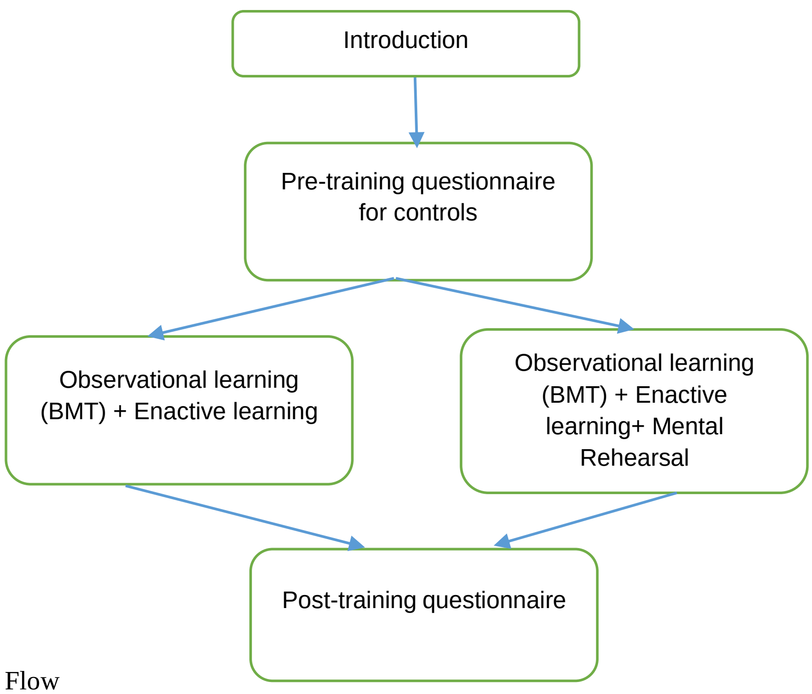


Figure 2. Study Flow

A total of 165 participants were recruited from business school ERP classes. Classes were randomly assigned to receive a rehearsal treatment. All trainees were introduced to the training

[1] ERPsim training was conducted in three rounds. Training was facilitated with the help of videos from HEC Montreal. A list of videos can be seen in Appendix B.

and given a pre-training questionnaire to capture individual traits and pre-training control variables. Figure 3 gives a more detailed view of the activities performed. The only difference between the two groups was the rehearsal intervention. Both groups were equalized on the amount of training time. However, since each class was facilitated by a different instructor, it was not possible to control for instructor-specific traits. After a manipulation check, 150 participants were retained for data analysis with 75 in each group. Demographic information of participants is presented in Table 4 and 5.

Table 4
Demographic details

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Age	150	18	55	21.90	3.67
Gender	150	0	1	NA	NA
GPA	150	1.80	4.00	3.16	0.60

Table 5
Gender distribution

Gender		
	Frequency	Percent
0 (female)	54	36
1 (male)	96	64
Total	150	100

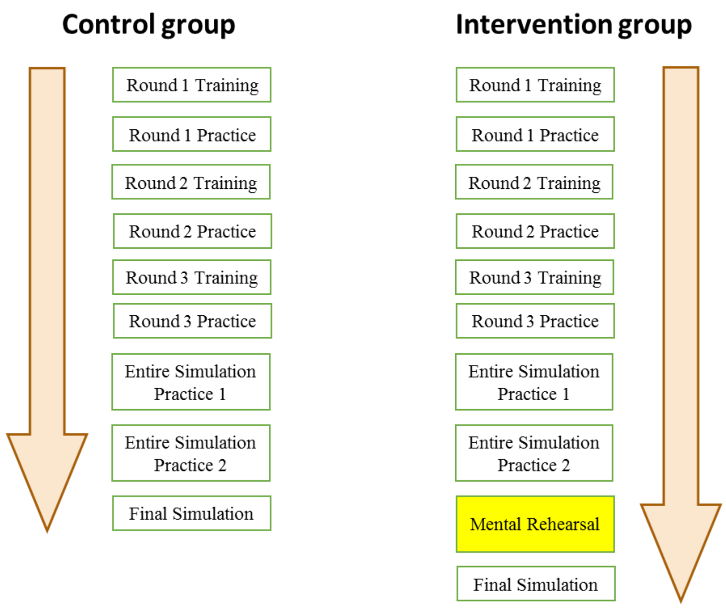


Figure 3. Details of activities

Treatment

The intervention group participants were asked to mentally note the important aspects of the videos they had watched. After practicing in the simulation environment, the participants were requested to mentally rehearse the solution. Previous research has shown that this step primes trainees to string the mental notes together. This process was carried out before the final practice session as shown in Figure 3. Participants in this group were encouraged to take additional notes about this process.

The control group participants were not asked nor encouraged to mentally rehearse and take notes. Time allocation across two group was constant; as the study was conducted over the same number of classes/sessions in the semester. The intervention group mentally rehearsed while the control group had access to the system (i.e., ERPsim). It must be noted that the study was conducted as a quasi-experiment, and instructor specific effect could not be controlled. Although the control group was instructed to explore the system as the intervention group engaged in mental rehearsal, there is currently no concrete way to ensure that participants in the control group did in fact explored ERPsim.

Manipulation check

Training utilized ERPsim videos. To ensure that participants saw the videos, they had to answer a short quiz after training videos in each round. Details of this quiz can be found in Appendix C. Only participants who answered 60% of the questions right were analyzed. The data were reduced to 150 participants, with 75 in each group.

To check if the rehearsal intervention worked, the number trainees who took notes in each group were compared. All trainees (n = 75) in the mental rehearsal condition performed symbolic coding and took notes, whereas only 4 of 75 trainees (5.3%) created any form of notes. Further, the intervention group scored significantly higher on the retentive process compared to the control group (Mean difference = 0.34; p = 0.04).

Measures

Measures were borrowed from prior research and were validated scales. Table 6 shows the measures used. The questionnaire/items can be pre-training and post-training can be found in Appendices G and H. Appendix I displays the IRB approval.

Table 6.
Construct measures

Construct	**Measures**
Observational Learning	Yi & Davis, 2003
Pre-training Motivation	Adapted from Baldwin, Magjuka, & Loher, 1991; Hicks & Klimoski 1987; Noe & Schmitt, 1986
Self-efficacy	Compeau & Higgins, 1995.
Business Process Knowledge	Cronan et al., 2012
Knowledge Integration	Cronan et al., 2012
Transaction Knowledge	Cronan et al., 2012
Simulation Experience	Cronan & Douglas, 2012

TAM variables	Davis 1989
Personal Innovativeness	Agarwal & Karahanna, 2000
Computer Playfulness	Agarwal & Karahanna, 2000
Conscientiousness	Goldberg, Johnson, Eber, Hogan, Ashton, Cloninger, & Gough, 2006

Knowledge structure similarity (KSS) measurement. In order to measure the similarity of trainees' knowledge structures to that of experts, PRONET pathfinder software (McGriff, & Van Meter, 2001; Schvaneveldt, 1990; Schvaneveldt, Dearholt, & Durso, 1988, 1989) was used. The terms used to formulate knowledge structures were decided in consultation with ERP experts who have been teaching ERP courses at a large southern US university for many years. These terms and their definitions can be found in Appendix D. Trainees were asked to rate 11 ERP concepts pairwise. From these ratings, their proximity matrices were generated. A proximity matrix gives an account of relatedness between ERP concepts. Proximity matrices were used to generate knowledge structures of trainees. Other techniques such as Multidimensional Scaling (MDS) and hierarchical clustering also take proximity matrices as input and generates output from proximity matrices, but in this case Pathfinder was the preferred method. The reason for employing pathfinder was its ability to resist noisy data. Pathfinder is able to distinguish between concepts that are highly similar as well as highly dissimilar. If two concepts are similar, then a discerning trainee would rate it higher on Pathfinder, and if two concepts are dissimilar, then he/she would rate it lower on pathfinder. For the purposes of illustration, consider that a trainee can rate a concept pair from 1 to 7 with 1 being "not at all similar" to 7 being "extremely similar." The difference between an extremely similar pair (score=7) and a very similar pair (score =6) is 1. Also, let us assume that this pattern is consistently seen in the data (i.e., many trainees rate these two concepts pairs as 7, and 6 respectively). The difference between an extremely dissimilar pair (score=1) and a very dissimilar pair (score =2) is also 1 but does not occur as consistently. Even though the magnitude of the difference is the same, the distance is psychologically real in the first case and mostly noise in the second. Techniques like Multidimensional Scaling (MDS) considers all concept pairs simultaneously and hence is susceptible to more noise (especially in a knowledge domain such as ERP where concepts are related to a high degree). Pathfinder algorithm, on the other hand, is more successful at discerning differences towards the “related end” (i.e., the domain of knowledge where concepts are likely to be related strongly). Given that the nature of the domain (i.e., ERP) in this study is largely integrated, pathfinder is a preferred method of knowledge elicitation. The distance from a trainee’s knowledge structures to the referent was used as a measure of KSS (Davis & Yi, 2004). This measure can range from 0 to 1, with the higher number indicating a greater degree of similarity.

Results

Nomological Model Results (PLS Output)

Partial Least Squares (PLS) (Chin & Frye, 2003) was used as a modeling tool to test the model. PLS was used as a structural equation modeling tool because it utilizes a component-based approach to estimation compared to covariance-based SEM tools such as LISREL, which employ a maximum likelihood function to obtain parameter estimates. PLS allows greater flexibility in theory building (Gefen et al., 2000) while placing minimal demands on measurement scales, sample size, and distributional assumptions (Chin 1998, Falk & Miller, 1992, Fornell & Bookstein, 1982, Wold, 1982). Measurement model was examined to assess the reliability and validity metrics before proceeding to test the structural model.

Measurement model. Table 7 presents information about the Cronbach's alpha, and composite reliability. The composite reliability score of the scales suggests that the scales employed were reliable. Table 8 represents correlations and average variance extracted (AVE).

The average variance extracted (AVE) was greater than .5 (except pre-training self-efficacy and conscientiousness which were control variables). Item loading (Fornell & Larker, 1981; Wu & Wang, 2005) on their corresponding construct is greater than the loading on other constructs (as shown in Table 9). Thus, the criteria for convergent validity are satisfied. The square root of AVE was greater than the correlation among constructs; thus construct measures displayed discriminant validity (Fornell & Larcker, 1981).

Table 7
Reliability of constructs used in PLS model

Construct	Cronbach's Alpha	Composite Reliability
Attention	.91	.93
Computer Playfulness	.87	.90
Conscientiousness	.88	.90
Motivation	.93	.95
Perceived Ease of Use	.92	.94
Perceived Usefulness	.97	.98
Personal Innovativeness	.90	.93
Pre-training Motivation	.94	.96
Pre-training Self-efficacy	.80	.84
Production	.93	.95
Retention	.91	.94

Table 8

Correlations and AVE

	KSS	PTM	ERPX	GPA	Age	GEN	RE/TR	PINT	CON	PSEC	PU	PEOU	CPL	OLA	OLP	OLR	OLM
KSS	**NA**																
PTM	.028	**.84**															
ERPX	.065	-.057	**NA**														
GPA	.124	.034	.027	**NA**													
Age	.048	.201*	-.094	-.071	**NA**												
GEN	-.199*	.040	.050	-.119	-.057	**NA**											
RE/TR	.187*	.123	-.023	-.031	.049	-.039	**NA**										
PINT	-.079	.333**	.115	-.077	.156	.158	-.208*	**.810**									
CON	-.059	.241**	.045	.211**	.034	-.112	-.030	.139	**.50**								
PSEC	.074	.456**	.141	.079	-.035	.061	-.008	.252**	.128	**.430**							
PU	.126	.055	.073	-.007	.060	.012	.196*	.052	-.059	.094	**.906**						
PEOU	.014	.146	-.005	.067	.051	.027	.021	.125	.135	.097	.655**	**.800**					
CPL	-.015	. 293**	.054	.001	-.025	.040	-.100	.480**	.231**	.323**	.041	.169*	**.567**				
OLA	-.048	.243**	.026	-.165*	.069	.170*	-.064	.054	.042	.080	.134	.227**	.088	**.770**			
OLP	.027	.194*	.024	-.015	-.002	.139	-.018	.129	.110	.131	.200*	.298**	.201*	.564**	**.794**		
OLR	.113	.121	.127	-.004	-.103	.065	.187*	-.035	-.004	.133	.242**	.260**	.097	.471**	.706**	**.828**	
OLM	-.048	.380**	-.011	-.015	-.083	.014	.061	.146	.117	.207*	.158	.260**	.248**	.590**	.644**	.692**	**.844**

Note: KSS – Knowledge Structure Similarity, PTM- Pre-training Motivation, ERPX- ERP experience, GPA – Grade Point Average, GEN- Gender, RE/TR- Mental rehearsal/Treatment, PINT- Personal Innovativeness, CON- Conscientiousness, PSEC- Pre-training Self-efficacy, PU- Perceived Usefulness, PEOU- Perceived Ease of Use, CPL- Computer Playfulness, OLA- Attention , OLR- Retention, OLP- Production, OLM-Motivation ,Gender (GNDR) was coded as 1-Male 0-Female

Table 9

Discriminant validity and loadings

		OLA	OLR	OLM	OLP	CPL	PEOU	CON	PINT	PTM	PU	PSEC	GEN	ERPX	GPA	TRT	AGE
OLA	OLA1	**.87**	.50	.60	.46	.20	.21	.15	.19	.30	.14	.17	.14	-.02	.02	-.11	.09
	OLA2	**.84**	.33	.42	.27	.03	.14	.17	.05	.20	.01	.06	.15	.00	.00	-.09	.15
	OLA3	**.91**	.49	.50	.41	.09	.23	.07	.20	.17	.18	.16	.20	.03	-.03	-.08	.05
	OLA4	**.90**	.57	.56	.53	.06	.24	.09	.06	.20	.16	.10	.12	.08	-.02	.05	-.03
OLR	OLR1	.51	**.84**	.57	.62	.28	.37	.07	.15	.25	.22	.15	.16	.00	.01	.07	-.01
	OLR2	.43	**.90**	.53	.75	.14	.34	.01	.05	.11	.29	.16	.08	.07	.07	.26	-.04
	OLR3	.51	**.93**	.58	.73	.19	.27	.08	.14	.13	.27	.21	.09	.06	-.03	.14	.00
	OLR4	.52	**.90**	.64	.74	.19	.27	.12	.14	.14	.21	.23	.05	.05	-.02	.03	-.02
OLM	OLM1	.62	.63	**.91**	.67	.28	.26	.28	.21	.39	.17	.32	.03	.03	.06	.09	-.05
	OLM2	.52	.61	**.93**	.66	.30	.22	.24	.22	.31	.12	.30	.00	.01	.09	.04	-.13
	OLM3	.55	.59	**.92**	.62	.23	.28	.16	.20	.35	.18	.22	.03	-.04	.02	.07	-.12
	OLM4	.50	.55	**.90**	.59	.28	.23	.11	.22	.34	.14	.20	-.01	-.05	.11	.01	.00
OLP	OLP1	.42	.72	.63	**.90**	.21	.24	.09	.02	.14	.19	.14	.06	.11	-.01	.09	-.11
	OLP2	.39	.74	.56	**.88**	.12	.29	-.03	-.01	.06	.29	.06	.10	.10	.08	.23	-.11
	OLP3	.49	.75	.65	**.94**	.11	.23	.12	.02	.13	.23	.18	.06	.09	.07	.22	-.06
	OLP4	.48	.68	.69	**.91**	.12	.21	.12	.06	.12	.16	.25	.02	.17	.09	.13	-.10
CPL	CPL1	.02	.03	.04	-.07	**.53**	.03	.05	.33	.20	-.05	.12	-.04	-.01	-.33	-.15	.00
	CPL2	.06	.12	.23	.05	**.84**	.04	.16	.37	.23	-.05	.16	.03	.03	-.21	-.09	-.10
	CPL3	.09	.16	.26	.08	**.85**	.12	.33	.49	.40	.00	.35	.03	.11	-.12	-.10	.10
	CPL4	.08	.14	.24	.08	**.88**	.21	.28	.51	.26	.07	.26	-.01	.04	-.21	-.11	.03
	CPL5_R	.05	.07	.09	-.02	**.64**	.22	.28	.45	.23	.13	.32	.09	.00	-.14	-.12	.05
	CPL6	.06	.15	.14	.12	**.61**	.12	.19	.12	.00	.04	-.05	.04	.05	-.12	.03	-.13
	CPL7	.17	.32	.33	.30	**.84**	.17	.19	.37	.22	.08	.18	.07	.07	-.11	.03	-.08
PEOU	PEOU1	.24	.37	.31	.28	.17	**.92**	.12	.15	.19	.70	.10	.06	.01	-.02	.10	.01
	PEOU2	.17	.28	.19	.21	.11	**.91**	.08	.09	.13	.60	.14	.00	.01	-.05	-.06	.05
	PEOU3	.17	.24	.19	.23	.16	**.91**	.17	.10	.11	.65	.10	-.02	.02	-.03	.08	.07
	PEOU4	.24	.31	.24	.22	.16	**.84**	.03	.16	.11	.42	.16	.05	-.05	-.14	-.03	.04

Table 9

Discriminant validity and loadings (cont.)

		OLA	OLR	OLM	OLP	CPL	PEOU	CON	PINT	PTM	PU	PSEC	GEN	ERPX	GPA	TRT	AGE
CON	CON1	.05	.11	.16	.07	.28	.04	**.76**	.06	.14	-.17	.09	-.07	.07	-.04	-.07	-.02
	CON2	.10	.12	.16	.04	.25	.06	**.73**	.25	.28	-.08	.26	-.15	.10	.13	.01	.12
	CON3	.03	-.04	.08	-.01	.19	.05	**.69**	.16	.22	-.08	.05	-.01	.07	.09	-.05	-.02
	CON4	.07	.03	.17	.08	.27	.12	**.82**	.07	.32	-.09	.24	-.07	.01	.05	.03	-.03
	CON5	.11	-.01	.16	.05	.20	.11	**.78**	.01	.24	-.10	.18	-.05	.06	-.01	.03	-.12
PINT	PINT1	.18	.13	.25	.03	.50	.12	.14	**.94**	.36	.01	.25	.11	.09	-.04	-.24	.13
	PINT3	.00	-.02	.05	-.06	.37	.01	.05	**.81**	.17	.03	.11	.19	.15	.01	-.23	.12
	PINT4	.13	.15	.22	.04	.44	.19	.08	**.94**	.37	.14	.23	.15	.10	.00	-.17	.14
PTM	PTM1	.25	.19	.36	.14	.30	.13	.20	.38	**.94**	.07	.45	.01	.00	.04	.16	.21
	PTM2	.25	.21	.38	.15	.30	.17	.20	.45	**.95**	.07	.47	.05	-.04	.03	.14	.19
	PTM3	.23	.11	.35	.09	.24	.16	.39	.19	**.86**	.04	.38	.07	-.10	.02	.04	.16
	PTM4	.18	.12	.30	.07	.26	.10	.26	.35	**.92**	.04	.43	.02	-.08	.12	.10	.18
PU	PU1	.09	.25	.10	.21	.04	**.62**	-.10	.04	.03	**.92**	.15	-.02	.10	.07	.23	.03
	PU2	.17	.31	.16	.27	.07	**.65**	-.11	.03	.04	**.96**	.15	.01	.03	.07	.17	.07
	PU3	.12	.25	.15	.21	.02	**.64**	-.15	.07	.05	**.97**	.09	.02	.05	.07	.18	.06
	PU4	.18	.24	.19	.21	.04	**.64**	-.10	.10	.10	**.96**	.12	.04	.10	.05	.16	.06

Note: KSS – Knowledge Structure Similarity, PTM- Pre-training Motivation, ERPX- ERP experience, GPA – Grade Point Average, GEN- Gender, RE/TR- Mental rehearsal/Treatment, PINT- Personal Innovativeness, CON- Conscientiousness, PSEC- Pre-training Self-efficacy, PU- Perceived Usefulness, PEOU- Perceived Ease of Use, CPL- Computer Playfulness, OLA- Attention , OLR- Retention, OLP- Production, OLM-Motivation ,Gender (GNDR) was coded as 1-Male 0-Female

Table 9

Discriminant validity and loadings (cont.)

		OLA	OLR	OLM	OLP	CPL	PEOU	CON	PINT	PTM	PU	PSEC	GEN	ERPX	GPA	TRT	AGE
PSEC	PSEC3	.10	.15	.21	.18	.19	.09	.06	.18	.32	.12	**.73**	.07	.16	-.14	.04	-.01
	PSEC4	-.12	-.07	.00	.01	.18	-.02	.12	.04	.27	-.03	**.54**	.02	.13	-.15	-.03	-.09
	PSEC5	.20	.18	.22	.15	.21	.10	.19	.28	.35	.04	**.70**	.08	.05	-.18	-.04	.04
	PSEC6	.15	.22	.24	.15	.16	.11	.19	.13	.35	.09	**.81**	.08	.07	-.03	-.04	.08
	PSEC7	.02	.04	.01	.01	.36	.03	.20	.23	.25	-.01	**.48**	.11	.05	-.21	-.01	.01
	PSEC8	.09	.14	.20	.07	.24	.11	.21	.18	.37	.11	**.72**	.05	.06	-.07	.05	-.04
	PSEC9	-.11	.01	.14	.03	.09	.07	.08	.07	.26	.14	**.54**	-.18	-.04	.12	.18	-.02
GEN	Gender	.17	.11	.01	.06	.04	.03	-.08	.15	.04	.02	.05	1.00	.05	-.12	-.04	-.06
ERPX	Experience With ERP	.03	.05	-.01	.13	.07	.00	.08	.11	-.06	.07	.10	.05	1.00	-.01	-.02	-.09
GPA	GPA	-.01	.01	.07	.06	-.19	-.06	.07	-.02	.06	.07	-.10	-.12	-.01	1.00	.26	.25
RE/TR	Treatment	-.06	.14	.06	.18	-.07	.03	-.03	-.22	.12	.19	.03	-.04	-.02	.26	1.00	.05
AGE	Age	.06	-.02	-.08	-.10	-.03	.05	-.02	.15	.20	.06	.02	-.06	-.09	.25	.05	1.00

Note: PTM- Pre-training Motivation, ERPX- ERP experience, GPA – Grade Point Average, GEN- Gender, RE/TR- Mental rehearsal/Treatment, PINT- Personal Innovativeness, CON- Conscientiousness, PSEC- Pre-training Self-efficacy, PU- Perceived Usefulness, PEOU- Perceived Ease of Use, CPL- Computer Playfulness, OLA- Attention, OLR- Retention, OLP- Production, OLM- Motivation. Gender (GNDR) was coded as 1-Male 0-Female

Structural model. Since individual characteristics of trainees were collected in a pre-training survey and outcomes were collected after training, CMV should not be a major concern in this study. However, since the common method (i.e., survey) was used to gather variables, common method bias was tested. Harmon's one-factor analysis in SPSS (Podsakoff, MacKenzie, & Podsakoff, 2003) was conducted to test for CMV. The single factor explained 21.1% of the variance as shown in Table 10. If CMV is a major concern, then a single factor explaining the majority of variance should emerge (Podsakoff & Organ, 1986). All the variables in the model were forced to load on a single factor, and variance explained by the single factor remained 21.1% indicating that CMV was not a major concern in this study.

Table 10
Common Method Bias Harman's Test

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.89	21.61	**21.61**	11.89	**21.61**	21.61

An additional CMV analysis following Liang, Saraf, Hu, & Xue (2007) was conducted to follow up. In this method, a method factor is created with all indicators that are employed in the model. This method factor is then loaded on to constructs in the model. For a specific indicator, the variance explained by its substantive factor is compared with that explained by a latent/common method factor. If the variance explained by the method factor is substantial, then it indicates a problem with CMV. The results of this test are found in Appendix E. As Appendix E shows, CMV was not a threat to this study as variance explained by the method factor is substantially lower compared to the substantive construct. Results of the PLS model are present in Table 11.

Table 11
Model Results

Path	Direct	Indirect	Total
Attention → Retention	.56***		.56***
Attention → Production		.44***	.44***
Attention → Motivation	.29***	.26***	.55***
Retention → Production	.75***		.75***
Retention → Motivation	.08	.34***	.41***
Production → Motivation	.45***		.45***
Rehearsal → Retention	.17**		.17**
Computer Playfulness → Motivation	.08		.08
ERP Experience→ Motivation	-.10		-.10
Business Process Experience→ Motivation	-.077		-.077
Gender → Motivation	-.09		-.09
Conscientiousness → Motivation	.03		.03
Perceived Ease of Use → Motivation	.04		.04
Perceived Usefulness → Motivation	-.04		-.04
Personal Innovativeness → Motivation	.09		.09
Pre-training Motivation→	.17*		.17*
Pre-training Self-efficacy → Motivation	.05		.05
Age → Motivation	-.13		-.13
Rehearsal→ Motivation		.07*	.07*
Rehearsal→ Production		.13*	.13*

* $p < .05$. ** $p < .01$. *** $p < .001$.

Based on the above results and Figure 4, all relationships hypothesized between OL processes are supported except H7 i.e. the retention process does not have a significant impact on the motivation process.

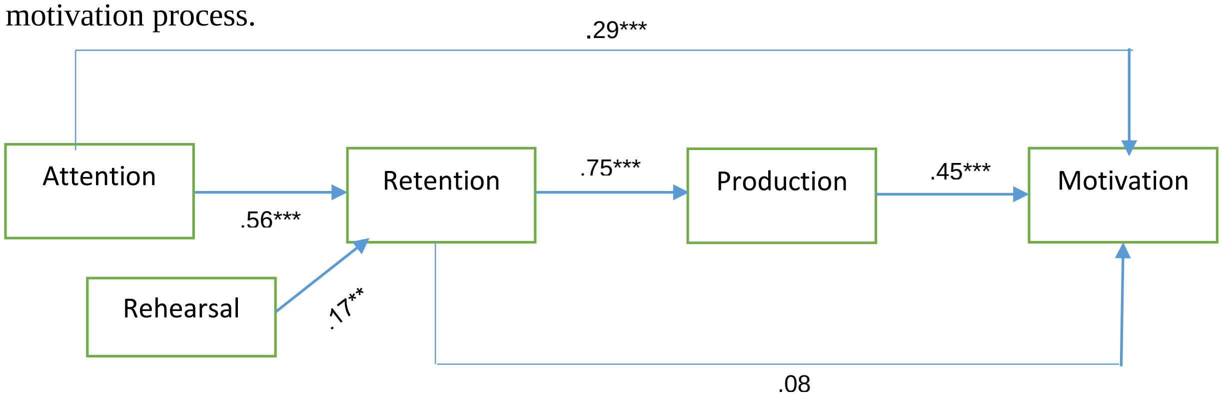


Figure 4. *Nomological model with values*

Results pertaining to the impact of the training intervention. In the previous section, results of the OL model were detailed. In this section, hypotheses related to the effectiveness of training intervention (i.e., from H11 to H17) are discussed. Effectiveness of training was measured by the following variables: (1) knowledge structure similarity (KSS) – The index ranging 0 to 1 and is measured with reference to the experts' knowledge structures; (2) score on ERP quiz; (3) self-assessed business process knowledge (4) self-assessed integration knowledge; (5) simulation experience; (6) post-training self-efficacy; and (7) self-assessed transaction knowledge. Descriptive statistics for outcomes across the groups are shown in Table 12.

Table 12.
Descriptive statistics for Outcomes across two groups

Outcome variable	Treatment	N	Mean	Std. Deviation	Std. Error Mean
Simulation Experience	1	75	5.80	.92	.11
	0	75	5.48	1.26	.14
Post-training Self-efficacy	1	75	6.21	2.24	.26
	0	75	5.83	2.41	.28
KSS	1	75	.21	.09	.01
	0	75	.18	.06	.01
ERP Quiz	1	75	.80	.13	.01
	0	75	.64	.11	.01
Business Process Knowledge	1	75	5.46	.77	.09
	0	75	5.00	.95	.11
Integration Knowledge	1	75	5.46	1.14	.13
	0	75	5.2	1.07	.12
Transaction Knowledge	1	75	5.06	1.09	.13
	0	75	5.04	1.19	.14

To find out if differences were significant across the two groups, a t-test was conducted. Table 13 show the result of the test.

Table 13

T-test Results

Outcome	t statistic	df
Simulation Experience	1.83	148
Post-training self-efficacy	1.01	148
KSS	2.31**	148
ERP Quiz	7.82***	148
Business Process Knowledge	3.19***	148
Integration Knowledge	2.02*	148
Transaction Knowledge	0.11	148

* $p < .05$. ** $p < .01$. *** $p < .001$.

As can be seen from Tables 12 and 13, there is a significant difference between the two groups in terms of integration knowledge, business process knowledge (BPK), KSS, and ERP quiz scores. However, post-training self-efficacy, simulation experience, and transaction knowledge was not different between the two groups. To further test the impact of training while controlling individual characteristics of the trainee, an ANCOVA was performed. The study controlled for individual differences such as age, gender, previous ERP experience, previous business process experience, computer playfulness, personal innovativeness, pre-training self-efficacy, pre-training motivation, GPA, TAM variables, and conscientiousness. Correlations between variables employed in the ANOVA are shown in Table 14[2]. Test of equality of variances among various training outcomes across two groups is shown in Table 15.

[2] **Note:** SIMX-> Simulation experience, KSS – Knowledge Structure Similarity, PTM- Pre-training Motivation, ERPX- ERP experience, BPX→ Business Process Experience, GPA – Grade Point Average, Age→, ERPQ→ERP Quiz, GEN- Gender, RE/TR- Mental rehearsal/Treatment, INTK-→ Integration knowledge, BPK→ Business Process Knowledge, SEC→ Post-training self-efficacy, PINT- Personal Innovativeness, CON- Conscientiousness, PSEC- Pre-training Self-efficacy, PU- Perceived Usefulness, PEOU- Perceived Ease of Use, CPL- Computer Playfulness, (GEN) was coded as 1-Male 0-Female

Table 14

Correlation among ANCOVA variables

	SIMX	KSS	PTM	ERPX	BPX	GPA	Age	ERPQ	GEN	RE/TR	INTK	BPK	SEC	PINT	GLO	PSEC	PU	PEOU	CPL
SIMX	1.00																		
KSS	.16*	1.00																	
PTM	.16	.03	1.00																
ERPX	-.04	.07	-.06	1.00															
BPX	.04	-.02	-.08	.19*	1.00														
GPA	.01	.12	.03	.03	.03	1.00													
Age	.03	.05	.20*	-.09	-.05	-.07	1.00												
ERPQ	.23**	.08	.14	-.01	-.03	-.05	.00	1.00											
GEN	-.02	-.199*	.04	.05	.19*	-.12	-.06	.05	1.00										
RE/TR	.15	.19*	.12	-.02	-.05	-.03	.05	.54**	-.04	1.00									
INTK	.12	.12	.04	-.01	-.07	.14	.03	.07	-.14	.16*	1.00								
BPK	.56**	.07	.16	.10	.03	.05	-.24**	.32**	.01	.25**	.01	1.00							
SEC	.33**	.11	.10	.18*	-.09	-.06	.05	.15	.03	.08	.03	.35**	1.00						
PINT	.09	-.08	.33**	.12	.13	-.08	.16	-.08	.16	-.21*	.06	-.01	.03	1.00					
GLO	.01	-.06	.24**	.05	.01	.21**	.03	.05	-.11	-.03	-.05	-.01	.08	.14	1.00				
PSEC	.15	.07	.46**	.14	.05	.08	-.04	-.02	.06	-.01	-.04	.18*	.25**	.25**	.13	1.00			
PU	.78**	.13	.06	.07	.05	-.01	.06	.18*	.01	.20*	.05	.38**	.39**	.05	-.06	.09	1.00		
PEOU	.70**	.01	.15	-.01	.03	.07	.05	.11	.03	.02	.05	.46**	.25**	.13	.14	.10	.65**	1.00	
CPL	.11	-.02	.30**	.05	.06	.00	-.03	.01	.04	-.10	.03	.13	.18*	.48**	.23**	.32**	.04	.17*	1.00

* $p < .05$. ** $p < .01$. *** $p < .001$.

ANCOVA's homogeneity of variances assumption was met for all outcomes as can be seen in Table 15. The normality assumption of ANCOVA was violated, but given the balanced cell sizes and sample size (n>30), it is not a threat to the study. ANCOVA is robust against deviation from non-normality (Benson, & Fleishman, 1994; Hair, Anderson, Tatham, & William, 1998; Neter, Wasserman, & Kutner, 1985). Table 16 shows the result of the ANCOVA analyses.

Table 15
Levene's test for equality of variances

Levene's Test of Equality of Error Variances				
	F	df1	df2	Sig.
ERP Quiz	.00	1	148	.95
KSS	1.69	1	148	.20
Simulation Experience	.07	1	148	.79
Integration knowledge	1.15	1	148	.29
Business process knowledge	3.77	1	148	.05
Post-training Self-efficacy	1.12	1	148	.29
Transaction knowledge	.10	1	148	.76

Table 16

Analysis of Covariance

Source	SS	df	MS	F	SS	df	MS	F	SS	df	MS	F
	Business Process Knowledge				KSS				Post-training Self-efficacy			
Age	7.94	1	7.94	14.81**	.003	1	.00	.50	2.72	1	2.72	.63
Gender	.20	1	.20	.38	.028	1	.03	4.76*	.08	1	.08	.02
Personal Innovativeness	.20	1	.20	.37	.001	1	.00	.12	8.17	1	8.17	1.88
Business Process Experience	.01	1	.01	.01	.00	1	.00	.00	14.46	1	14.46	3.33
GPA	.03	1	.03	.06	.015	1	.01	2.54	6.81	1	6.81	1.57
Conscientiousness	1.08	1	1.08	2.01	.010	1	.01	1.69	5.50	1	5.50	1.27
Pre training Self-Efficacy	.38	1	.38	.70	.003	1	.00	.52	22.78	1	22.78	5.25*
ERP experience	.67	1	.67	1.24	.003	1	.00	.57	17.82	1	17.82	4.10*
Computer Playfulness	.33	1	.33	.61	.000	1	.00	.04	13.61	1	13.61	3.13
Pre-training Motivation	1.05	1	1.05	1.96	.00	1	.00	.00	.89	1	.89	.20
Perceived Usefulness	.19	1	.19	.35	.001	1	.00	.14	61.98	1	61.98	14.27**
Perceived Ease of Use	10.58	1	10.58	19.74**	.004	1	.00	.63	.58	1	.58	.13
Treatment/Rehearsal	5.27	1	5.27	9.83**	.026	1	.03	4.42*	.01	1	.01	.00
Error	72.89	136	.54		.797	136	.01		590.48	136	4.34	
Total	119.05	150			6.704	150			806.22	150		

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 16
Analysis of Covariance (cont.)

Source	SS	Df	MS	F	SS	df	MS	F	SS	Df	MS	F
	Integration Knowledge				ERP Quiz				Simulation Experience			
Age	.02	1	.02	.01	.01	1	.01	.47	.24	1	.24	.59
Gender	4.90	1	4.90	4.03*	.01	1	.01	.62	.17	1	.17	.42
Personal Innovativeness	3.31	1	3.31	2.73	.00	1	.00	.09	.00	1	.00	.01
Business Process Experience	.49	1	.49	.40	.00	1	.00	.04	.15	1	.15	.37
GPA	5.68	1	5.68	4.68*	.01	1	.01	.39	.02	1	.02	.05
Conscientiousness	2.46	1	2.46	2.03	.01	1	.01	.51	.07	1	.07	.18
Pre training Self-Efficacy	1.12	1	1.12	.92	.02	1	.02	1.01	.34	1	.34	.85
ERP experience	.00	1	.00	.00	.00	1	.00	.05	1.40	1	1.40	3.48
Computer Playfulness	.09	1	.09	.08	.00	1	.00	.29	.01	1	.01	.03
Pre-training Motivation	.04	1	.04	.04	.02	1	.02	1.16	.40	1	.40	1.00
Perceived Usefulness	.07	1	.07	.06	.00	1	.00	.21	29.99	1	29.99	74.55***
Perceived Ease of Use	.24	1	.24	.20	.01	1	.01	.37	9.51	1	9.51	23.64***
Treatment/Rehearsal	6.53	1	6.53	5.37*	.70	1	.70	45.96***	.10	1	.10	.25
Error	165.18	136	1.21		Error	2.08	136	.02	54.71	136	.40	
Total	185.50	150			Total	3.07	150		183.26	150		

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 16
Analysis of Covariance (cont.)

Source	SS	df	MS	F
	Transaction Knowledge			
Age	1.99	1	1.99	2.14
Gender	.11	1	.11	.12
Personal Innovativeness	.03	1	.03	.03
Business Process Experience	.04	1	.04	.04
GPA	1.68	1	1.68	1.81
Conscientiousness	.71	1	.71	.77
Pre training Self-Efficacy	.03	1	.03	.03
ERP experience	.20	1	.20	.21
Computer Playfulness	1.04	1	1.04	1.12
Pre-training Motivation	.48	1	.48	.51
Perceived Usefulness	1.82	1	1.82	1.95
Perceived Ease of Use	20.59	1	20.59**	22.07
Treatment/Rehearsal	.13	1	.13	.13
Error	126.87	136	.93	
Total	193.69	150		

* $p < .05$. ** $p < .01$. *** $p < .001$.

ANCOVA results indicate that hypotheses H11, H13, H14, and H17 were supported, as the treatment had a significant impact on KSS, integration knowledge, business process knowledge, and the ERP quiz. H15, H16, and H18 were not supported. To further understand how the training intervention impacted trainees' knowledge structures; the similarity of experts' knowledge structures (i.e., the referent) with the knowledge structures obtained from the average training-group-network and the average control-group-network was calculated. Results are shown in Table 17[3].

---

[3]C – Common links
C-E[C]: C minus the C expected by chance
Similarity (S): C / (Links in network1 + Links in network 2 – C)
S-E[S]: S minus S expected by chance
P(C or more): probability of C or more links in common by chance

Table 17
Comparison of expert referent and two groups knowledge structure similarity

	Common links	**C-E[C]**	**Similarity**	**S-E[S]**	**P(C or more)**
Expert referent - Control Group	5.00	3.00	.31	.20	.02
Expert referent - Intervention Group	7.00	5.00	.50	.39	.00

As we can see from Table 17, the experts' knowledge structures shared more commonality with the intervention group (similarity score = .50) as compared to the control group (similarity score 104
= .31). The metric S-E[S] in the pathfinder output indicates what the similarity score would have been between two networks based on chance. Another metric, P(C or more), indicates whether the observed similarity between a focal network pair and the expected similarity between the same pair by chance is significantly different. Based on Table 17, any similarity (i.e. KSS value) observed between the two groups and the expert referent is due to the training provided. These scores were derived by comparing experts' knowledge structures with knowledge structures obtained from a mean network in respective groups (i.e. control and intervention)[4]

Although the magnitude of similarity score for intervention group is greater than the control group, one cannot statistically determine which group benefitted more from training. This is because, for both network pairs (i.e. *intervention-expert*, *control-expert*), the similarity (KSS value) is significantly different from what it would have been by pure chance. To further understand this result, each trainee's network of knowledge structures was compared with the referent. This comparison resulted in knowledge structure similarity (KSS) for each individual in the study. The average of KSS in the intervention ground (KSS=.21) was significantly higher (t =

[4] Pathfinder software allows to average proximity files. Proximity files for each group were averaged, and pathfinder network derived from this mean proximity file was compared to the pathfinder network derived from the proximity file of the expert reference. R statistical software was used for data manipulation. Appendix J gives the codes used to derive proximity files from raw data. These are used as input for pathfinder software.

2.31, $p < 0.05$) than the control group (KSS=.18) as seen in Table 13. This supports hypothesis H12. Details of each trainee's KSS can be found in Appendix F. Table 18 below shows the snapshot of results.

Table 18
Results of analyses

Hypothesis	Result
H1	Supported
H2	Supported
H3	Supported
H4	Supported
H5	Supported
H6	Supported
H7	Not supported
H8	Supported
H9	Supported
H10	Supported
H11	Supported
H12	Supported
H13	Supported
H14	Supported
H15	Not supported
H16	Not supported
H17	Supported
H18	Not supported

Discussion

The purpose of this research was to develop a nomological model of observational learning (OL) by establishing relationships among various OL processes (i.e., *attention, retention, production, and motivation*) as put forward by Bandura's SCT. This study also answers the recent calls in IS literature to develop effective training methods for technology training (Alavi, & Leidner, 2001; Gupta & Bostrom, 2013). It examined OL processes in an enactive learning context. Hypothesized relationships in the nomological OL model were supported, except that retention did not significantly impact motivation in observational learning.

Prior work has shown that the act of retention facilitates the formation of symbolic codes, which not only act as the basis of production but also have been shown to impact the motivation of trainees. Research on schemas in the psychological literature (Baumeister & Newman, 1994; Bluck & Habermas 2000) has shown that mental structures formed through learning and life experience potentially direct the motivation of a person. Mental structures produced by training under certain motivational conditions (Siegel, 1997) are likely to direct similar motivational states in the future. Retentive cues formed from life experience have been shown to motivate the person to exercise the behavior during which these cues were formed. Thus, a trainee learning and retaining cues from a motivated model's behavior would be motivated to perform the behavior. However, this was not supported in this study. The underlying reason for this may possibly be related to the length the study. The study was conducted within a timeframe of an academic semester. The length of the study may not have been adequate to form cues that impact motivation without the need for practicing learned behavior.

This study was also concerned with implementing symbolic rehearsal in an ERP simulation setting, and examining the impact of rehearsal treatment on training outcomes. Results show that rehearsal is effective when the training context contains both vicarious and enactive components. The treatment group performed better in terms of business process knowledge, integration knowledge, ERP quiz, and knowledge structure similarity (KSS) as a result of the treatment. The training intervention did not have a significant impact on simulation experience, transaction knowledge, and post-training self-efficacy. As seen from Table 16, these outcomes (i.e. simulation experience, transaction knowledge, and post-training self-efficacy) were driven by TAM variables. Overall, results indicated the effectiveness of rehearsal intervention in an enactive training context like ERP simulation. While not all outcomes were enhanced by training intervention, the outcomes most important to enterprise system training (Cronan et al., 2011, Cronan & Douglas, 2012) such as business process knowledge and integration knowledge are enhanced significantly compared to the control group. Administrators and training professionals can consider opting for retention enhancement add-on to the ERPsim training to improve relevant outcomes.

As the two groups differed in terms of training outcomes, a posthoc analysis of observation learning processes, across two groups was conducted. Table 19, and Figure 5 display the results for the intervention group. Table 20, and Figure 6 displays results for the control group. There were some key differences between the two sets of results as discussed.

Table 19
Intervention Group

	Direct	Indirect	Total
Attention → Retention	.60***		.60***
Attention → Production		.30***	.51***
Attention → Motivation	.42***	.29**	.71***
Retention → Production	.50***		.50***
Retention → Motivation	.11	.22**	.33**
Production → Motivation	.44***		.44***
R-square	.68		

* $p < .05$. ** $p < .01$. *** $p < .001$.

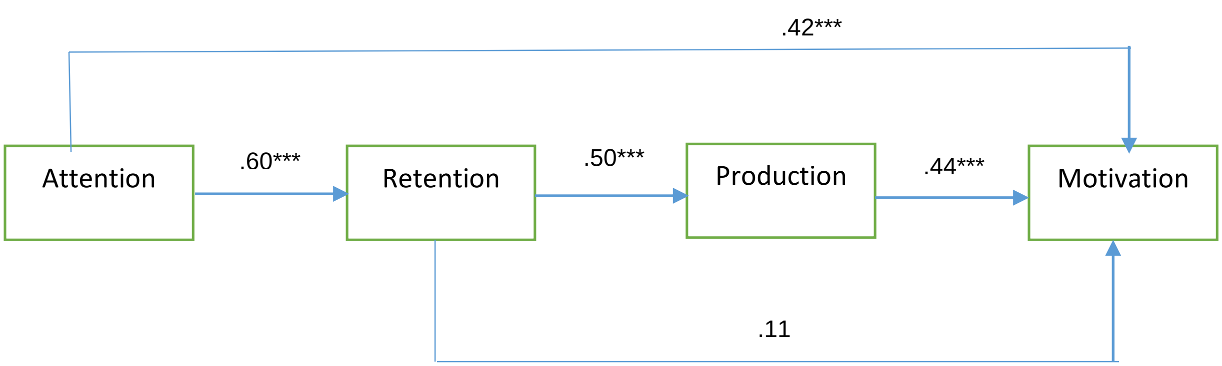


Figure 5. *Intervention group*

Table 20
Control group

	Direct	Indirect	Total
Attention → Retention	.53**		.53**
Attention → Production		.52**	.52**
Attention → Motivation	0.20	.30**	.50**
Retention → Production	0.97***		.97***
Retention → Motivation	0.16	0.41	0.57**
Production → Motivation	0.42		0.42
R-square	.49		

* *p* < .05. ** *p* < .01. *** *p* <.001.

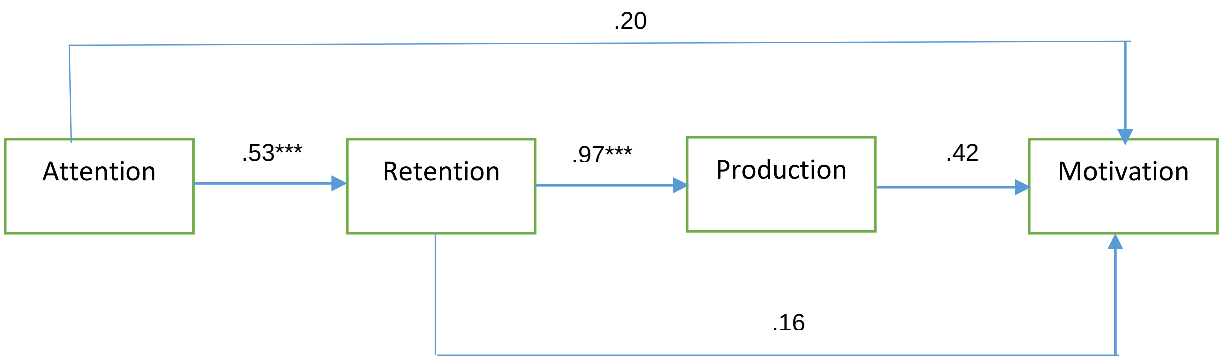


Figure 6. Control group

One of the most important differences was that there was no significant impact of the production process on the motivation process in the control group (production→motivation = .42, p = .58) whereas this path was highly significant in the intervention group (production→motivation = .44, p < 0.001). Production process also mediated the effect of the retentive process in the intervention group (retention→production→motivation = .22, p <0.01), but this path was not significant in the control group (retention→production→motivation = .41, n.s.) This indicates that even though the control group had additional opportunity to practice (while intervention group engaged in mental rehearsal), this practice had no impact on the motivation of the group to master the material. Further, the attention process significantly impacted the motivation process in the intervention group (attention → motivation = .42, p<.001) but did not in have the same effect in the control group (attention → motivation = .20, n.s). Explained variance in the case of the intervention was 68%, and in the control group was 49%. The classes were randomly assigned to the treatment, pre-training differences were controlled, and beginning education level of all students was the same (i.e., junior level). Thus, mental rehearsal aided the retentive process of OL such that it motivated trainees to perform the desired behavior as evidenced by the difference in the variance explained between the two groups.

Considering these results together indicated that OL processes led to a higher degree of motivation in the treatment group. It also indicated that in the intervention group, the attention process had a significant direct impact on the motivation process, while this effect was entirely indirect in the case of the control group. It indicates that augmenting practice with mental rehearsal was more effective in enhancing motivation than practice alone. The control group had more practice opportunities while the intervention group engaged in mental rehearsal, but the production process did not help in transferring the impact of the retentive process to the motivation process. It also indicated that mental rehearsal reduced dependency on enactive practice. On the other hand, in the intervention group the retentive process had an indirect positive impact on the motivation process via the production process. Posthoc analyses showed that mental rehearsal was applicable in a real-life enactive context like ERP training using a simulation. It also showed that observation learning was applicable to both groups, but the intervention group benefited more as the intervention enhanced key learning processes. However, more research in a variety of different learning contexts is needed before establishing this notion. Future research can look into this topic. Analysis on saturated OL model was conducted to investigate whether the paths not hypothesized in the nomological model were significant. Further details on the saturated model can be found in Appendix K.

Theoretical Contributions

This research makes several important contributions to the literature. First, to my knowledge, this study is one of the first studies to explore the efficacy of theory-based training interventions in a vicarious and enactive learning context such as ERPsim. It extends previous training literature (Bandura, 1986; Renkl, 2014) by operationalizing and testing observational learning processes in accordance with the SCT theory, and augments recent IS training literature (Davis & Yi, 2004; Yi & Davis, 2003).

Second, it examines social cognitive theory's (SCT) underpinnings by integrating literature on the theory of mind (ToM) and mirror neurons. Training professionals and researchers who employ SCT to design technology-based training may want to consider designing training interventions in accordance with the tenets of ToM. Humans innately attend to observational learning under the right circumstances.

Finally, this research shows the efficacy of mental rehearsal in enactive and real-life settings such as ERPsim. The findings of this research are also relevant to other enactive training settings where training can be made more effective by including mental rehearsal. For example, there is a heavy emphasis on "hands-on learning and exploration of systems" in teaching basic computer science concepts via MOOCS (Klawe, 2015).

In all, this study contributes to a better understanding of technology-mediated learning (TML) from a psychological point of view, which would help in the design of effective training programs.

Limitations and Future Research

Like all research, this research also has some limitations. Data in this study were self-reported, and the study was conducted as a part of ERP courses in a business school setting. Given this setting, it may have biased the results as participants may have been keen on learning ERP from the outset. On the other hand, students presented an adequate sample to test the effectiveness of a training intervention as these are future employees. Future research can examine the effectiveness of training on employees in a corporation. Also, this study focused on individual learning and did not control for team learning effects. Given that problem-based enactive learning contexts are heavily used by teams, future research can potentially explore team processes relevant to learning.

The current study considered knowledge structures as the collection of "facts, things or concepts" (Day, Arthur Jr, & Gettman, 2001; Edwards, Day, Arthur Jr, & Bell, 2006; Johnson-Laird, 1983; Rouse & Morris, 1986; Rowe & Cooke, 1995). However, neuroscience literature suggests that knowledge structures or mental schemas are hierarchical structures that encode sequential actions (Botvinik, 2007; Grafton & Hamilton 2007). Langston, Kramer, & Glenberg (1998) point out the nature of mental schemas is "quintessentially semantic". The meaning in schemas is inherent. It implies a sense of hierarchy or sequence among the concepts. Future research can further explore the hierarchical nature of schemas or knowledge structures.

Conclusion

The purpose of this research was to understand OL processes and interrelationships between them as well as to examine the efficacy of a training intervention which combined vicarious learning, enactive learning, and mental rehearsal. Study findings explained observational learning in terms of the theory of mind (ToM). It also suggested the possibility of designing a theory based effective training intervention. Specifically, ERP training interventions which afford mental rehearsal led to better outcomes in terms of business process knowledge and integration knowledge. This finding is of significant importance as the primary goal of ERP training is to make a trainee aware of various business processes as well as their integration. Findings can potentially extend to other enactive training contexts.

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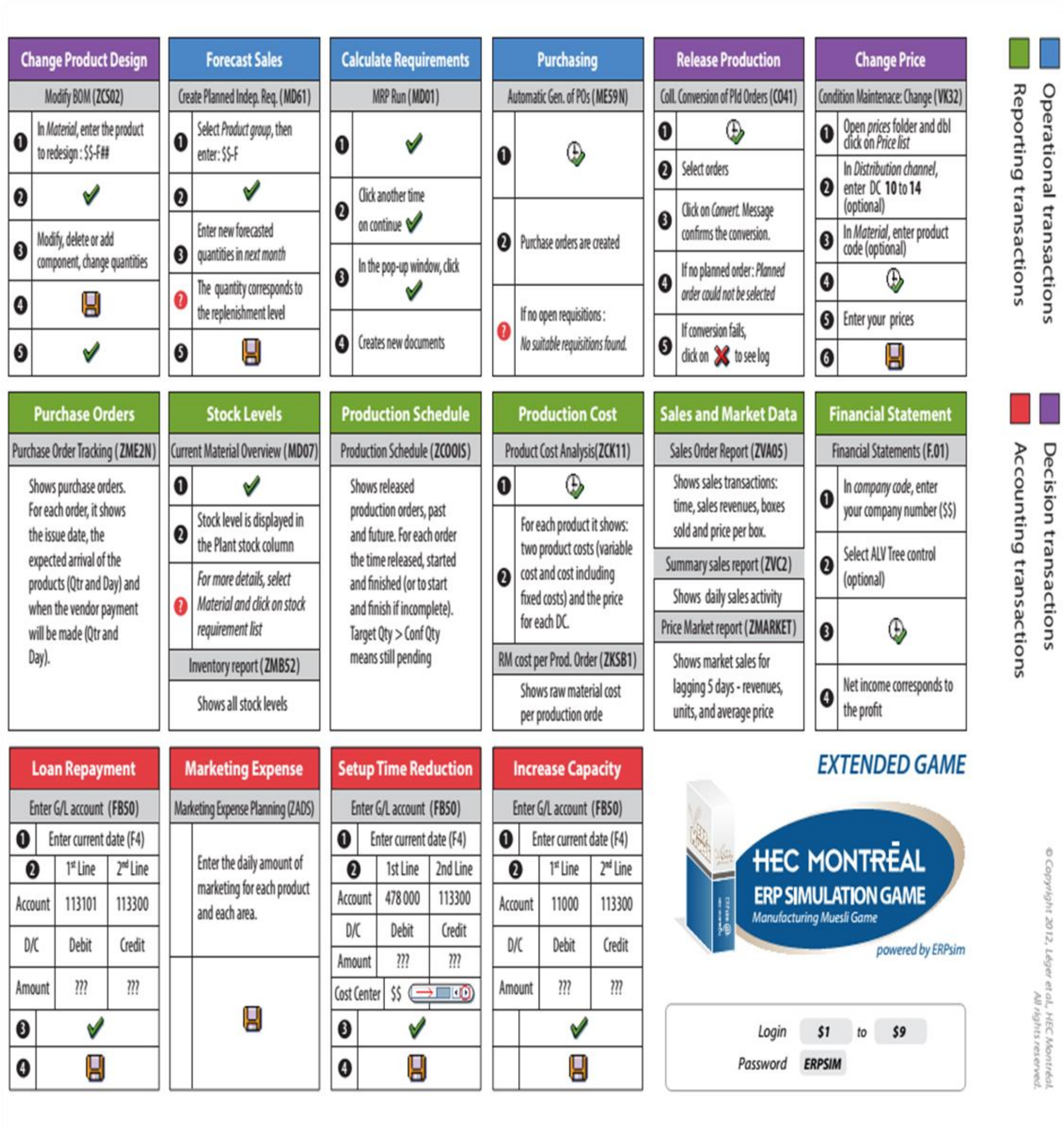
Appendix A- ERPsim Job Aid



Nut - 1 kg	$$-F01
Wheat	40%
Oat	40%
Nuts	20%
Box	1
Bag	1

Blueberry - 1 kg	$$-F02
Wheat	40%
Oat	40%
Blueberries	20%
Box	1
Bag	1

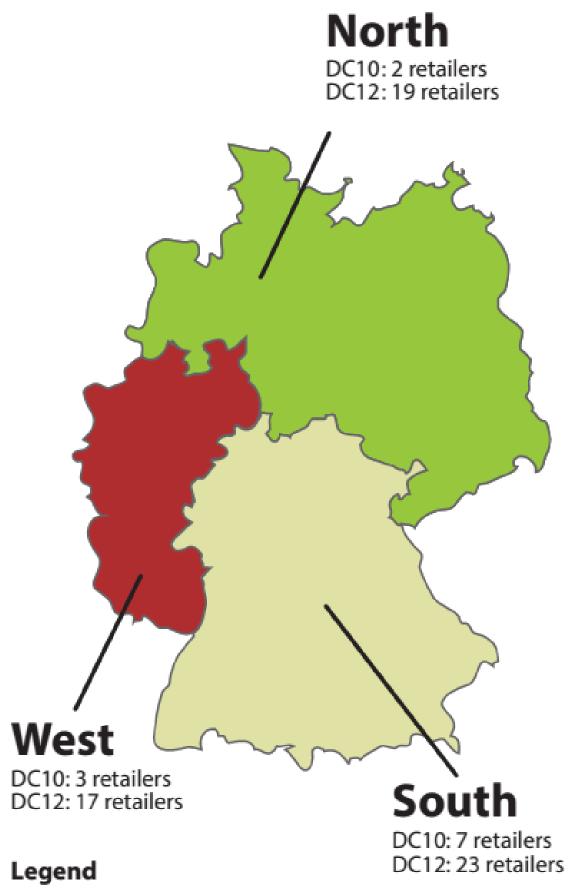
Strawberry - 1 kg	$$-F03
Wheat	40%
Oat	40%
Strawberries	20%
Box	1
Bag	1

Raisin - 1 kg	$$-F04
Wheat	40%
Oat	40%
Raisins	20%
Box	1
Bag	1

Original - 1 kg	$$-F05
Wheat	50%
Oat	50%
Box	1
Bag	1

Mixed - 1 kg	$$-F06
Wheat	35%
Oat	35%
Fruits and nuts*	30%
Box	1
Bag	1

*10% nuts, 5% blueberries, 5% strawberries, 10% raisins



Legend
DC10: Hypermarkets
DC12: Grocery Stores

General information

Customers		
	DC 10	DC 12
Lead time (days)	0	0
Payment time (days)	20	10-15

Suppliers	
Lead time (days)	3-5
Payment time (days)	15

Days / Round
30

Total Market Size
Approx. €80,000 per team per day

Production Capacity
25,000 / day

Appendix B – ERP Videos

Round 1:

1) https://www.youtube.com/watch?v=aqIRT3v9j8k
2) https://www.youtube.com/watch?v=5KMW5VPKpsg
3) https://www.youtube.com/watch?v=g6LPUbN8YY4

Round 2:

1) https://www.youtube.com/watch?v=P0jbd0Zadek

Round 3:

1) https://www.youtube.com/watch?v=r7uXavtT34k

Appendix C- Attention Check Quiz to Ensure Participants Watched Videos

Note that score in this exercise has no impact on any of the test, quizzes in your ERP fundamentals course. This is a part of a two-stage survey for extra credit. Your name, id, and email will be used for survey purposes and shredded thereafter.

Please answer following questions about round 1 and introductory ERPsim videos.

1) How many boxes of each product does each team start with in Round 1?

a) 100,000
b) 2,355
c) 50,674
d) None of the above

2) What currency is being used in the ERP simulation?

a) US dollars
b) Euros

3) How many products can each company have at one time?

a) 6 type of cereals/muesli
b) 5 types of bottled water
c) 4 ready to eat meals
d) None of the above

4) Advertising/marketing is allocated based on:

a) Geographic region (i.e. South/North/West) and a specific product (i.e. type of muesli)
b) Distribution channel
c) Spending power of customers

d) Gross Domestic Product of Germany

Please answer following questions about round 2 ERPsim videos.

1) True or False – Finished Goods Inventory from Round 1 is carried over to Round 2.

   (a) True
   (b) False

2) True or False – A production order is created first and then it is converted to the planned order.

   (a) True
   (b) False

3) In the ERPsim game we have been playing, how many boxes can be produced in one day?

   (a) 25,000
   (b) 10,000
   (c) 24,000
   (d) 27,000

Please answer following questions about round 3 manufacturing ERPsim videos.

1) True or False – ***purchase requisitions*** and ***purchase orders*** are one and the same thing.

   (a) True
   (b) False

2) True or False – ***planned orders*** and ***production orders*** are one and the same thing

   (c) True
   (d) False

3) In the ERPsim game how many days does it take for a supplier to deliver the raw materials to us i.e. what is the lead time?

   (e) 3 to 5 days
   (f) No delay
   (g) 20 days
   (h) 8 days

Appendix D – For ERP Concepts

Table D1

ERP concepts

ID	Concept	Definition/Meaning
1	Sales Order	A document sent to us by the customer when they wish to buy one of our product i.e. a type of a Muesli. This process is automated in ERPsim simulation
2	Production Order	The order that we send to our production line to produce Muesli
3	Planned Production Order	A stage prior to generating a production order, it is a planned document while once it is confirmed/authorized it turns into a production order
4	Purchase Order	An order that we send to our vendors for materials
5	Purchase Requisition	A document produced as a precursor to Purchase Order
6	Materials Requirement Planning (MRP)	Automatic ERP/SAP process of managing inventory based on Independent Demand Forecast and current inventory
7	Invoice (from vendors)	Money we owe to the vendors
8	Independent Demand Forecast	Projection of independent demand by us using ERP/SAP
9	Stock levels (Inventory)	Current stock levels of each product in ERPsim
10	Bill of Materials (BOM)	The structure of the product i.e. the details of constituents which makes a particular type of Muesli
11	Procurement	The process of generating a Purchase Requisition and then a Purchase Order

Appendix E Common Method Bias Analysis

I used Liang et al.'s (2007) unmeasured latent variable technique to assess common method bias. The average variance explained by the method factor was under .01 and that explained by the substantive factor was around .70 (See Table E1). Thus, overall, CMV does not pose a detrimental threat to this study.

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Table E1

Common method bias analysis

	Substantive Factor Loading	Substantive Construct R^2 (approximated as square value of the loading)	Method Factor Loading	Method R^2 (approximated as square value of the loading)
OLA1	1.03	1.06	-0.25	0.06
OLA2	0.91	0.84	-0.01	0.00
OLA3	0.77	0.60	0.13	0.02
OLA4	0.83	0.69	0.10	0.01
OLR1	0.75	0.56	0.11	0.01
OLR2	0.86	0.73	0.05	0.00
OLR3	0.97	0.94	-0.08	0.01
OLR4	0.98	0.96	-0.06	0.00
OLM1	0.94	0.89	-0.02	0.00
OLM2	0.80	0.64	0.13	0.02
OLM3	0.94	0.89	-0.03	0.00
OLM4	0.97	0.95	-0.09	0.01
OLP1	0.90	0.81	0.01	0.00
OLP2	0.88	0.77	0.01	0.00
OLP3	0.95	0.90	-0.01	0.00
OLP4	0.91	0.83	-0.01	0.00
CPL1	0.69	0.47	0.20	0.04
CPL2	0.68	0.47	-0.15	0.02
CPL3	0.86	0.73	0.00	0.00
CPL4	0.89	0.78	-0.07	0.01
CPL5_AR	0.55	0.31	0.03	0.00
CPL6	0.89	0.79	0.01	0.00
CPL7	0.71	0.51	-0.03	0.00
PEOU1	0.82	0.68	0.02	0.00
PEOU2	0.96	0.91	0.06	0.00
PEOU3	0.86	0.73	0.10	0.01
PEOU4	0.95	0.89	-0.05	0.00
GLO1	0.73	0.53	0.02	0.00
GLO2	0.74	0.55	0.00	0.00
GLO3	0.62	0.38	-0.10	0.01
GLO4	0.80	0.64	0.02	0.00
GLO5	0.65	0.43	0.05	0.00
PINT1	0.92	0.84	0.07	0.00
PINT3	0.89	0.79	0.06	0.00
PINT4	0.93	0.86	-0.13	0.02
PTM1	0.93	0.87	0.02	0.00
PTM2	0.94	0.88	0.05	0.00
PTM3	0.94	0.89	-0.06	0.00
PTM4	0.86	0.74	-0.01	0.00
PU1	0.97	0.94	-0.02	0.00
PU2	0.95	0.90	-0.04	0.00
PU3	0.95	0.89	0.04	0.00
PU4	0.95	0.90	0.02	0.00

Pre_SEC3	0.65	0.42	0.10	0.01
Pre_SEC4	0.73	0.54	0.07	0.01
Pre_SEC5	0.72	0.52	0.05	0.00
Pre_SEC6	0.62	0.38	0.05	0.00
Pre_SEC7	0.73	0.53	-0.19	0.04
Pre_SEC8	0.69	0.48	0.04	0.00
Pre_SEC9	0.55	0.30	-0.06	0.00
Average Variance Explained		0.70		0.01

Appendix F KSS details

Table F1

KSS details

Group	Participant No	Nodes	Links1	Links2	Common	C-E[C]	Similarity	S-E[S]	P(C_or_more)
Intervention	1	11.00	11.00	39.00	9.00	1.20	0.22	0.03	0.31
Intervention	2	11.00	11.00	55.00	11.00	0.00	0.20	0.00	1.00
Intervention	3	11.00	11.00	23.00	6.00	1.40	0.21	0.06	0.27
Intervention	4	11.00	11.00	34.00	7.00	0.20	0.18	0.00	0.59
Intervention	5	11.00	11.00	55.00	11.00	0.00	0.20	0.00	1.00
Intervention	6	11.00	11.00	21.00	5.00	0.80	0.19	0.03	0.41
Intervention	7	11.00	11.00	15.00	5.00	2.00	0.24	0.10	0.13
Intervention	8	11.00	11.00	19.00	7.00	3.20	0.30	0.16	0.03
Intervention	9	11.00	11.00	21.00	3.00	1.20	0.10	0.05	0.88
Intervention	10	11.00	11.00	19.00	5.00	1.20	0.20	0.05	0.30
Intervention	11	11.00	11.00	33.00	5.00	1.60	0.13	0.05	0.92
Intervention	12	11.00	11.00	20.00	5.00	1.00	0.19	0.04	0.36
Intervention	13	11.00	11.00	16.00	3.00	0.20	0.13	0.01	0.69
Intervention	14	11.00	11.00	24.00	5.00	0.20	0.17	0.01	0.58
Intervention	15	11.00	11.00	25.00	6.00	1.00	0.20	0.04	0.37
Intervention	16	11.00	11.00	26.00	5.00	0.20	0.16	0.01	0.68
Intervention	17	11.00	11.00	24.00	6.00	1.20	0.21	0.05	0.32
Intervention	18	11.00	11.00	21.00	8.00	3.80	0.33	0.18	0.01
Intervention	19	11.00	11.00	22.00	5.00	0.60	0.18	0.02	0.47
Intervention	20	11.00	11.00	17.00	3.00	0.40	0.12	0.02	0.74
Intervention	21	11.00	11.00	19.00	3.00	0.80	0.11	0.04	0.82
Intervention	22	11.00	11.00	19.00	5.00	1.20	0.20	0.05	0.30
Intervention	23	11.00	11.00	32.00	10.00	3.60	0.30	0.13	0.01
Intervention	24	11.00	11.00	47.00	8.00	1.40	0.16	0.03	0.96
Intervention	25	11.00	11.00	21.00	7.00	2.80	0.28	0.13	0.06
Intervention	26	11.00	11.00	33.00	5.00	1.60	0.13	0.05	0.92
Intervention	27	11.00	11.00	22.00	5.00	0.60	0.18	0.02	0.47

Intervention	28	11.00	11.00	11.00	3.00	0.80	0.16	0.04	0.38
Intervention	29	11.00	11.00	15.00	4.00	1.00	0.18	0.05	0.34
Intervention	30	11.00	11.00	32.00	10.00	3.60	0.30	0.13	0.01
Intervention	31	11.00	11.00	26.00	8.00	2.80	0.28	0.11	0.06
Intervention	32	11.00	11.00	28.00	5.00	0.60	0.15	0.02	0.77
Intervention	33	11.00	11.00	13.00	3.00	0.40	0.14	0.02	0.51
Intervention	34	11.00	11.00	55.00	11.00	0.00	0.20	0.00	1.00
Intervention	35	11.00	11.00	16.00	10.00	6.80	0.59	0.45	0.00
Intervention	36	11.00	11.00	24.00	6.00	1.20	0.21	0.05	0.32
Intervention	37	11.00	11.00	22.00	10.00	5.60	0.44	0.28	0.00
Intervention	38	11.00	11.00	55.00	11.00	0.00	0.20	0.00	1.00
Intervention	39	11.00	11.00	18.00	5.00	1.40	0.21	0.06	0.25
Intervention	40	11.00	11.00	55.00	11.00	0.00	0.20	0.00	1.00

Group	Participant No	Nodes	Links1	Links2	Common	C-E[C]	Similarity	S-E[S]	P(C_or_more)
Intervention	41	11.00	11.00	18.00	1.00	2.60	0.04	0.11	0.99
Intervention	42	11.00	11.00	55.00	11.00	0.00	0.20	0.00	1.00
Intervention	43	11.00	11.00	16.00	3.00	0.20	0.13	0.01	0.69
Intervention	44	11.00	11.00	21.00	5.00	0.80	0.19	0.03	0.41
Intervention	45	11.00	11.00	20.00	4.00	0.00	0.15	0.00	0.63
Intervention	46	11.00	11.00	13.00	8.00	5.40	0.50	0.37	0.00
Intervention	47	11.00	11.00	35.00	9.00	2.00	0.24	0.06	0.15
Intervention	48	11.00	11.00	23.00	8.00	3.40	0.31	0.15	0.02
Intervention	49	11.00	11.00	36.00	9.00	1.80	0.24	0.05	0.18
Intervention	50	11.00	11.00	24.00	2.00	2.80	0.06	0.10	0.99
Intervention	51	11.00	11.00	19.00	7.00	3.20	0.30	0.16	0.03
Intervention	52	11.00	11.00	16.00	5.00	1.80	0.23	0.09	0.17
Intervention	53	11.00	11.00	16.00	4.00	0.80	0.17	0.04	0.40
Intervention	54	11.00	11.00	21.00	6.00	1.80	0.23	0.08	0.18
Intervention	55	11.00	11.00	19.00	3.00	0.80	0.11	0.04	0.82
Intervention	56	11.00	11.00	21.00	4.00	0.20	0.14	0.01	0.68
Intervention	57	11.00	11.00	21.00	5.00	0.80	0.19	0.03	0.41
Intervention	58	11.00	11.00	16.00	4.00	0.80	0.17	0.04	0.40
Intervention	59	11.00	11.00	15.00	2.00	1.00	0.08	0.05	0.87
Intervention	60	11.00	11.00	21.00	6.00	1.80	0.23	0.08	0.18
Intervention	61	11.00	11.00	22.00	6.00	1.60	0.22	0.07	0.22
Group	**Participant No**	**Nodes**	**Links1**	**Links2**	**Common**	**C-E[C]**	**Similarity**	**S-E[S]**	**P(C_or_more)**
Intervention	62	11.00	11.00	16.00	5.00	1.80	0.23	0.09	0.17
Intervention	63	11.00	11.00	16.00	5.00	1.80	0.23	0.09	0.17
Intervention	64	11.00	11.00	16.00	7.00	3.80	0.35	0.21	0.01

Intervention	65	11.00	11.00	55.00	11.00	0.00	0.20	0.00	1.00
Intervention	66	11.00	11.00	35.00	9.00	2.00	0.24	0.06	0.15
Intervention	67	11.00	11.00	30.00	4.00	2.00	0.11	0.07	0.96
Intervention	68	11.00	11.00	42.00	10.00	1.60	0.23	0.04	0.20
Intervention	69	11.00	11.00	14.00	6.00	3.20	0.32	0.19	0.02
Intervention	70	11.00	11.00	26.00	10.00	4.80	0.37	0.20	0.00
Intervention	71	11.00	11.00	11.00	4.00	1.80	0.22	0.11	0.14
Intervention	72	11.00	11.00	16.00	4.00	0.80	0.17	0.04	0.40
Intervention	73	11.00	11.00	25.00	6.00	1.00	0.20	0.04	0.37
Intervention	74	11.00	11.00	21.00	8.00	3.80	0.33	0.18	0.01
Intervention	75	11.00	11.00	14.00	6.00	3.20	0.32	0.19	0.02

Group	Participant No	Nodes	Links1	Links2	Common	C-E[C]	Similarity	S-E[S]	P(C_or_more)
Control	1	11.00	11.00	25.00	8.00	3.00	0.29	0.12	0.04
Control	2	11.00	11.00	51.00	11.00	0.80	0.22	0.02	0.40
Control	3	11.00	11.00	21.00	4.00	0.20	0.14	0.01	0.68
Control	4	11.00	11.00	23.00	4.00	0.60	0.13	0.03	0.77
Control	5	11.00	11.00	20.00	4.00	0.00	0.15	0.00	0.63
Control	6	11.00	11.00	17.00	4.00	0.60	0.17	0.03	0.46
Control	7	11.00	11.00	17.00	5.00	1.60	0.22	0.08	0.21
Control	8	11.00	11.00	21.00	6.00	1.80	0.23	0.08	0.18
Control	9	11.00	11.00	19.00	3.00	0.80	0.11	0.04	0.82
Control	10	11.00	11.00	30.00	7.00	1.00	0.21	0.03	0.37
Control	11	11.00	11.00	48.00	10.00	0.40	0.20	0.01	0.57
Control	12	11.00	11.00	13.00	3.00	0.40	0.14	0.02	0.51
Control	13	11.00	11.00	15.00	5.00	2.00	0.24	0.10	0.13
Control	14	11.00	11.00	13.00	6.00	3.40	0.33	0.21	0.01
Control	15	11.00	11.00	11.00	3.00	0.80	0.16	0.04	0.38
Control	16	11.00	11.00	39.00	9.00	1.20	0.22	0.03	0.31
Control	17	11.00	11.00	32.00	5.00	1.40	0.13	0.05	0.90
Control	18	11.00	11.00	55.00	11.00	0.00	0.20	0.00	1.00
Control	19	11.00	11.00	12.00	5.00	2.60	0.28	0.16	0.05
Control	20	11.00	11.00	17.00	4.00	0.60	0.17	0.03	0.46
Control	21	11.00	11.00	14.00	6.00	3.20	0.32	0.19	0.02
Control	22	11.00	11.00	18.00	4.00	0.40	0.16	0.02	0.52
Control	23	11.00	11.00	19.00	5.00	1.20	0.20	0.05	0.30
Control	24	11.00	11.00	34.00	8.00	1.20	0.22	0.04	0.32
Control	25	11.00	11.00	12.00	2.00	0.40	0.10	0.03	0.76
Control	26	11.00	11.00	24.00	7.00	2.20	0.25	0.09	0.12
Control	27	11.00	11.00	25.00	5.00	0.00	0.16	0.00	0.63
Control	28	11.00	11.00	14.00	5.00	2.20	0.25	0.12	0.10

Control	29	11.00	11.00	16.00	6.00	2.80	0.29	0.15	0.05
Control	30	11.00	11.00	26.00	5.00	0.20	0.16	0.01	0.68
Control	31	11.00	11.00	13.00	3.00	0.40	0.14	0.02	0.51
Control	32	11.00	11.00	22.00	7.00	2.60	0.27	0.11	0.08
Control	33	11.00	11.00	18.00	6.00	2.40	0.26	0.12	0.09
Control	34	11.00	11.00	14.00	3.00	0.20	0.14	0.01	0.58
Control	35	11.00	11.00	14.00	1.00	1.80	0.04	0.09	0.97
Control	36	11.00	11.00	12.00	1.00	1.40	0.05	0.08	0.95
Control	37	11.00	11.00	16.00	4.00	0.80	0.17	0.04	0.40
Control	38	11.00	11.00	13.00	3.00	0.40	0.14	0.02	0.51
Control	39	11.00	11.00	55.00	11.00	0.00	0.20	0.00	1.00

Group	Participant No	Nodes	Links1	Links2	Common	C-E[C]	Similarity	S-E[S]	P(C_or_more)
Control	40	11.00	11.00	36.00	7.00	0.20	0.18	0.01	0.70
Control	41	11.00	11.00	19.00	3.00	0.80	0.11	0.04	0.82
Control	42	11.00	11.00	22.00	2.00	2.40	0.07	0.09	0.98
Control	43	11.00	11.00	24.00	5.00	0.20	0.17	0.01	0.58
Control	44	11.00	11.00	48.00	10.00	0.40	0.20	0.01	0.57
Control	45	11.00	11.00	20.00	5.00	1.00	0.19	0.04	0.36
Control	46	11.00	11.00	16.00	2.00	1.20	0.08	0.06	0.90
Control	47	11.00	11.00	24.00	6.00	1.20	0.21	0.05	0.32
Control	48	11.00	11.00	20.00	5.00	1.00	0.19	0.04	0.36
Control	49	11.00	11.00	13.00	3.00	0.40	0.14	0.02	0.51
Control	50	11.00	11.00	15.00	3.00	0.00	0.13	0.00	0.63
Control	51	11.00	11.00	23.00	7.00	2.40	0.26	0.10	0.10
Control	52	11.00	11.00	16.00	2.00	1.20	0.08	0.06	0.90
Control	53	11.00	11.00	16.00	2.00	1.20	0.08	0.06	0.90
Control	54	11.00	11.00	20.00	8.00	4.00	0.35	0.20	0.01
Control	55	11.00	11.00	24.00	6.00	1.20	0.21	0.05	0.32
Control	56	11.00	11.00	12.00	3.00	0.60	0.15	0.03	0.45
Control	57	11.00	11.00	21.00	4.00	0.20	0.14	0.01	0.68
Control	58	11.00	11.00	54.00	11.00	0.20	0.20	0.00	0.80
Control	59	11.00	11.00	18.00	5.00	1.40	0.21	0.06	0.25
Control	60	11.00	11.00	17.00	1.00	2.40	0.04	0.11	0.99
Control	61	11.00	11.00	16.00	5.00	1.80	0.23	0.09	0.17
Control	62	11.00	11.00	27.00	5.00	0.40	0.15	0.02	0.73
Control	63	11.00	11.00	11.00	4.00	1.80	0.22	0.11	0.14
Control	64	11.00	11.00	23.00	6.00	1.40	0.21	0.06	0.27
Control	65	11.00	11.00	32.00	8.00	1.60	0.23	0.05	0.23
Control	66	11.00	11.00	17.00	5.00	1.60	0.22	0.08	0.21
Control	67	11.00	11.00	55.00	11.00	0.00	0.20	0.00	1.00

Control	68	11.00	11.00	14.00	3.00	0.20	0.14	0.01	0.58
Control	69	11.00	11.00	20.00	5.00	1.00	0.19	0.04	0.36
Control	70	11.00	11.00	54.00	10.00	0.80	0.18	0.02	1.00
Control	71	11.00	11.00	22.00	5.00	0.60	0.18	0.02	0.47
Control	72	11.00	11.00	55.00	11.00	0.00	0.20	0.00	1.00
Control	73	11.00	11.00	24.00	4.00	0.80	0.13	0.03	0.81
Control	74	11.00	11.00	34.00	9.00	2.20	0.25	0.07	0.12
Control	75	11.00	11.00	15.00	3.00	0.00	0.13	0.00	0.63

Appendix G- Pre-training Questionnaire Items.

Personal Innovativeness

- If I hear about a new IT application, I would look for ways to experiment with it
- In general, I am hesitant to try out new IT applications
- Among my peers, I am usually the first to try out new IT application
- I like to experiment with new IT applications

Self-efficacy

The trainees were presented with the following scenario.

Please answer following questions about your ability to learn from computers. We are interested in your views about learning through information technology. Often in our work we are told that new software will make our job easier. For the following questions, imagine that you were given SAP software which will make some aspects of your work easier. At this time, the specific functions of SAP do not matter, just that it makes your work easier. In the following questions, the first part asks you whether you can use relatively unfamiliar software such as SAP under a variety of conditions. For each of the conditions, please indicate whether you think you would be able to complete the job using the software package. In the second part, for each condition that you answered "Yes", please rate your confidence about your first judgment.

I believe I have the ability to use the SAP system even if there is no one around to tell me what to do.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system even if there is no one around to tell me what to do.

I believe I have the ability to use the SAP system even if have never used a similar system before.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system even if have never used a similar system before.

I believe I have the ability to use the SAP system if I can have access to software manuals.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system if I can have access to software manuals.

I believe I have the ability to use the SAP system if I observe someone else using it before I try.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system if I observe someone else using it before I try.

I believe I have the ability to use the SAP system if I have used similar packages for business processes.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system if I have used similar packages for business processes.

I believe I have the ability to use the SAP system if I have access to SAP's inbuilt help facility.

❍ Yes
❍ No
Please rate following.

______ I believe I have the ability to use the SAP system if I have access to SAP's inbuilt help facility.

I believe I have the ability to use the SAP system if I have adequate time to explore it.

❍ Yes
❍ No
Please rate the following.

______ I believe I have the ability to use the SAP system if I have adequate time to explore it.

I believe I have the ability to use the SAP system if I can get help when I am stuck.

❍ Yes
❍ No
Please rate the following.

______ I believe I have the ability to use the SAP system if I can get help when I am stuck.

I believe I have the ability to use the SAP system if someone guides me.

❍ Yes
❍ No
Please rate the following.

______ I believe I have the ability to use the SAP system if someone guides me.

Computer Playfulness

- I am spontaneous when I interact with the application
- I am playful when I interact with the application
- I am flexible when I interact with the application
- I am creative when I interact with the application
- I am unimaginative when I interact with the application
- I am original when I interact with the application
- I am inventive when I interact with the application

Conscientiousness

- I am always prepared

- I pay attention to details
- I get chores done right away
- I carry out my plans
- I make plans and stick to them
- I waste my time
- I find it difficult to get down to work
- I do just enough work to get by
- I do not see things through
- I shirk my duties
- I am able to stick to my goals even when there are distractions

Pre-training Motivation

- I am very much interested in attending this ERP training session
- I am excited about learning the ERP skills that will be covered in this training class
- I will try to learn as much as I can from this training class.
- I am motivated to learn the training material in this session

Appendix H- Post-training Questionnaire Items.

ERP Quiz

Please answer following question about SAP to the best of your abilities, while applying the knowledge gained from recently completed ERPsim game. You need not remember the actual transaction code but if you recall what a particular transaction achieved in the question, you will be able to answer following questions

Which of the following is the transaction enabling the creation of sales forecast is:

- ❍ Forecasting (MD61)
- ❍ Executing the MRP (MD01)
- ❍ Financial Statement (F.01)
- ❍ Sales Market report (VA05)

Which transaction that calculates for purchasing the production requirements based on forecasting decision and current inventory is:

- ❍ Executing the MRP (MD01)
- ❍ Forecasting (MD61)
- ❍ Pricing (VK32)
- ❍ Sales report (VA05)

Which transaction would you update price list is:

- ❍ Pricing (VK32)
- ❍ Inventory Report (MB52)
- ❍ Financial Statement (F.01)
- ❍ Purchasing (ME59N)

Transaction that sends the purchasing order to the vendors is:

- ❍ Purchasing (ME59N)
- ❍ Pricing (VK32)
- ❍ Sales Report (VA05)
- ❍ Inventory Report (MB52)

Please tell us if you think following statements are true.

Report on the current balance sheet and P/L of the company can be seen using transaction F.01

- ❍ True
- ❍ False

Transaction MB52 report on the current inventory of both finished product and raw materials

- ❍ True
- ❍ False

To schedule the order in which production order are released on the assembly line, transaction Production Scheduling (ME59N) is used

- ❍ True
- ❍ False

Your potential market is three geographic regions in Germany.

- ❍ True
- ❍ False

In the extended ERPsim game, you can change the recipe of the Muesli cereal (i.e. you can alter Bill of Materials (BOM)) at the beginning or when its inventory reaches zero.

- ❍ True
- ❍ False

In the ERPsim game procurement, production, and sales processes are automated so you can focus on the most important aspect of learning i.e. running a business and making important decisions.

- ❍ True
- ❍ False

OL-Attention

- I was able to concentrate on the demonstration
- I paid close attention to the demonstration
- The demonstration held my attention
- During the video demonstration, I was absorbed by the demonstrated activities

OL-Retention

- I had the opportunity to summarize the key aspects of demonstrated SAP functions
- I had the opportunity to symbolically process the presented information
- I had the opportunity to mentally visualize the demonstrated SAP functions
- I had the opportunity to mentally practice the demonstrated SAP functions

OL-Production

- I had the opportunity to accurately reproduce the demonstrated SAP functions
- I had enough practice to explore SAP functions
- The training provided me with the opportunity to produce the procedural steps demonstrated
- The training helped me explore the key component skills required to produce the various SAP functions

OL-Motivation

- The training provided information that motivated me to use SAP
- The training helped me see the usefulness of SAP
- The training increased my intention to master SAP
- The training showed me the value of using SAP to integrate business processes

Knowledge Integration

- I have the ability to analyze the impact of integrated information on managerial decision-making
- I have the ability to analyze the impact of individual employee actions on the operations of other functional areas
- I have the ability to understand the role and complexity of technology in enterprise system software solutions

Business Process Knowledge

- I have the knowledge of business terminology in Sales and Distribution (such as sales order, goods issue, etc.)
- I have the knowledge of business terminology in Procurement process (such as purchase order, goods receipt, etc.)
- I have the knowledge of integrated nature of the business processes
- I have the knowledge of interrelationship between various functions such as accounting, marketing, production, etc.)
- I have the knowledge of Sales and Distribution Business Processes
- I have the knowledge of Production Business Processes
- I have the knowledge of Financial Accounting Business Processes

Transaction Knowledge

- I have the ability to accomplish transactions to procure inventory in SAP
- I have the ability to accomplish transactions to set and modify product price in SAP
- I have the ability to accomplish transactions to set up production in SAP
- I have the ability to accomplish transactions to collect payment from customers (accounts receivable).
- I have the ability to accomplish transactions to pay for the purchases (accounts payable).

Please give us a quick intuitive judgment of following concept pairs "relatedness" as you best understand in the context of Enterprise Resource Planning (ERP), and SAP in particular. "Relatedness" of a concept pair can range from 1 to 7. We are concerned with 11 concepts that are related to ERPsim. They are briefly explained below.

ID	Concept	Definition/Meaning
1	Sales Order	A document sent to us by the customer when they wish to buy one of our product i.e. a type of a Muesli. This process is automated in ERPsim simulation
2	Production Order	The order that we send to our production line to produce Muesli
3	Planned Production Order	A stage prior to generating a production order, it is a planned document while once it is confirmed/authorized it turns into a production order
4	Purchase Order	An order that we send to our vendors for materials
5	Purchase Requisition	A document produced as a precursor to Purchase Order
6	Materials Requirement Planning (MRP)	Automatic ERP/SAP process of managing inventory based on Independent Demand Forecast and current inventory
7	Invoice (from vendors)	Money we owe to the vendors
8	Independent Demand Forecast	Projection of independent demand by us using ERP/SAP
9	Stock levels (Inventory)	Current stock levels of each product in ERPsim
10	Bill of Materials (BOM)	The structure of the product i.e. the details of constituents which makes a particular type of Muesli
11	Procurement	The process of generating a Purchase Requisition and then a Purchase Order

Concept pairs
Materials Requirement Planning (MRP) - Sales Order
Materials Requirement Planning (MRP) - Production Order
Materials Requirement Planning (MRP) -Planned Production Order
Materials Requirement Planning (MRP) - Purchase Order
Materials Requirement Planning (MRP) - Purchase Requisition
Invoice (from vendors) - Sales Order
Invoice (from vendors) - Production Order
Invoice (from vendors) - Planned Production Order
Invoice (from vendors) - Purchase Order
Invoice (from vendors) - Purchase Requisition
Independent Demand Forecast - Sales Order
Independent Demand Forecast -Production Order
Independent Demand Forecast -Planned Production Order
Independent Demand Forecast - Purchase Order
Independent Demand Forecast - Purchase Requisition
Stock Levels (Inventory) - Sales Order
Stock Levels (Inventory) - Production Order
Stock Levels (Inventory) - Planned Production Order
Stock Levels (Inventory) - Purchase Order
Stock Levels (Inventory) - Purchase Requisition
Bill of Materials (BOM) - Sales Order
Bill of Materials (BOM) - Production Order
Bill of Materials (BOM) - Planned Production Order
Bill of Materials (BOM) - Purchase Order
Bill of Materials (BOM) - Purchasing Requisition
Procurement - Sales Order
Procurement - Production Order
Procurement - Planned Production Order
Procurement - Purchase Order
Procurement - Purchasing Requisition

Concept pairs
Sales Order - Production Order
Sales Order - Planned Production Order
Sales Order - Purchase Order
Sales Order - Purchase Requisition
Production Order - Planned Production Order
Production Order - Purchase Order
Production Order - Purchase Requisition
Planned Production Order - Purchase Order
Planned Production Order - Purchase Requisition
Materials Requirement Planning (MRP) - Invoice
Materials Requirement Planning (MRP) - Independent Demand Forecast
Materials Requirement Planning (MRP) - Stock levels (Inventory)
Materials Requirement Planning (MRP) - Bill of Materials (BOM)
Materials Requirement Planning (MRP) - Procurement
Invoice (from vendors) - Independent Demand Forecast
Invoice (from vendors) - Stock levels (Inventory)
Invoice (from vendors) - Bill of Materials (BOM)
Invoice (from vendors) - Procurement
Independent Demand Forecast - Stock levels (Inventory)
Independent Demand Forecast - Bill of Materials (BOM)
Independent Demand Forecast - Procurement
Stock levels (Inventory) - Bill of Materials (BOM)
Stock levels (Inventory) - Procurement
Bill of Materials (BOM)- Procurement

Often in our work we are told that new software will make our job easier. For the following questions, imagine that you were given SAP software which will make some aspects of your work easier. At this time, the specific functions of SAP do not matter, just that it makes your work easier. In the following questions, the first part asks you whether you can use relatively unfamiliar software such as SAP under a variety of conditions. For each of the conditions, please indicate whether you think you would be able to complete the job using the software package. In the second part, for each condition that you answered "Yes", please rate your confidence in your first judgment.

I believe I have the ability to use the SAP system even if there is no one around to tell me what to do.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system even if there is no one around to tell me what to do

I believe I have the ability to use the SAP system even if have never used a similar system before.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system even if have never used a similar system before

I believe I have the ability to use the SAP system if I can have access to software manuals.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system if I can have access to software manuals

I believe I have the ability to use the SAP system if I observe someone else using it before I try.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system if I observe someone else using it before I try

I believe I have the ability to use the SAP system if I have used similar packages for business processes.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system if I have used similar packages for business processes

I believe I have the ability to use the SAP system if I have access to SAP's inbuilt help facility.

❍ Yes
❍ No

Please rate following.

______ I believe I have the ability to use the SAP system if I have access to SAP's inbuilt help facility

I believe I have the ability to use the SAP system if I have adequate time to explore it.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system if I have adequate time to explore it

I believe I have the ability to use the SAP system if I can get help when I am stuck.

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system if I can get help when I am stuck

❍ Yes
❍ No

Please rate the following.

______ I believe I have the ability to use the SAP system if someone guides me

❍ Yes
❍ No

Simulation Experience

- The ERP simulation was a worthwhile learning experience
- I learned about Enterprise Resource Planning as a result of the ERP simulation
- I learned about SAP as a result of the ERP simulation
- I learned how to use SAP to accomplish business processes as a result of the ERP simulation
- SAP is a great system to accomplish integrated business processes

Perceived Usefulness

- Using the SAP system improves my performance in my job
- Using the SAP system in my job/simulation increases my productivity
- Using the SAP system enhances my effectiveness in my job/simulation
- I find the SAP system to be useful in my job

Perceived Ease of Use

- My interaction with the SAP system is clear and understandable
- I find the SAP system to be easy to use
- I find it easy for me to become skillful at using the SAP system
- Interacting with the SAP system does not require a lot of my mental effort

Appendix I – IRB Approval

December 15, 2014

MEMORANDUM

TO:	Vishal Shah Fred Davis
FROM:	Ro Windwalker IRB Coordinator
RE:	New Protocol Approval
IRB Protocol #:	14-11-314
Protocol Title:	*Investigating Technology Training: Implications for Design and Evaluation*
Review Type:	☒ EXEMPT ☐ EXPEDITED ☐ FULL IRB
Approved Project Period:	Start Date: 12/15/2014 Expiration Date: 12/14/2015

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (https://vpred.uark.edu/units/rscp/index.php). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval. Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

This protocol has been approved for 1,120 participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 210 Administration Building, 5-2208, or irb@uark.edu.

Appendix J – R and UNIX Code for Proximity Files

1) To read the knowledge structure file

- > library (XLConnect)   # load XLConnect package to read a excel file
- wk = loadWorkbook ("file_name.xls")
- df = readWorksheet (wk, sheet="Sheet1")
- # df is the data frame holding knowledge structure
- # Each row in df represents a vector belonging to a specific participants

2) Convert each row in data frame to a symmetric matrix

- library (corpcor)   # load corpcor package for matrix manipulation
- m <- list() # Define m as a list object
- # covert all vectors into matrix and store in list ‘m’
- for (i in 1:nrow(df)) {m[[i]]<-vec2sm(unname(unlist(df[i,])),diag=FALSE)}

3) Print the each lower matrix from a list object m containing symmetric matrices

- library (psych) # load pysch package for matrix printing
- z <- list() # Define z as a list object
- i = 1
- for (i in seq_along(m))
- + {z[[i]]<-capture.output(lowerMat(m[[i]]))
- +write.table(z[[i]],paste("filename",i,".txt",sep=""),col.names=FALSE,row.names=FALSE,sep=" ",quote=FALSE)}

4) UNIX commands to make the file suitable for pathfinder analysis

- for f in filename*.txt ; do cut -d " " -f 3- "$f" > "${f}".tmp && mv "${f}".tmp "$f"; done
- for f in filename*.txt ; do tail -n+2 "$f" > "${f}".tmp && mv "${f}".tmp "$f"; done
- for f in filename*.txt ; do cat trianing.txt "$f" > "${f}".tmp && mv "${f}".tmp "$f"; done

Further, notepad++ was used for batch formatting.

Appendix K – Post-hoc Analyses

In order to understand how interrelationships change among observation learning processes change, if one includes paths in the analysis, I tested a fully saturated model. The dashed/dotted arrows indicate the path that were not part of the model. According to prior arguments, they should not be significant.

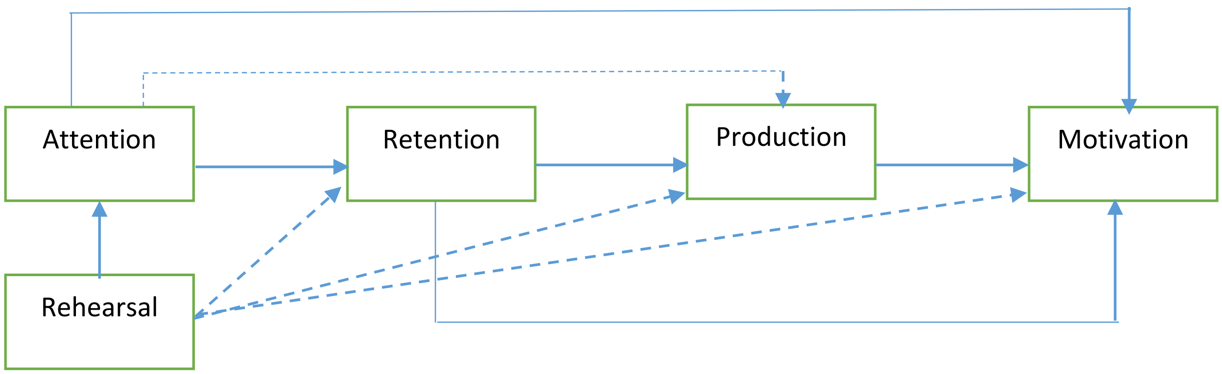

Figure K. Saturated OL model

Table K1 shows the relationship between OL processes in the saturated model

Table K1.
Saturated OL model

	Direct	Indirect	Total
Attention → Retention	.56***		.60***
Attention → Production	.09	.41***	.50**
Attention → Motivation	.29***	.27***	.56***
Retention → Production	.73***		.73***
Retention → Motivation	0.11	.22**	.33**
Production → Motivation	.44***		.44***
Rehearsal→ Attention	-.06		-.06
Rehearsal→ Production	09		.09
Rehearsal→ Motivation	-.03		-.03
R-square	.68		

As we can see from the table K1, paths not included in the hypothesized model (indicated by dotted line), were not significant.

Chapter 4

ESSAY 3: Examining Effectivity of Mental Rehearsal: A Cognitive Load Perspective

Abstract

This study investigated the central idea that effectiveness of mental rehearsal stems from its ability to guide and focus participant's attention on the learning material. Cognitive load theory (CLT) was used as a theoretical lens for this investigation. As a result of mental rehearsal, the perception of learning (i.e., germane load) was hypothesized to increase, while noise (i.e., extraneous load) was hypothesized to decrease. Mental rehearsal's effectiveness was also measured through knowledge structure similarity (KSS) metric. A randomized two-group post-test online experiment was conducted with a sample size of 258 to test hypotheses. Results supported the hypotheses related to germane load and extraneous load. Mental rehearsal cohort formed knowledge structures which shared greater similarity with experts' knowledge structures compared to the control group. Generalized computing knowledge, ability to program, training experience, and post-training self-efficacy were also collected as training outcomes. Mental rehearsal significantly improved post-training self-efficacy but did not have a significant impact on generalized computing knowledge, ability to program, and training experience. Instead, these outcomes were driven by technology acceptance model (TAM) variables.

Introduction

Training is very important for workplace performance (Barrett & O'Connell, 2001; Gupta & Bostrom, 2013; Park & Jacobs, 2011). In 2012, US corporations spent $164.2 billion on learning and development (ASTD, 2013). Only 13% of the employees were able to perform the newly learned skills while on the job, and only 3% of the employees were able to translate the training provided to reduce cost and improve quality (ASTD, 2005). Corporations need human capital to gain a competitive advantage. Failure to maintain an adequately trained workforce can erode a firm's competitive advantage. This is especially true in the current digital economy. In fact, training is deemed as one of the most critical components of information systems (IS) success (Medsker & Medsker, 1987; Nelson & Cheney, 1987; Cronan & Douglas, 1990; Yaverbaum & Nosek, 1992). Many sub-fields in IS face this issue, but this lack of human capital is extremely apparent, and growing in programming and coding related jobs, as seen from following quotes from Miller (2014):

According to the U.S. Bureau of Labor Statistics, by 2020 there will be 1.4 million new computer science jobs. However, between current professionals and university students, we will only have 400,000 computer scientists trained to fill those roles. (Miller, 2014 p. 3)

A workforce savvy in computer programming can considerably improve the current situation that plagues STEM fields (Seetharaman, 2014; Wright, 2014). Given the shift to data-based decision-making, programming literacy is not limited to computer scientists but is increasingly required for jobs ranging from traditional business marketing to local government and healthcare. One of the prevalent ways of developing programming training is through MOOC videos (Klawe, 2015). Thus, I chose basic computer science training using videos from a Massively Open Online Class (MOOC) as the context of this study.

In following paragraphs, I explain why MOOCs present an ideal context for this research. Massively Online Open Courses (MOOCs) are heralded as information technology's incredible feat. The introduction of MOOCs to higher education has been very swift and unprecedented (Breslow et al., 2013). MOOCs are seen as a vehicle to ameliorate STEM and programming worker shortage (Johnson-Bey, Girma, Udofa, & Parker, 2013; Schelmetic, 2013; Waßmann, Schönfeldt, & Tavangarian, 2014; Wilner, 2014). In fact, the year 2012 was called the year of the MOOC by time magazine. A MOOC generally does not require fees or prerequisites apart from the Internet access. Also, most MOOCs have no expectation in terms of participation, and offer no formal accreditation (McAuley, Stewart, Cormier, & Siemens, 2010), while some MOOC's do provide a certificate of participation.

Basic training materials for a MOOC often consists of a series of well-designed instructional videos presented in an interactive learning context. Videos are provided in the hopes of motivating students and increasing their participation in learning. Additionally, there is usually an online community built around the MOOC offering. The ability to create and apply knowledge is critical for the current digital economy. IT innovations such as MOOCs have the potential to radically increase the rate at which knowledge is created and distributed. MOOCS also promise to reduce the barrier to knowledge consumption. Innovations such as MOOCs alter the traditional hierarchy of pedagogical relationships in a learning organization (Cope & Kalantzis, 2000). MOOCs may serve as an ecosystem to gain knowledge, skills and attitudes individuals need to thrive in the current digital economy. MOOCs are open, and no one is excluded based on prior academic experience, so it has huge potential to educate masses. This inclusive approach can induce a participatory scenario called "legitimate peripheral participation" (McAuley et al., 2010).

MOOCs are used for a myriad of subjects including history, medicine, computer science and economics. However, they are particularly useful in delivering classes with heavy "learning by doing" and enactive components (Beaven, Comas-Quinn, Hauck, de los Arcos, & Lewis, 2013; Heutte, Kaplan, Fenouillet, Caron, & Rosselle, 2014; Romero, 2013). For this reason, teaching computer programming using MOOCs has been on the rise. The most recent examples of this can be seen in the rise of well-financed MOOC providers such as edX, Coursera (Carr, 2012), and Udacity (Klawe, 2015). A MOOC uses well-designed videos as a primary tool to impart training (i.e., lectures are video-recorded and distributed to students). In addition to the videos, MOOCs provide other features such as online forum(s) where participants can interact with each other. It has all the components of the traditional classroom as far as assignments and quizzes are concerned. MOOC videos are designed meticulously, and embody the principles of problem-based learning (PBL) such as *authentic learning, learning by doing, and providing practice environment* so that participants can interact with teaching materials (Billsberry, 2013; Chen, Barnett & Stephens, 2013; de Waard, Koutropoulos, Keskin, Abajian, Hogue, Rodriguez, & Gallagher, 2011; Mackness, Mak, & Williams, 2010; Taradi, Taradi, Radić & Pokrajac, 2005). MOOCs presents themselves as an ideal platform to disseminate computer programming training. However, there is a great deal of skepticism about MOOCs as explained below.

There are two divergent views on the impact of MOOC on higher education and training. Some universities see MOOCs as a panacea to democratize education while others see them as substantial investments which may not yield adequate returns (Chen et al., 2013). MOOCs are free or very low cost for participants, but it requires substantial investment to produce a MOOC class. A MOOC course offering on edX.org, which is run by MIT, Harvard, and Berkeley, can cost the focal school upwards of $300,000 per course (Kolowich, 2013a, 2013b). Certain university administrators have expressed strong doubts about the future of MOOCs as can be seen from the following quote from Greenstein (2013): "MOOCs are a perfect storm of hype, hyperbole, and hysteria…" (p. 5). Further, current ventures in MOOC space (e.g. Coursera and Udacity) are well-funded, but a repeatable revenue generation model has yet to be established. Also, there is a looming problem of completion rates (Mackness et al., 2010); at most, 8 to 10% of the MOOC participants complete the course (Reilly, 2013).

Given the attention, funding and controversies that MOOC providers are garnering, it is worthwhile to explore more fundamental issues related to learning before reaching any verdict on the usability and effectivity of MOOCs in transforming education. One such fundamental question would be: How to measure and enhance the effectivity of the training methods used by MOOCs. MOOCs heavily rely on well-designed recorded videos to demonstrate the subject matter and motivate users to "actively take part" in the learning process. The demonstration is based on Bandura's social cognitive theory (SCT) which posits that humans have an innate ability to learn via observation. Educational technologist, administrators, teachers, and researchers must examine the effectiveness of these training videos, and explore ways to enhance it further using known instructional strategies. Does the delivery of educational contents via a well-designed video lecture espouse learning? Is there any existing educational strategy that can enhance its efficacy?

Mental rehearsal has been repeatedly shown to be effective in a variety of contexts (Cooper, Tindall-Ford, Chandler, & Sweller, 2001; De Beni, & Moè, 2003; DeWitt, 2007; Ginns, Chandler, & Sweller, 2003), including situations where material to be learned is cognitively complex (Leahy & Sweller, 2004). Learning computer programming is a complex cognitive task (Van Merriënboer, 1997; Van Merriënboer and Paas, 1990). Thus, there is the possibility of designing a training intervention which combines mental rehearsal with existing MOOC training to enhance the learning experience as well as training outcomes. This study focuses on developing such an intervention, and in the process explicates how mental rehearsal works from a cognitive standpoint.

Education literature has shown that mental rehearsal provides assistance to the trainees in transferring information to long-term memory and is more likely to enhance learning when associated with complex information acquisition (DeWitt 2007; Leahy & Sweller, 2004). The current study builds on this finding and further investigates the mechanism behind this effect. Mental rehearsal is concerned with information processing, and information transfer from working memory to long-term memory. Detailed exploration of mental rehearsal would benefit from a theoretical framework which deals with human cognitive architecture.

Cognitive load theory (CLT) (Sweller, 1988) considers characteristics of human cognitive architecture as key elements in designing and evaluating efficacious training interventions. Cognitive load theory is one of the most prevalent theories in training literature and deals with information processing tendencies of human information processing and bottlenecks of the human cognitive architecture. Thus, CLT was chosen as a theoretical framework for this study. In the next section, the relationship between CLT and mental rehearsal is described in detail.

Theoretical Background

Mental rehearsal can be combined with existing training methods to increase the efficacy of computer programming training. The focus of this research is to investigate the mechanism underlying the effectiveness of mental rehearsal in technology-mediated settings utilized in MOOCs. Training videos used in this study are borrowed from a well-designed MOOC class on basic computer programming. These videos contain the demonstration of programming tasks with visualizations, verbal, and pictorial explanations. The demonstration is based on Bandura's social cognitive theory (SCT) which posits that humans have an innate ability to learn via observation. SCT operates on the tacit premise that a trainee learns from observing a model (either anthropomorphic or computer) demonstrating the skilled behavior. Bandura's emphasis on learning from observation is evident in the following quote (Bandura, 1977):

Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action. (p22).

A well-designed training program based on the tenets of SCT may be hampered due to the limited cognitive capacity of humans. Demonstration of a complex task with visualizations and explanations can overwhelm a learner's cognitive threshold. One of the ways to enhance the effectiveness of instruction is through mental rehearsal. Cognitive load theory emphasizes working memory limitations as an important factor in determining the effectiveness of instructional methods (Paas, Renkl, & Sweller, 2003; 2004; Sweller, 1988; 1999; 2004; Sweller, van Merriënboer, & Paas, 1998; van Merriënboer & Sweller, 2005). It also offers a lens through which effectiveness of mental rehearsal can be examined. In the following section, I explain CLT in brief.

Cognitive Load Theory (CLT)

For learning, two factors are crucial: (1) Working memory; and (2) Long-term memory. Before understanding two different type of memories, it is useful to understand the meaning of the term “element”. It refers to a concept or procedure that needs to be learned. Material low in element interactivity will allow the learner to learn without referencing the information originating from other elements (i.e. concepts or procedures). For example, learning chemical symbols of the periodic table is low in element interactivity as one can learn one symbol independent of others. On the other hand, a task high in element interactivity would make it very difficult to understand the concept or process in isolation. For example, consider a novice computer programmer learning to apply grammar rules in a programming language to deduce the meaning of the statement, it would require the application of many rules at once, and hence would require high element interactivity for a successful application.

Working memory. It has limited processing capacity and is inadequate to meet the complexity of information that learners face in acquiring a complex skill such as programming. It has been argued in the education literature that working memory can hold five plus or minus two elements (Cowan, 2011; Miller 1956).

Long-term memory. It refers to the body of knowledge and skills that we hold in a more-or-less permanently accessible form. Its threshold is not yet known, and it is believed to have virtually limitless holding capacity. Long-term memory forms cognitive structures also known as schemas in that can be processed by working memory (Paas et al., 2003). The information present in the long-term memory can be readily cached by working memory in the form of a single element. It is shown pictorially in Figure 1 below.

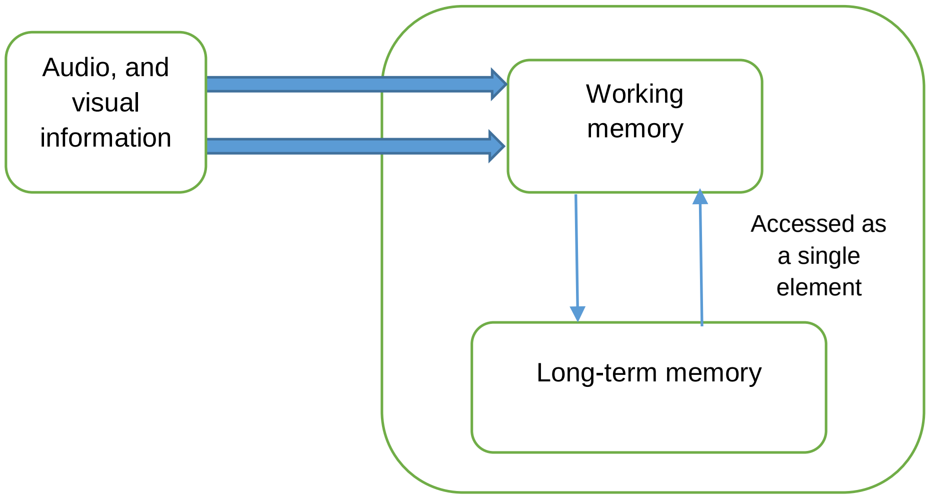

Figure 1. Human memory conceptualization

Some previous research suggests that it is not the number of information elements but the time that an information element could remain active that defines working memory capacity (Baddeley, 1992). Irrespective of whether it is the number of elements or the passage of time that the learner is exposed to, it is clear that the limited capacity of working memory can hamper learning. The goal of an effective instructional strategy is to minimize constraints on the working memory and present it with information in such a way that it can be transferred to long-term memory. For this goal to be achieved, training must be designed in keeping with learners' cognitive architecture. Cognitive load theory (CLT) holds that there are three different types of cognitive loads; namely intrinsic cognitive load, extraneous cognitive load, and germane cognitive load. Intrinsic and extraneous mental loads vie for the working memory. These different type of loads have a varying effect on learning as explained below. Each type of load is explained briefly in the following paragraphs.

Intrinsic load. This type of load refers to the inherent difficulty of the material. The difficulty level of any subject is a function of the number of interacting information elements the material contains (Chandler & Sweller, 1991). Simultaneous processing of information originating from different information elements places a constraint on the working memory. Learning a new material that contains a high number of interacting elements will constitute a higher intrinsic load. This load remains constant if the number of elements is not altered. For example, if in a learning experiment if two groups receive the exact same training material, then intrinsic load across two groups remains the same. The intrinsic load is concerned with the natural complexity of information, ignoring the instructional issues such as information presentation. It can only be changed by changing the nature of the subject.

Extraneous load. This type of load refers to the load that is generated by the design of training, and issues that are not related to the intrinsic nature of the material. At times, trainees have to process information that is not related to the learning material or information can be presented in a manner that facilitates learning. For example, teaching a programming construct will be more effective if the training makes appropriate use of graphics and text rather than a text-only presentation. One of the most common examples is called the "split-attention effect" (Kalyuga, Chandler, & Sweller, 1999; Mayer & Moreno, 1998; Tarmizi & Sweller, 1988). This effect takes place if a trainee has to search and process information from two or more sources. Combining information from various elements to understand the subject matter is a crucial step in gaining mastery of the subject. However, it can prove to be redundant or detrimental in cases where it is irrelevant to the problem. For example, consider a diagram in a training video segment which presents the overall structure of the lesson but the textual information is not presented in the same frame. A trainee has to rewind the video, search and integrate both sources of information in order to make sense of the information coming from two disparate sources while holding them active in memory. This type of cognitive load imposed by the design is ineffective or detrimental to learning. It can be avoided by designing a better video where diagram and text are present in the same frame. Intrinsic and extraneous loads are concerned with material characteristics, and it is only related to learner characteristics to the extent that a learner has prior experience in the knowledge domain.

Prior research in education has stressed the need to developed training material based on human information processing tendencies (Mayer & Moreno, 2003). Prior literature suggests that training should be based on dual channel assumption (Paivio 1969; 1971; 1986) and limited capacity assumption (Sweller, 1991). Humans are assumed to possess separate channels for processing verbal and visual material, and this processing capacity is limited. Further, learning is seen as a result of active processing of material through verbal and visual channels. Hence, training technique should not overload either channel as it can result in increasing the extraneous load. Also, training should promote conditions for active processing of subject materials. Previous research in education domain has shown that the extraneous load can be reduced by judicious use of segmentation, signaling, reduction of redundancy, and synchronization of verbal and visual cues (Mayer & Moreno, 2003). Training material used in this study is professionally developed, and in keeping with the human cognitive architecture and is expected to espouse learning. The major thrust of this research is to prompt trainees to actively process the training material. A method called mental rehearsal is used to achieve high levels of active processing. This method holds the promise to enhance actual learning (i.e., germane load) while reducing the extraneous load. Thus, providing trainees with a greater opportunity to commit learning material to the long-term memory. The germane load is discussed in detail in following paragraphs.

Germane load. It refers to the type of load that enhances learning and creates favorable learning conditions. An optimized instructional strategy minimizes *extraneous* load and enhances *germane* load. The underlying assumption is that active processing of parts of the learning material relevant to the focal skill will yield germane cognitive load.

The initial theory of cognitive load had two forms of load; intrinsic, and extraneous (Sweller, 1988). The germane load was introduced later (Sweller, Van Merrienboer, & Pass, 1998). Intrinsic load for is thought to be the function of element interactivity. For many years, the extraneous load was thought to be a function of instructional delivery and information presentation, but recently it has been defined in terms of element interactivity (Beckmann, 2010). If element interactivity can be reduced without compromising the core content/meaning of the material, then it is seen as a contributing factor to extraneous load. As explained, element interactivity can lead to extraneous load. Often learners cannot distinguish if the element interactivity is *central or peripheral* to learning. In such situations, training interventions which directs a learner's attention on actual learning material and manage to pull away learner's attentional resources from unneeded/superfluous/detrimental element interactivity is desired. If this happens, it gives rise to what is now known as *germane load.* The germane load is directly dependent on the working memory resources that a learner devotes to the material. In this sense, the germane load is the type of load that "arises or materializes" when a learner focuses on the material (Kalyuga, 2011) and is reasoned to espouse learning.

The germane load is the type of load that an effective training intervention espouses to generate. Higher germane load indicates that the learner is employing working memory resources towards mastering the material, fostering the formation of schemas (Sweller et al., 1998). For the same level of intrinsic load, the training method that generates higher germane load is more likely to build schemas or cognitive representations. If a learner devotes working memory resources to deal with the complexity of the material, then germane load associated with it will increase. The effectiveness of the training intervention is seen a consequence of a learner's engagement with the actual material (i.e. intrinsic material), and avoidance/reduced engagement with elements not related to learning (i.e. extraneous load) (Sweller, 2010). Thus, a natural question then arises about the mechanism through which this can be achieved. According to education literature, mental rehearsal is one such mechanism. In the following section, mental rehearsal is explained in greater detail.

Mental Rehearsal

Education literature has recently explored how mental rehearsal impacts acquisition of new materials (Leahy & Sweller, 2004). Research on mental rehearsal has a long history (Clark, 1960; Corbin, 1972; Egstrom, 1964; Perry, 1939; Rawlings & Rawlings, 1974; Sackett, 1935), and has been explored in areas as diverse as sport psychology (Etnier & Landers, 1996; Grouios, 1992a, 1992b; Kelsey, 1961; Phipps & Morehouse, 1969; Romero & Silvestri, 1990; Shick, 1970; Surburg, 1968; Ungerleider & Golding, 1991), to behavior counselling (Hazler & Hipple, 1981). Mental rehearsal has also been referred to as 'symbolic rehearsal', 'introspective rehearsal', and 'conceptualization'.

Prior research on mental rehearsal indicates that it can act as a bolstering mechanism and aid in the formation of trainees' knowledge structures (Clark & Herrelson, 2002). Mental rehearsal has been shown to prompt the trainee to segmentize training materials and then integrate them (Clark, Nguyen, & Sweller, 2011). Following the prior literature, this study employs mental rehearsal after trainees had an opportunity to practice the materials taught to them (Clark, 2011).

Imagining or mentally rehearsing a procedure has been considered a form of deliberate practicing (Leahy & Sweller, 2004). The act of imagining a solution or procedure nudges learners to form connections between concepts acquired from the training, and is likened to anticipative reasoning (Renkl, 1997). Anticipative reasoning is the result of mentally working through a solution/idea/procedure. Thus, it causes the learner to focus and recall the learning material, devoting working memory resources to actively process the material. Recent work in education has investigated the relationship between mental rehearsal and cognitive load (Leahy & Sweller, 2004; Leahy & Sweller, 2008). It has been studied in experimental conditions, and mainly on subjects who were grade/school children. Further, the effectiveness of mental rehearsal has not been attributed to any specific component of the cognitive load. This essay builds on education literature and tests the relationship between cognitive load and mental rehearsal in a more realistic technology-mediated training environment.

H1: Addition of mental rehearsal to baseline training will increase the germane load.

Extraneous load is concerned with elements not related to learning material. Mental rehearsal has the potential to reduce it if applied it in a way explained in following paragraphs.

The literature on mental schemas suggests that even after the rudimentary schemas are formed, they are accessed as a single element in the working memory in for the future production of desired behavior. This single element (cached from long-term memory) interacts with other elements present in the working memory, based on which further mental models develop. If mental rehearsal is applied after each learning activity, it will facilitate the formation of knowledge structures/mental schemas, which can then be accessed as a single element in working memory next time around, and used as an anchor. Let us imagine that the same learning material is presented to two learners one of which goes through mental rehearsal, and one who does not. The learner who engages in mental rehearsal after each learning activity can theoretically access schemas built during prior activities as a single element in working memory, and integrate it with other elements. Thus, working memory resources that are saved can be spent on dealing with the extraneous load. On the other hand, the learner who does not engage in mental rehearsal after each learning activity does not have this advantage, as he/she will have to integrate elements in the working memory, leaving him/her with scant working-memory resources to deal with the extraneous load. He/she cannot call on schemas built in prior activities, and treat it is a single element. A learner who engages in rehearsal would have more working memory resources to deal effectively with elements unrelated to the learning (i.e., extraneous load). Thus, he/she would not perceive the extraneous to be as detrimental as a learner who does not engage in mental rehearsal.

H2: Addition of mental rehearsal to baseline training will reduce the extraneous load.

Training Outcomes

Mental rehearsal can aid in the formation of schemas, and this can be observed by its effect on extraneous load and germane load. The effectiveness of mental rehearsal can be observed in the degree of similarity between trainees' schemas/knowledge structures and the expert referent, at the end of training sessions. It can also be assessed by other outcomes as explained in the following section.

Following prior research on technology-mediated training, general computing knowledge, ability to program, multiple choice quiz, and post-training self-efficacy (Cronan, Douglas, Alnuaimi, & Schmidt, 2011; Yi & Davis, 2003) were captured as training outcomes. Further, affective reaction to the training was captured in the form of training experience. Objective training outcomes were captured via knowledge structures and a programming quiz.

Knowledge structures of a trainee/participant by itself are not interpretable unless their relative similarity to the expert or reference knowledge structures is measured. For this reason, the same task that the trainees performed was performed by an expert. After that, the experts' knowledge structures were taken as reference. The distance between a trainee's knowledge structures network and that of the expert reference is termed *knowledge structure similarity* (KSS). It is a similarity measure ranging from 0 to 1 and is based on well-established research in education and information systems. KSS was also used in Davis & Yi (2004). The goal of mental rehearsal was to form a trainee's knowledge structures and enhance its congruence with the expert referent.

H3: Addition of mental rehearsal to the baseline training will have a positive impact on KSS

If the mental rehearsal is effective in increasing the effectiveness of the training, then it will be reflected in other training outcomes as well.

H4: Addition of mental rehearsal to baseline training will enhance generalized computing knowledge.

H5: Addition of mental rehearsal to the baseline training will a trainee's enhance the ability to program.

H6: Addition of mental rehearsal to the baseline training will enhance the training experience.

H7: Addition of mental rehearsal to the baseline training will have a positive impact on the quiz score.

H8: Addition of mental rehearsal to the baseline training will enhance post-training self-efficacy.

Table 1 presents the summary of hypotheses.

Table 1
Summary of hypotheses

H1: Addition of mental rehearsal to baseline training will increase the germane load.
H2: Addition of mental rehearsal to baseline training will reduce the extraneous load
H3: Addition of mental rehearsal to baseline training will have a positive impact on KSS.
H4: Addition of mental rehearsal to baseline training will enhance generalized computing knowledge.
H5 Addition of mental rehearsal to baseline training will enhance the ability to program.
H6: Addition of mental rehearsal to baseline training will enhance the training experience.
H7: Addition of mental rehearsal to baseline training will have a positive impact on the quiz score.
H8: Addition of mental rehearsal to baseline training will enhance post-training self-efficacy.

Controls

Personal traits of the learner can greatly impact learning outcomes. Factors such as pre-training self-efficacy and motivation to learn (Yi & Davis, 2003) can impact how a learner approaches new training material. Also, the manner in which an individual interacts with the technology can alter his/her chances of learning from it. It has been shown that individual traits such as computer playfulness, personal innovativeness (Agarwal & Karahanna, 2000) can play an important part in a technology-mediated environment. Perceptions about the technology itself (i.e., TAM variables) can also impact learning to a great degree in a technology-mediated environment. Further, one of the most important personal factors in learning new material is goal orientation (Beaubien & Payne, 1999). Goal orientation is seen as consisting of three factors: *learning orientation, performance-approach, and performance-avoidance orientations* (VandeWalle 1997, Zweig & Websterm 2004). Learning orientation refers to the degree to which an individual eagerly learns new material and masters it. The other two factors come into play in comparative settings. *Performance-approach* refers to a learner's desire to outperform peers while *performance-avoidance* refers to a learner's desire to avoid performing poorly compared to peers. Since the study was done on individuals and there was no competitive aspect to it, only the first factor (i.e., learning orientation) is relevant to this study. Age, gender, previous programming experience, and education of a learner can also be a factor in learning experience. Thus, I control for age, gender, education, previous programming experience, TAM variables, personal innovativeness, computer playfulness, pre-training self-efficacy, motivation to learn, and learning orientation of the learner.

Procedure

Participants were shown 15 short videos split across four modules: (1) Introduction to Python; (2) Understanding ambiguity, and avoiding in Python through the use of grammar; (3) Variables in Python; and (4) Strings in Python.

Training was delivered in four rounds. Before each round participants were instructed to watch the video detailing information about the subject matter and demonstrating basic Python programs. After that, participants practiced on the relevant problems using the in-browser python interpreter. A flowchart (Figure 2) displays the process. The training consisted of 15 training videos[5]. The total duration of the training was 90 minutes over four rounds. No individual video was greater than 6 minutes. The treatment group went through additional mental rehearsal after round 2, round 3, and round 4. Links and other details on videos can be found in Appendix A. Details on the practice environment can be found in Appendix B.

[5] Training was conducted in four rounds. Training was facilitated with help of the videos from MOOC videos from Udacity.com. The list of videos can be accessed from Appendix A.

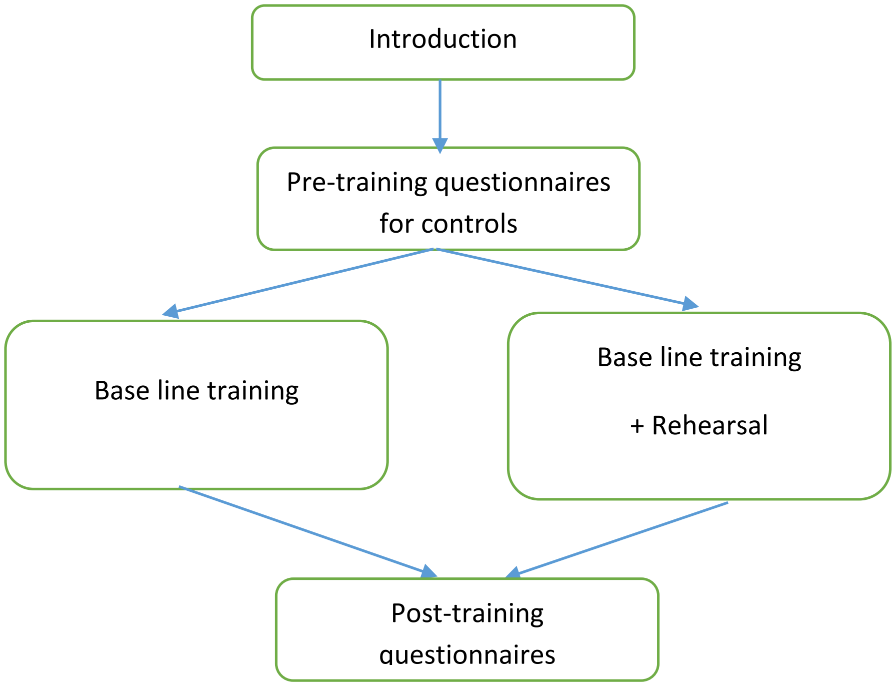

Figure 2. Study Flow

Although, the study was conducted as an online experiment, the duration of the videos could be controlled precisely using Qualtrics survey. It was made sure that participants had to watch the video; otherwise they could not proceed with the experiment. Also, it was ensured that after playing the video, the page would move on after the stipulated time period (i.e. duration of the video). In this way, in spite of the experiment being online, it was a much more controlled environment compared to that used in Essay 2. It also helped eliminate instructor specific effect which was unavoidable in the previous study.

As shown in Figure 2, the study was conducted in two phases. Mechanical Turk was used as a data collection tool. Mechanical Turk is an online consumer panel provided by Amazon.com. Researchers can recruit participants on Mechanical Turk. It has proven to be an effective data collection tool in IS and other fields. Quality and distribution of data obtained from Mechanical Turk have been found to be comparable to those obtained via traditional methods such as a survey of students or corporation employees (Buhrmester, Kwang, & Gosling 2011; Paolacci, Chandler, & Ipeirotis, 2010). Recent work on comparing Mechanical Turk data to data obtained from traditional sources (Steelman, Hammer, & Limayem, 2014) found no qualitative difference in the data from the two sources. Given the convenience and feasibility of Mechanical Turk to conduct online surveys and experiment, it has gained popularity among behavioral researchers as a data collection tool.

300 participants were recruited for the pre-training survey using Mechanical Turk. These 300 participants were split into two groups randomly; the rehearsal intervention group and the control group. Participants in both groups were contacted again after one week to participate in the experiment and a follow-up survey. Their unique Mechanical Turk IDs were used to contact them. The sample had no geographical limitations, anyone with an internet connection could take part in the study. The study controlled for previous programming experience and a host of other variables which can impact learning. Each participant who completed both phases was awarded $12. Table 2 and 3 provide details of the demographic information of the sample. After training, initial manipulation check was conducted to ensure that the participants were paying attention to the videos. Manipulation check details are described in the following paragraph. After a manipulation check, 137 responses were retained in the treatment group, while 121 responses were kept in the control group.

Table 2
Demographic details

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Gender	258	0	1	NA	NA
Age	258	0	67	32.94	9.56
Programming Experience	258	0	5	1.49	1.47

Note: Gender was coded 0 as female and 1 as male.

Table 3
Gender distribution

Gender		
	Frequency	Percent
0 (female)	154	59.69
1 (male)	104	40.31
Total	258	100.00

Intervention

Mental Rehearsal intervention refers to following two activities (Decker, 1980). (1) Reducing elements of modeled performance into easily stored symbols that can be easily stored and retrieved to guide behavior; (2) cognitively rehearsing the process in which individuals simulate/visualize themselves performing the target behavior. According to Bandura (1986), during mental rehearsal trainees must be encouraged to “transform what they observe into succinct symbols to capture the essential features and structures of the modeled activities” (p. 56). These symbols act as a guide for future action. Such interventions have been used successfully in IS research (Davis & Yi, 2004; Yi & Davis, 2003). Following prior literature (Clark, 2011), this study employs rehearsal after trainees have watched the videos and practiced the materials taught to them in the online environment.

Participants in the intervention group were asked to mentally note the important aspects of the videos they had watched. After practicing in the online environment, participants were requested to mentally rehearse the solution, priming them to string the mental notes together. This process was repeated after each round except round 1 (i.e., introductory round). A detailed sequence of activities can be found in Appendix A. Participants in the intervention group were encouraged to take additional notes throughout the process. The control group participants were not instructed or encouraged to take notes and mentally rehearse the material learned from training videos.

Measures

Measures were borrowed from prior research. Table 4 shows the measures used.

Table 4
Construct measures

Construct	Measures
Motivation to learn	Hicks & Klimoski, 1987
Self-efficacy	Compeau & Higgins, 1995
General Programing Knowledge	Cronan et al., 2011
Ability to program	Adapted from Cronan et al., 2011
Transaction Knowledge	Adapted from Cronan et al., 2011
Training Experience	Adapted from Cronan et al., 2011
TAM variables	Davis, 1989
Personal Innovativeness	Agarwal & Karahanna, 2000
Computer Playfulness	Agarwal & Karahanna, 2000
Types Cognitive Load	Leppink, Paas, Van der Vleuten, Van Gog & Van Merriënboer, 2013
Learning Orientation	VandeWalle, 1997, Zweig & Webster, 2004

Manipulation Checks

Some participants may have clicked on the video but may not have paid attention to the videos. These participants essentially represent noise, and should not be taken into account in data analysis. All participants were presented with a simple declarative six T/F questions (available in Appendix F) to filter out such cases. Only those who scored 4 or above on these statements were retained in the analysis. There were 137 participants in the treatment group, and 121 participants in the control group after this step. The two groups were not significantly different in terms of sample size (Z= 1.41, p-value = 0.16).

After this, the next step was to ensure that the participants in the treatment group went through the process of rehearsing. Their comments and notes were collected. In the treatment group, all participants had prepared some form of notes, while only 7 participants did so in the control group. A chi-square test of the differences resulted in $X^2(1) = 231.00$, $p < .001$ indicating that the treatment group indeed went through the process of note taking and rehearsal while the control group did not.

Knowledge structure similarity (KSS) Measurement

In order to measure the similarity of trainees' knowledge structures to that of the expert referent, PRONET pathfinder software (McGriff, & Van Meter, 2001; Schvaneveldt 1990; Schvaneveldt, Dearholt, & Durso, 1988, 1989) was used. The terms used to formulate the knowledge structures were decided in consultation with programming experts who have been teaching programming courses at a large southern US university. These terms and their definitions can be found in Appendix C. Trainees were asked to rate 10 programming concepts pairwise. From these ratings, a proximity matrix was generated for each participant. A proximity matrix for a specific trainee gives an account of relatedness between programming concepts. Proximity matrices were used to generate the knowledge structures of trainees. Other techniques such as Multidimensional Scaling (MDS) and hierarchical clustering also take proximity matrices as input and generate output from proximity matrices. However, pathfinder was employed in this study. The reason for employing pathfinder was its ability to resist noisy data. Pathfinder is able to distinguish between concepts that are highly similar as well as highly dissimilar. If two concepts are similar, then a discerning trainee would rate it higher on pathfinder, and if two concepts are dissimilar, then he/she would rate it lower on pathfinder. For the purposes of illustration, consider that a trainee can rate a concept pair from 1 to 7 with 1 being "not at all similar" to 7 being "extremely similar". The difference between an extremely similar pair (score=7) and a very similar pair (score =6) is 1. For example, let us assume that this pattern is consistently seen in the data i.e. many trainees rate these two concepts pairs as 7, and 6 respectively. The difference between an extremely dissimilar pair (score=1) and a very dissimilar pair (score =2) is also 1 but does not occur as consistently. Even though the magnitude of the difference is the same, the distance is psychologically real in the first case and mostly noise in the second. Techniques like Multidimensional Scaling (MDS) consider all concept pairs simultaneously and hence is susceptible to more noise (especially in knowledge domains such as programming where concepts are related to a high degree). On the other hand, the pathfinder algorithm is more successful as discerning differences towards the "related end" (i.e., the domain of knowledge where concepts are likely to be related strongly). Thus, pathfinder was used for eliciting knowledge structures. The distance of a trainee's knowledge structures from the referent was used as a measure of KSS (Davis & Yi, 2004). This measure can range from 0 to 1, with a higher number indicating a greater degree of similarity.

All measures were borrowed or adapted from prior research. The measure for cognitive load was recently developed (Leppink et al., 2013), and has not been employed in perceptual research so far. To test its suitability in this context, factor analysis on the cognitive load measure was conducted. As predicted by Leppink et al. (2013), three factors related to the corresponding cognitive load type emerged. It must be noted that cognitive load is not considered a second-order reflective construct, but this study is rather concerned with individual components of cognitive load. However, the instrument should yield three factors for it to be useful in this research where each factor (i.e., type of cognitive load) is treated separately. Table 5 shows the factor analysis with direct oblimin rotation. One the items from related to extraneous load from Leppink et al. (2013) was dropped to obtain a reliable factor structure.

Table 5
Cognitive load factors

Pattern Matrix			
	Component		
	1	2	3
IL1	**.93**	.00	-.04
IL2	**.94**	.01	.02
IL3	**.93**	-.02	.04
EL1	.08	.00	**.89**
EL2	-.04	-.02	**.95**
EL3	-.02	.01	**.95**
GL1	.01	**.82**	.00
GL2	-.05	**.85**	.03
GL3	-.01	**.86**	.02
GL4	.05	**.83**	-.06
Extraction Method: Principal Component Analysis. Rotation Method: Oblimin with Kaiser Normalization.			

Note: IL – Intrinsic load, EL- Extraneous load, GL- Germane load

Cronbach's alpha and composite reliability are displayed in Table 6. The composite reliability score of the scales suggests that the scales employed were reliable with the exception of personal innovativeness (PINT) which was used as a control variable. Table 7 has correlations and average variance extracted (AVE). The average variance extracted (AVE) was greater than .5 (Fornell & Larker, 1981). The item loadings (Wu & Wang, 2005) on their corresponding construct was greater than the loading on other constructs (as shown in Table 8), and thus the criteria for convergent validity are satisfied. The square root of AVE was greater than the correlation between constructs. Thus, construct measures displayed discriminant validity (Fornell & Larker, 1981).

Table 6

Reliabilities and AVE

Construct	Cronbach's alpha	Composite Reliability	AVE
Motivation to learn	.94	.96	.82
Self-efficacy	.88	.90	.62
General Computing Knowledge	.88	.91	.68
Ability to program	.87	.90	.62
Training Experience	.91	.92	.75
Perceived Ease of Use	.89	.92	.74
Perceived Usefulness	.87	.92	.79
Personal Innovativeness	.56	.78	.53
Computer Playfulness	.87	.91	.60
Intrinsic Load	.94	.97	.90
Extraneous Load	.93	.95	.87
Germane Load	.86	.90	.70
Learning Orientation	.87	.89	.61

Table 7 *Correlations*

Correlations																					
	TRM	PINT	LO	SEC	PEXP	GEN	EDU	Age	MVL	PEOU	EL	GL	IL	PU	TEXP	PSEC	CPL	Quiz	GPK	ABL	KSS
TRM	NA																				
PINT	-.036	.730																			
LO	-.039	-.312**	.783																		
SEC	.007	-.161**	.463**	.788																	
PEXP	.271**	.103	-.111	-.029	NA																
GEN	-.083	-.031	.100	.064	-.154*	NA															
EDU	-.107	.044	-.049	-.027	.087	-.048	NA														
Age	.006	-.069	-.003	-.034	-.255**	.108	.046	NA													
MVL	.004	-.092	.064	.117	-.162*	.070	-.052	.112	.904												
PEOU	.018	.055	.023	-.009	-0.055	-.058	.040	.054	.211**	.864											
EL	-.161**	.044	-.011	-.069	0.025	.023	.032	-.145*	-.229**	-.455**	.931										
GL	.554**	.019	-.030	.002	.167*	-.129*	.058	.019	.219**	.417**	-.289**	.837									
IL	-.087	.065	.039	-.140*	0.009	.042	-.012	-.036	-.099	-.265**	.536**	-.115	.951								
PU	.021	.071	.024	-.002	-.104	-.045	.049	.082	.144*	.602**	-.258**	.380**	-.051	.890							
TEXP	.057	.075	.020	-.017	-.109	-.014	.022	.010	.184**	.687**	-.376**	.497**	-.056	.655**	.867						
PSEC	.196**	-.042	-.006	.011	-.015	-.106	-.103	-.004	-.079	.200**	.010	.197**	-.029	.285**	.214**	.788					
CPL	-.152*	-.074	.045	.032	-.222**	.060	-.008	.027	-.012	.260**	-0.065	.026	.017	.335**	.286**	.315**	.777				
Quiz	.172**	-.064	-.051	-.014	-.076	.060	-.037	.104	.095	.086	-.194**	.010	-.110	0.058	.025	-.024	-.045	NA			
GCK	.000	.049	.076	-.031	-.054	-.048	.079	.101	.264**	.689**	-.353**	.419**	-.052	.595**	.651**	.191**	.239**	.059	.825		
ABL	.010	-.022	.128*	.086	-.112	-.128*	.070	.077	.216**	.717**	-.344**	.394**	-.224**	.529**	.584**	.245**	.224**	.025	.685**	.790	
KSS	.164**	.029	-.029	.003	.024	-.015	.045	-.09	-.039	-.131*	-.045	.043	-.095	-.070	-.090	-.054	-.149*	.054	-.137*	.139*	NA

Note: TRM→ Treatment/Mental Rehearsal, PINT→Personal Innovativeness, LO→Learning Orientation, SEC→Pre-training self-efficacy, PEXP→Previous programming experience, GEN→ Gender, EDU→Education, MVL→ Motivation to learn, PEOU->Perceived ease of use, EL→Extraneous load, GL→Germane load, IL→Intrinsic load, PU→Perceived Usefulness, TEXP→ Training experience , PSEC→Post-training Self-efficacy, CPL→ Computer Playfulness, GCK→ Generalized Computing Knowledge , ABL→ Ability to program, KSS→Knowledge Structure Similarity

Table 8
Item loadings

	ABL	EXP	GPK	LO	EL	IL	GL	CPL	MVL	PEOU	PINT	PU	SEC
ABL1	**.82**	.46	.64	.11	-.40	-.17	.30	.15	.29	.62	.04	.51	.15
ABL2	**.85**	.48	.66	.08	-.41	-.24	.32	.10	.21	.67	.01	.54	.22
ABL3	**.82**	.45	.56	.10	-.29	-.18	.30	.19	.20	.55	-.07	.41	.14
ABL4	**.83**	.46	.62	.08	-.29	-.15	.33	.14	.20	.59	-.04	.44	.15
ABL5	**.61**	.35	.34	.01	-.03	-.12	.22	.23	.04	.33	-.04	.26	.16
ABL6	**.78**	.59	.47	.02	-.22	-.20	.35	.36	.08	.61	-.07	.49	.29
EXP1	.56	**.92**	.63	.01	-.39	-.08	.43	.24	.23	.64	.00	.56	.17
EXP2	.54	**.94**	.48	-.04	-.32	-.10	.43	.25	.16	.57	-.01	.57	.13
EXP3	.46	**.75**	.56	.02	-.34	-.01	.41	.21	.10	.54	.10	.58	.22
EXP4	.56	**.85**	.59	.04	-.29	-.01	.44	.29	.18	.63	.02	.62	.17
GCK1	.59	.59	**.78**	-.01	-.38	-.10	.39	.24	.29	.67	.09	.63	.12
GCK2	.61	.59	**.88**	.06	-.32	.01	.37	.23	.19	.61	.04	.55	.19
GCK3	.62	.45	**.83**	.04	-.37	-.13	.32	.23	.30	.61	-.06	.54	.22
GCK4	.49	.42	**.79**	.05	-.20	-.01	.26	.11	.16	.43	.06	.39	.11
GCK5	.57	.45	**.84**	.02	-.27	-.10	.30	.14	.22	.56	.00	.37	.18
LO1	.06	.00	.01	**.82**	.04	.07	-.01	.01	.01	.01	-.18	-.01	-.04
LO2	.11	.00	.07	**.92**	.01	.10	-.07	.07	.03	.01	-.09	.01	-.01
LO4	.12	.04	.13	**.53**	-.09	-.01	.02	.06	.08	.06	-.13	.03	-.01
LO5	.06	-.03	.03	**.88**	.00	.08	-.05	.06	.01	.02	-.14	.00	-.04
LO6	.13	.02	.07	**.71**	-.01	.02	-.04	.04	.10	-.01	-.17	.05	-.05
EL1	-.36	-.33	-.32	.02	**.94**	.55	-.27	.07	-.20	-.43	.06	-.26	-.03
EL2	-.29	-.36	-.35	.02	**.93**	.48	-.28	.04	-.21	-.42	.09	-.30	-.02
EL3	-.38	-.37	-.40	.02	**.93**	.48	-.25	-.02	-.25	-.47	.03	-.33	-.03
IL1	-.20	-.07	-.07	.12	.50	**.92**	-.13	.09	-.08	-.24	.07	-.08	-.05
IL2	-.21	-.09	-.07	.11	.50	**.97**	-.09	.07	-.12	-.25	.07	-.09	-.03
IL3	-.25	-.11	-.10	.05	.53	**.97**	-.11	.04	-.10	-.30	.07	-.12	-.07
GL1	.37	.41	.36	-.03	-.23	-.10	**.82**	-.02	.15	.35	.05	.33	.12
GL2	.27	.31	.29	-.05	-.24	-.12	**.88**	-.05	.12	.27	-.03	.27	.15
GL3	.37	.40	.36	-.05	-.23	-.10	**.86**	.03	.23	.35	.03	.37	.08
GL4	.32	.49	.33	-.06	-.26	-.07	**.80**	.07	.23	.40	.02	.36	.15

	ABL	EXP	GCK	LO	EL	IL	GL	CPL	MVL	PEO U	PINT	PU	SEC
CPL1	.17	.27	.21	.03	-.06	.07	.03	**.71**	.00	.24	-.07	.29	.22
CPL2	.19	.21	.23	.06	-.05	.05	.04	**.73**	-.01	.24	-.04	.23	.25
CPL3	.20	.25	.21	.06	-.05	.04	.03	**.79**	.03	.24	-.06	.28	.25
CPL4	.21	.24	.20	.09	.04	.07	-.01	**.83**	.00	.18	-.10	.26	.20
CPL6	.20	.17	.17	-.01	.12	.07	-.02	**.79**	-.04	.12	-.04	.18	.27
CPL7	.16	.12	.09	.03	.12	.05	-.06	**.81**	-.02	.08	-.08	.15	.28
MVL1	.19	.18	.27	.04	-.25	-.14	.18	.01	**.92**	.24	-.06	.17	-.06
MVL2	.21	.14	.23	.07	-.2	-.09	.21	.01	**.89**	.18	-.06	.14	-.07
MVL3	.18	.16	.24	-.02	-.22	-.12	.15	-.04	**.91**	.22	-.03	.15	-.09
MVL4	.22	.2	.28	-.01	-.19	-.06	.2	-.03	**.91**	.24	-.03	.19	-.07
MVL5	.2	.23	.26	.02	-.16	-.03	.2	.01	**.89**	.16	-.04	.15	-.08
PEOU1	.62	.63	.7	.01	-.44	-.16	.38	.22	.19	**.83**	.02	.63	.23
PEOU2	.69	.59	.64	.02	-.49	-.27	.4	.19	.29	**.93**	-.01	.55	.15
PEOU3	.62	.62	.55	.03	-.25	-.18	.33	.26	.07	**.76**	-.04	.54	.22
PEOU4	.61	.51	.58	-.02	-.39	-.31	.28	.17	.21	**.92**	.02	.52	.13
PINT1	0	-.04	.08	-.13	.07	.09	.02	-.08	-.01	-.03	**.78**	.05	-.03
PINT3	-.05	.01	-.03	-.05	.03	-.03	-.03	-.04	-.05	.05	**.65**	.04	.03
PINT4	-.03	.05	-.02	-.15	.04	.09	.04	-.06	-.05	-.02	**.76**	.04	-.01
PU1	.5	.54	.53	-.02	-.33	-.11	.3	.25	.23	.58	.06	**.91**	.19
PU2	.52	.57	.52	.02	-.23	-.05	.36	.28	.13	.57	.08	**.91**	.33
PU3	.52	.55	.55	.02	-.27	-.09	.38	.26	.1	.53	.03	**.86**	.28
SEC3	.19	.11	.13	-.02	-.08	-.1	.1	.22	-.13	.21	.01	.23	**.82**
SEC4	.18	.18	.18	-.06	.06	.05	.16	.39	-.05	.1	-.06	.27	**.82**
SEC5	.24	.23	.19	-.09	-.07	-.05	.13	.2	-.05	.24	.02	.24	**.74**
SEC6	.21	.1	.19	-.01	-.01	-.1	.08	.25	-.05	.13	.01	.24	**.83**
SEC7	.18	.06	.17	.02	-.05	-.07	.11	.21	-.05	.14	0	.18	**.81**
SEC8	.13	.08	.1	-.01	-.05	-.03	.12	.14	-.05	.11	.02	.17	**.7**

Note: PINT→Personal Innovativeness, LO→Learning Orientation, SEC→Self-efficacy, PEXP→Previous programming experience, Motivation to learn, PEOU->Perceived ease of use, EL→Extraneous load, GL→Germane load, IL→Intrinsic load, PU→Perceived Usefulness, TEXP→ Training experience , SEC→Self-efficacy, CPL→ Computer Playfulness, GCK→ Generalized Computing Knowledge , ABL→ Ability to program

Means and standard deviation of construct/variables in the study are shown in Table 9.

Table 9
Descriptive Statistics

Descriptive Statistics			
	N	Mean	Std. Deviation
Personal Innovativeness (PINT)	258	5.44	1.54
Learning Orientation (LO)	258	5.99	.84
Pre-training Self-efficacy (SEC)	258	6.88	2.08
Motivation to learn (MVL)	258	6.27	.83
Perceived ease of use (PEOU)	258	6.13	.88
Intrinsic load (IL)	258	5.38	1.2
Extraneous load (EL)	258	2.57	1.71
Germane load (GL)	258	5.58	.84
Perceived Usefulness (PU)	258	6	.88
Training Experience (TEXP)	258	6.22	.84
Computer Playfulness (CPL)	258	5.27	.94
Quiz*	258	.79	.13
Generalized Computing Knowledge (GCK)	258	6.04	.83
Ability to program (ABL)	258	5.96	.85
Knowledge Structure Similarity (KSS)*	258	.24	.07
Post-training Self-efficacy (PSEC)	258	8	1.47

* Quiz and KSS range from 0 to 1.

Results

ANCOVA and T-test were employed. Table 10 shows dependent variables descriptive statistics, and t-test. Before conducting the ANCOVA, the equality of variance across two groups was tested using Levene's statistic as shown in Table 11.

Table 10
Means and T-test

Variable	Group	N	Mean	Std. Deviation	t statistic
KSS	0	121	.22	.07	-2.66
	1	137	.25	.07	
GPK	0	121	6.04	.86	.03
	1	137	6.04	.80	
ABL	0	121	5.95	.82	.16
	1	137	5.96	.87	
Quiz	0	121	.77	.12	-2.79
	1	137	.82	.15	
TEXP	0	121	6.17	.87	-.91
	1	137	6.26	.82	
PSEC	0	121	7.70	1.73	-3.2
	1	137	8.27	1.13	
EL	0	121	2.86	1.88	2.61
	1	137	2.31	1.51	
GL	0	121	5.08	.67	-10.64
	1	137	6.01	.73	

Groups are significantly different with respect to extraneous load, germane load, knowledge structure similarity, post-training self-efficacy, and quiz score.

Table 11
Levene's test for equality of variance

	Levene's Statistic	df1	df2	Sig.
GPK	.00	1	256	.96
AB	.57	1	256	.45
KSS	.10	1	256	.75
Quiz	3.38	1	256	.07
PSEC	18.50	1	256	.00
TEXP	.00	1	256	.99
EL	12.72	1	256	.00
GL	.13	1	256	.72

Note: EL→ Extraneous load, GL→ Germane load, TEXP→ Training experience, GCK→ Generalized Computing Knowledge, ABL→ Ability to program, KSS→ Knowledge Structure Similarity, Quiz→ Programming Quiz

Some of the outcome variables (post-training self-efficacy and extraneous load), do not have equal variance across two groups In order to counteract this violation, it is suggested that in researcher use a stricter p-value resulting from Welch and Brown-Forsythe test (Brown, & Forsythe, 1974). The results in Table 12 suggests that adjusting for unequal variance, the control and treatment groups are still significantly different (i.e., results in Table 10 holds).

Table 12
Brown-Forsythe and Welch test results

		Statistic	df1	df2	Sig.
GCK	Welch	.00	1	245.76	1.00
	Brown-Forsythe	.00	1	245.76	1.00
ABL	Welch	.03	1	254.97	.87
	Brown-Forsythe	.03	1	254.97	.87
KSS	Welch	7.07	1	252.10	.01
	Brown-Forsythe	7.07	1	252.10	.01
Quiz	Welch	7.95	1	254.85	.01
	Brown-Forsythe	7.95	1	254.85	.01
PSEC	Welch	9.73	1	201.36	.00
	Brown-Forsythe	9.73	1	201.36	.00
TEXP	Welch	.82	1	247.26	.37
	Brown-Forsythe	.82	1	247.26	.37
EL	Welch	6.62	1	229.86	.01
	Brown-Forsythe	6.62	1	229.86	.01
GL	Welch	114.37	1	255.53	.00
	Brown-Forsythe	114.37	1	255.53	.00

Given that there is no significant difference in the proportion of participants across the two the groups, and sample size in two groups is approximately equal, the experiment can be considered to have balanced design, bolstering ANCOVA's robustness against normality and variance homogeneity violations (Hair, Anderson, Tatham, & William, 1998; Neter, Wasserman, & Kutner, 1985). Table 13 shows ANCOVA results.

Table 13
ANCOVA Results

	EL				EXP				GL				GPK			
Source	Sum of Squares	df	Mean Square	F	Sum of Squares	Df	Mean Square	F	Sum of Squares	df	Mean Square	F	Sum of Squares	df	Mean Square	F
PINT	.13	1	.13	.06	.07	1	.07	.24	.03	1	.03	.08	.11	1	.11	.34
LO	.19	1	.19	.10	.00	1	.00	.00	.01	1	.01	.03	1.03	1	1.03	3.25
SEC	.51	1	.51	.26	.01	1	.01	.03	.00	1	.00	.01	.55	1	.55	1.74
PEXP	1.27	1	1.27	.64	.86	1	.86	2.78	.28	1	.28	.81	.02	1	.02	.06
GEN	.02	1	.02	.01	.10	1	.10	.32	.54	1	.54	1.53	.12	1	.12	.37
EDU	.99	1	.99	.50	.01	1	.01	.04	1.65	1	1.65	4.70*	.53	1	.53	1.66
Age	5.58	1	5.58	2.82	.66	1	.66	2.13	.06	1	.06	.18	.26	1	.26	.81
MVL	7.59	1	7.59	3.84	.23	1	.23	.76	3.92	1	3.92	11.17**	2.61	1	2.61	8.23*
PEOU	42.39	1	42.39	21.44***	23.63	1	23.63	76.81***	6.39	1	6.39	18.18***	26.13	1	26.13	82.36***
PU	.00	1	.00	.00	13.47	1	13.47	43.78***	3.95	1	3.95	11.25**	6.75	1	6.75	21.29***
CPL	.04	1	.04	.02	.31	1	.31	.99	.01	1	.01	.02	.06	1	.06	.18
IL	67.20	1	67.20	33.99***	1.50	1	1.50	4.88*	.01	1	.01	.03	1.12	1	1.12	3.50
TRM	10.71	1	10.71	5.41*	.37	1	.37	1.20	51.83	1	51.83	147.59***	.00	1	.00	.00
Error	482.43	244	1.98		75.06	244	.31		85.69	244	.35		77.40	244	.32	
Total	752.22	257			182.27	257			182.80	257			175.73	257		

* $p < .05$. ** $p < .01$. *** $p < .001$.

Note: PINT→Personal Innovativeness, LO→Learning Orientation, SEC→Self-efficacy, PEXP→Previous programming experience, GEN→ Gender, EDU→Education, MVL→ Motivation to learn, PEOU->Perceived ease of use, EL→Extraneous load, GL→Germane load, IL→Intrinsic load, PU→ Perceived Usefulness, TEXP→ Training experience, SEC→Self-efficacy, CPL→ Computer Playfulness, GCK→ Generalized Computing Knowledge, ABL→ Ability to program, KSS→ Knowledge Structure

Table 13
ANCOVA Results (cont.)

	PSEC				Quiz				KSS				ABL			
Source	Sum of Squares	Df	Mean Square	F	Sum of Squares	Df	Mean Square	F	Sum of Squares	df	Mean Square	F	Sum of Squares	df	Mean Square	F
PINT	.81	1	.81	.46	.024	1	.024	1.32	.251	1	.00	.42	.05	1	.05	.14
LO	.29	1	.29	.16	.022	1	.022	1.24	.266	1	.00	.01	1.17	1	1.17	3.58
SEC	.18	1	.18	.10	.000	1	.000	.00	1.000	1	.00	.01	.19	1	.19	.57
PEXP	.13	1	.13	.07	.008	1	.008	.47	.495	1	.00	.03	.10	1	.10	.30
GEN	4.31	1	4.31	2.44	.022	1	.022	1.22	.269	1	.00	.01	2.00	1	2.00	6.10*
EDU	4.99	1	4.99	2.82	.002	1	.002	.09	.764	1	.00	.82	.31	1	.31	.93
Age	.05	1	.05	.03	.021	1	.021	1.17	.281	1	.00	.01	.13	1	.13	.39
MVL	6.83	1	6.83	3.86	.010	1	.010	.58	.448	1	.00	.04	.51	1	.51	1.57
PEOU	.24	1	.24	.14	.012	1	.012	.67	.415	1	.03	5.17	33.04	1	33.04	101.03**
PU	11.65	1	11.65	6.59*	.002	1	.002	.10	.750	1	.00	.37	2.34	1	2.34	7.14**
CPL	34.43	1	34.43	19.46***	.014	1	.014	.80	.373	1	.01	1.74	.07	1	.07	.21
ILM	.40	1	.40	.23	.004	1	.004	.23	.631	1	.03	4.82*	1.15	1	1.15	3.52
TRM	22.54	1	22.54	12.74***	.098	1	.098	5.44*	.020	1	.03	5.87*	.02	1	.02	.05
Error	431.69	244	1.77		4.398	244	.018			244	.01		79.80	244	.33	
Total	554.45	257			4.720	257			1.44	257			184.40	257		

* *p* < .05. ** *p* < .01. *** *p* <.001.

Note: PINT→Personal Innovativeness, LO→Learning Orientation, SEC→Self-efficacy, PEXP→Previous programming experience, GEN→ Gender, EDU→Education, MVL→ Motivation to learn, PEOU->Perceived ease of use, EL→Extraneous load, GL→Germane load, IL→Intrinsic load, PU→ Perceived Usefulness, TEXP→ Training experience, SEC→Self-efficacy, CPL→ Computer Playfulness, GCK→ Generalized Computing Knowledge, ABL→ Ability to program, KSS→ Knowledge Structure

As seen from Table 10 and 13, mental rehearsal was effective in reducing the extraneous load. The treatment group had significantly lower extraneous load ($t = 2.61$, $p<0.05$) and significantly higher germane load ($t= -10.64$, $p<0.05$). The intervention also enhanced post-training self-efficacy. The treatment group had significantly higher post-training self-efficacy ($t= -2.79$, $p <0.04$).

Each trainee's network of knowledge structures was compared with the reference to obtain KSS for each individual in both groups. The average of KSS in the intervention group (KSS=.25) was significantly higher ($t = -2.66$, $p <0.05$) than the control group (KSS=.22) as seen from Table 10. Thus, mental rehearsal was effective in the formation of learners' schemas that corresponded more closely to the experts' knowledge structures. H1, H2, H3, H7, and H8 are supported by the analysis, while hypotheses H4, H5, H6 did not find significant support. To further understand how training intervention impacted trainees knowledge structures, the similarity measure of experts' knowledge structures (i.e., the referent) with knowledge structures obtained from the average training-group network and the average control-group network was investigated. Results are shown Table 14[6]. Details of each trainee's KSS can be found in Appendix D

Table 14
Knowledge structure similarity with respect to domain expert

Comparison	Common links	C-E[C]	Similarity	S-E[S]	P(C_or_more)
Expert- Treatment	7	3.7	0.39	0.23	0.000
Expert-Control	6	2.7	0.32	0.16	0.052

[6] Where C-E[C]: C minus the C expected by chance
Similarity (S): C / (Links1 + Links2 – C)
S-E[S]: S minus S expected by chance
P(C or more): probability of C or more links in common by chance:

As Table 14 shows, experts knowledge structures shared more commonality with the intervention group (similarity score =.39) as compared to the control group (similarity score =.32). The metric S-E[S] in the pathfinder output, indicates what the similarity score would have been between two networks based on chance. Other metric, P(C or more), indicate whether the observed similarity, and that expected by chance was significantly different. Essentially, it tested the null hypothesis that the similarity measure (i.e., KSS) for a focal pair of networks obtained from data is equal to the one that is purely based on the chance for the same pair. Based on Table 14, the similarity measure for *treatment group-expert referent* obtained from data was significantly different from the similarity metric obtained for the same pair based on chance, thus rejecting the null. On the other hand, one fails to reject the null hypothesis that the similarity measure for *control group-expert referent* obtained from data was significantly different from the similarity metric obtained for the same pair based on chance at $\alpha = .05$. Thus, any similarity observed treatment and the expert referent was due to the training provided. It must be noted that the p-value for the for *control group-expert referent* pair was tending towards significance and was only slightly greater than 0.05. Based on the magnitudes, it was concluded that the treatment group indeed had formed schemas which related to the expert referent significantly more compared to the control group. These scores were derived by comparing the reference with the knowledge structures obtained from the mean network in respective groups (i.e. control and intervention)[7]. Table 15 shows the snapshot of analyses.

[7] Pathfinder software allows to average proximity files. Proximity files for each group were averaged, and pathfinder network derived from this mean proximity file was compared to the pathfinder network derived from the proximity file of the expert reference. R statistical software was used for data manipulation. Appendix E gives the codes used to derive proximity files from raw data. These are used as input for pathfinder software.

Table 15
Summary of results

Hypothesis	Support
H1: Addition of mental rehearsal to the baseline training will increase the germane load.	Yes
H2: Addition of mental rehearsal to the baseline training will reduce the extraneous load.	Yes
H3: Addition of mental rehearsal to the baseline training will have a positive impact on KSS.	Yes
H4: Addition of mental rehearsal to the baseline training will enhance generalized knowledge.	No
H5 Addition of mental rehearsal to the baseline training will enhance the ability to program.	No
H6: Addition of mental rehearsal to the baseline training will enhance the training experience.	No
H7: Addition of mental rehearsal to the baseline training will have a positive impact on the quiz score.	Yes
H8: Addition of mental rehearsal to the baseline training will enhance post-training self-efficacy.	Yes

Discussion

The purpose of this research was to establish relationships between mental rehearsal and cognitive load. Mental rehearsal has long been shown to be effective in various settings, and for different types of training context (Clark, 1960; Corbin, 1967; Egstrom, 1964; Etnier & Landers, 1996; Grouios, 1992a, 1992b; Perry, 1939; Rawlings & Rawlings, 1974; Romero & Silvestri, 1990; Sackett, 1934; Ungerleider & Golding, 1991).

Education research has shown that mental rehearsal increases the efficacy of the training intervention (Dewitt, 2007; Leahy & Sweller, 2007). Cognitive load theory (Sweller, 1998) provides a useful framework to understand how mental rehearsal works. Results indicated that mental rehearsal was useful in reducing perceptions of extraneous load, while increasing perceptions of the germane load. The study provided validation of mental rehearsal effectivity using a well-established theoretical framework. Further, the study was conducted in the context of a technology-mediated MOOC environment and provided a way in which effectiveness of MOOCs can be increased. This study found that compared to the control group, the intervention led to the reduction of extraneous load, increased germane load, increased post-training self-efficacy, and increased scores on the quiz. The intervention group also formed knowledge structures that were in greater agreement with experts in comparison to the control group. Interestingly, there was no significant difference found in generalized computing knowledge, training experience, and ability to program. These outcomes were significantly predicted by TAM variables. Additionally, training experience was significantly predicted by the intrinsic load. This underscores prior IS research's emphasis on TAM, but at the same time sheds light on the need to explore theoretical frameworks relevant to learning, especially when research revolves around technology training. Designing a challenging training program while making the system easy to use and useful leads to high degree of learning, but at the same time leaves some room for improvement in focal participant's objective understanding of the training material. This is evident by different levels of knowledge similarity and the quiz scores across the two groups. This study controlled for variables that may have offered rival explanations for the effectiveness of mental rehearsal. Overall, the results indicated that mental rehearsal was effective in a technology-mediated environment. Administrators and training professionals can consider opting for retention enhancement add-on to the MOOC training to improve outcomes.

Theoretical Contributions

This research makes several important contributions to the literature. This research contributes to two domains: (1) Education; and (2) Information Systems.

Education research has long argued about the well-demonstrated effectiveness of mental rehearsal and recently tied it with the cognitive load theory (Leahy & Sweller, 2004). This study went further, and empirically examined the components of cognitive load contributing to the effectiveness of mental rehearsal. In terms of IS contribution, it answered the recent calls to develop effective training methods for technology training (Alavi, & Leidner, 2001; Gupta & Bostrom, 2013). It tested the effectiveness of an intervention using a well-established framework of CLT in a context of technology-mediated learning (i.e., MOOCs.) As the need for technology-savvy workforce increases, education delivered by MOOCs play an ever-increasing role in satisfying the demand. This study was an attempt to develop a theoretically tested training intervention in the context of TML.

The ideas of schemas and knowledge structures are very important in training research (Bandura 1969, Sweller 1998). They have received some attention in IS research (Davis & Yi 2004) but need to be explored and employed more. After all, one of the objective ways to understand the effectiveness of a training intervention is to measure knowledge structures of the participants. This study empirically tested relationships between cognitive load theory and knowledge structures. The notion that a well-designed training intervention (i.e. high in inducing germane load, and low in extraneous load), leads to the formation of problem-relevant knowledge structures was empirically examined. By placing CLT in a technology-mediated context, and weaving it into extant work on knowledge structures, this study extended IS literature on training. In all, this research drew from two field education and IS, and contributed back to them by providing a more nuanced understanding of learning processes.

Limitations and Future Research

Like all research, this research also has limitations. The study was conducted as an on-line experiment, and all possible steps were taken to control all aspects the study, but results could differ if it occurred as a lab study. Further, the total training duration was restricted to 90 minutes, while actual training programs can run substantially longer, and could lead to different results.

The current study focused on individual learning. Given that programming usually has a heavy team component, future research can potentially explore team processes relevant to learning. In future, more research can be done on shared mental models (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Mohammed, Klimoski, & Rentsch, 2000), as they are relevant in team programming context.

Every attempt was made to equalize the intervention and the control group. Training duration was equalized across the two groups. The control group was encouraged to practice with the online coding environment while the intervention group engaged in the mental rehearsal. Due to technology limitations it was not possible to track the control group. Hence, one cannot be entirely sure about the nature of the activity that the control group engaged in while intervention group was performing mental rehearsal. This limitation can be avoided in the future if the study is replicated in the controlled physical lab environment where facilitator(s) can monitor the participants.

Another limitation was in terms of nature of knowledge structures. The current study considered knowledge structures as a collection of "facts, things or concepts" (Day, Arthur Jr, & Gettman, 2001; Edwards, Day, Arthur Jr, & Bell, 2006; Johnson-Laird, 1983; Rouse & Morris, 1986; Rowe & Cooke, 1995). However, recent neuroscience literature suggests that knowledge structures or mental schemas are hierarchical structures that encode sequential actions (Botvinik, 2007; Grafton & Hamilton, 2007). Langston, Kramer, & Glenberg (1998) points out the nature of mental schema is "quintessentially semantic". The meaning in schemas is inherent; this implies a sense of hierarchy or sequence among the concepts. Future research can further explore the hierarchical nature of schemas.

Conclusion

The purpose of this research was to understand cognitive processes relevant to the learning and their relationship with mental rehearsal. This study focused on understanding how mental rehearsal works. Cognitive load theory (CLT) was used as a theoretical lens for this study. The effectiveness of mental rehearsal was hypothesized to stem from the manner in which it relates to the cognitive architecture. Mental rehearsal can guide and focus participants' attention on learning the subject material, increasing the perception of learning (i.e. germane load) while minimizing noise (i.e. extraneous load). Mental rehearsal's effectiveness was also captured in the schema formation. The rehearsal group formed knowledge structures that shared greater similarity to experts' knowledge structures compared to the control group. Generalized computing knowledge, ability to program, training experience, and post-training self-efficacy were also collected as additional training outcomes. Rehearsal significantly improved post-training self-efficacy but did not have a significant impact on generalized computing knowledge, ability to program, training experience. Instead, these outcomes were driven by TAM variables.

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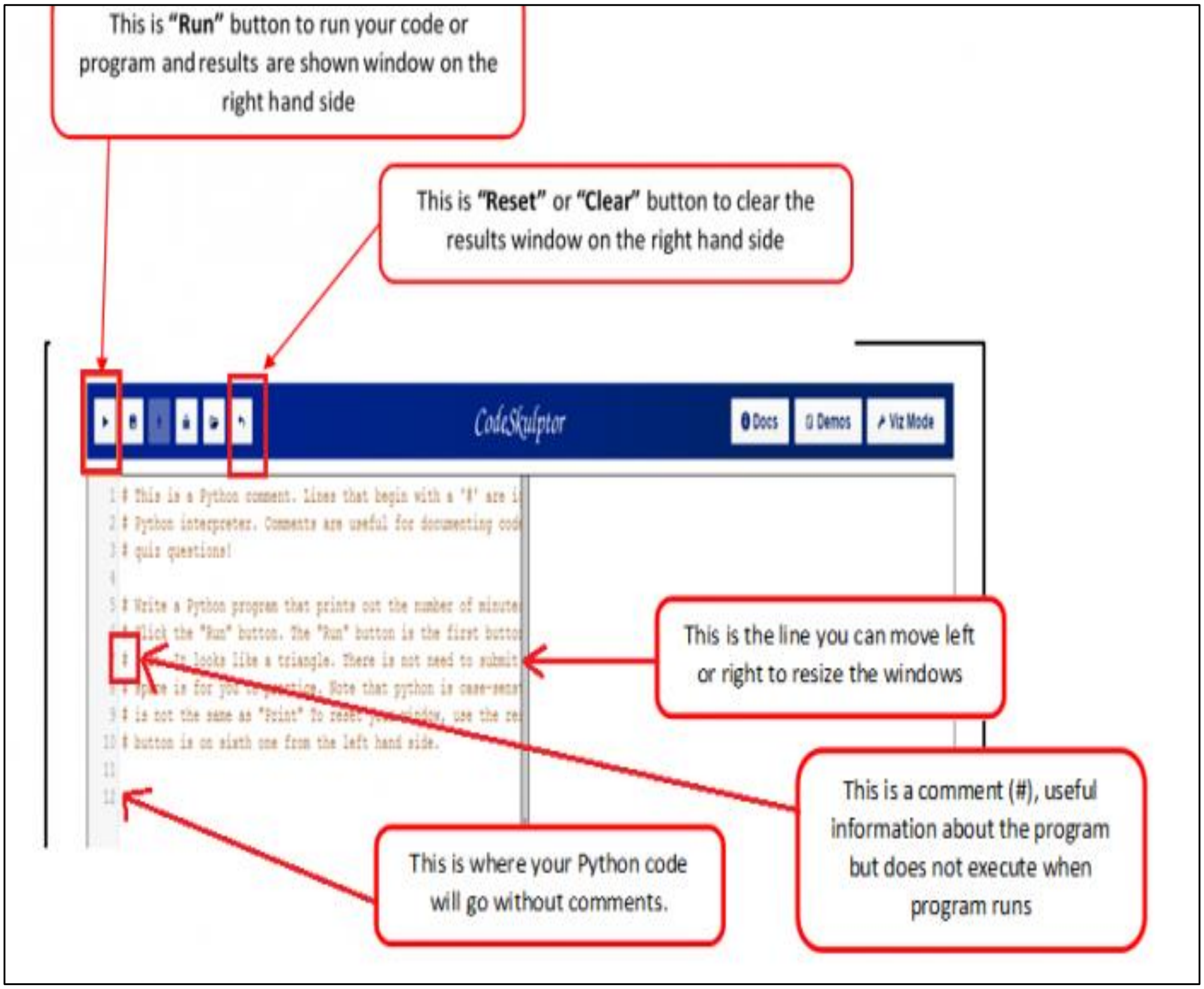
Appendix A – Activity Details

Control		Intervention		Video Link
Round 1- Introduction		Round 1- Introduction		
Video 1	2 minutes	Video 1	2 minutes	https://www.youtube.com/watch?v=XFZxSogAwXo
Video2	4 minutes	Video2	4 minutes	https://www.youtube.com/watch?v=tAR3ZAwKc78#t=33
Video 3	2 minutes	Video 3	2 minutes	https://www.youtube.com/watch?v=wCVrTLsYEng
Video 4	4 minutes	Video 4	4 minutes	https://www.youtube.com/watch?v=4sdCAEJ6XIA
Practice	4 minutes	Practice	4 minutes	
Practice	4 minutes	Practice	4 minutes	
Round 2- Ambiguity & Grammar		Round 2- Ambiguity & Grammar		
Video 1	2 minutes	Video 1	2 minutes	https://www.youtube.com/watch?v=7lNWFzAJWys
Video 2	4 minutes	Video 2	4 minutes	https://www.youtube.com/watch?v=MDUusVkDCXA
Video 3	5 minutes	Video 3	5 minutes	https://www.youtube.com/watch?v=B4wMpOhOako
Video 4	1 minute	Vide 4	1 minute	https://www.youtube.com/watch?v=JBiT_Nl-QtQ#t=13
Practice	4 minutes	Practice	4 minutes	
Video 5	6 minutes	Video 5	7 minutes	https://www.youtube.com/watch?v=mFkc8ktkAXE
Practice	3 minutes	Practice	3 minutes	
Practice	3 minutes	Practice	3 minutes	
Video 6	1 minute	Video 6	1 minute	https://www.youtube.com/watch?v=I_zY4o8ocFY
Practice	4 minutes	Rehearsal	4 minutes	
Round 3 – Variables		Round 3 – Variables		
Video 1	3 minutes	Video 1	3 minutes	https://www.youtube.com/watch?v=EkF4R4HRsuk
Video 2	2 minutes	Video 2	2 minutes	https://www.youtube.com/watch?v=wx5--g_2UPo#t=49
Practice	3 minutes	Practice	3 minutes	
Video	5 minutes	Video	5 minutes	https://www.youtube.com/watch?v=3l33WBJuAFI
Practice	4 minutes	Practice	4 minutes	
Practice	4 minutes	Rehearsal	4 minutes	
Round 4 – Strings		Round 4 – Strings		
Video 1	4 minutes	Video 1	4 minutes	https://www.youtube.com/watch?v=3A3TFVDrLCA
Practice	3 minutes	Practice	3 minutes	
Video	2 minutes	Video	2 minutes	https://www.youtube.com/watch?v=-2ioTOZML34
Practice	3 minutes	Practice	3 minutes	
Practice	4 minutes	Rehearsal	4 minutes	

Appendix B – Practice Environment



It can be accessed at http://www.codeskulptor.org/#user40_XzS3p71lOW_0.py

1) Run button: This is the first button from left, and look like a triangle (as highlighted in the image above), when you click it, it will run the code participants type.

2) Reset or Clear button: This is the last button (or the right-most button again highlighted in the image above). When you click, this button, it will clear/reset the window. If a participant makes mistakes and wants to rewrite the code, then this button should be clicked.

Comments: In Python language, the statements starting with **"#"** sign are called comment and ignored by Python in-browser editor. They are useful for the programmer to know more about the program but are not executed when you run the program.

Again, note that comment starts with symbol **#.** As soon as one remove this symbol, that line will be considered as part of the Python program and will run when you execute the program. Comments are a useful way for programmers to know what their program does.

Note: participants need not need to submit or save anything, this in-browser Python window is designed for practice. The rest of the buttons are **not useful or required** for training purposes.

Further**, windows can be resized** by moving the middle line. So for example if participants want to increase the size of the left-hand side where the code is written then they will move the divider line to the right.

Appendix C – Concepts

Concept	**Working Definition**
Program	Coded instructions for (a computer or other machine) for the automatic performance of a particular task i.e. implementation of algorithms.
Algorithm	A process or set of rules to be followed in calculations or other problem-solving operations.
Interpreter	An interpreter translates high-level instructions from a computer program into an intermediate form, which it then executes immediately.
Grammar	Rules followed by a specific computer language such as python to construct instructions.
Backus-Naur Form (BNF)	One of most prevalent notation techniques for implementing programming language grammars often used to describe the syntax of languages used in computer programming.
Expression	It is any legal combination of symbols, variables and/or constants that represents a value, and evaluated as per evaluation rules of a programming language such as Python.
Variables	A named unit of storage that can be changed to any of a set of specified values during execution of a program. A variable can change value throughout the computer program. A variable can be of any type (i.e. integer, string, etc.) as allowed by rules of the computer language.
String	A data type used in programming, such as an integer, but is used to represent text rather than numbers. It is comprised of a set of characters that can also contain spaces and numbers. For example, the word "hamburger" and the phrase "I ate 3 hamburgers" are both strings. Even "12345" could be considered a string if specified correctly. Typically, programmers must enclose strings in quotation marks for the data to recognize as a string and not a number or variable name.
Syntax Error	A situation resulting from incorrect code (i.e. code is not following grammatical/syntax rules of the language) in the computer program leading to the undesired result.
Semantic Error	A situation resulting from a logical or arithmetic mistake in the computer program produces an undesired result. Note that semantic error may be harder to catch because often times there are no apparent mistakes in the grammar of the code but in the meaning, flow or logic of the statement.

Appendix D – KSS details

ID	Group	Nodes	Links1	Links2	Common	C-E[C]	Similarity	S-E[S]	P(C_or_more)
1	Treatment	10	14	16	7	2.00	0.30	0.10	0.15
2	Treatment	10	14	14	5	0.60	0.22	0.03	0.45
3	Treatment	10	14	22	7	0.20	0.24	0.00	0.59
4	Treatment	10	14	16	7	2.00	0.30	0.10	0.15
5	Treatment	10	14	27	11	2.60	0.37	0.11	0.08
6	Treatment	10	14	16	8	3.00	0.36	0.16	0.05
7	Treatment	10	14	15	5	0.30	0.21	0.01	0.54
8	Treatment	10	14	16	3	2.00	0.11	0.09	0.96
9	Treatment	10	14	17	7	1.70	0.29	0.08	0.21
10	Treatment	10	14	17	8	2.70	0.35	0.14	0.07
11	Treatment	10	14	16	5	0.00	0.20	0.00	0.62
12	Treatment	10	14	35	9	1.90	0.23	0.06	0.97
13	Treatment	10	14	23	8	0.80	0.28	0.03	0.41
14	Treatment	10	14	13	6	2.00	0.29	0.11	0.15
15	Treatment	10	14	22	8	1.20	0.29	0.05	0.34
16	Treatment	10	14	17	7	1.70	0.29	0.08	0.21
17	Treatment	10	14	15	6	1.30	0.26	0.07	0.28
18	Treatment	10	14	34	11	0.40	0.30	0.01	0.53
19	Treatment	10	14	27	9	0.60	0.28	0.02	0.48
20	Treatment	10	14	30	9	0.30	0.26	0.01	0.72
21	Treatment	10	14	28	11	2.30	0.36	0.09	0.12
22	Treatment	10	14	15	6	1.30	0.26	0.07	0.28
23	Treatment	10	14	14	5	0.60	0.22	0.03	0.45
24	Treatment	10	14	17	7	1.70	0.29	0.08	0.21
25	Treatment	10	14	18	6	0.40	0.23	0.01	0.52
26	Treatment	10	14	45	14	0.00	0.31	0.00	1.00
27	Treatment	10	14	19	7	1.10	0.27	0.05	0.35
28	Treatment	10	14	12	6	2.30	0.30	0.13	0.10
29	Treatment	10	14	14	5	0.60	0.22	0.03	0.45
30	Treatment	10	14	13	3	1.00	0.13	0.06	0.86
31	Treatment	10	14	13	7	3.00	0.35	0.17	0.04
32	Treatment	10	14	21	5	1.50	0.17	0.07	0.91
33	Treatment	10	14	18	6	0.40	0.23	0.01	0.52
34	Treatment	10	14	45	14	0.00	0.31	0.00	1.00
35	Treatment	10	14	45	14	0.00	0.31	0.00	1.00
36	Treatment	10	14	30	12	2.70	0.38	0.10	0.07
37	Treatment	10	14	16	1	4.00	0.03	0.17	1.00
38	Treatment	10	14	19	8	2.10	0.32	0.10	0.15
39	Treatment	10	14	16	5	0.00	0.20	0.00	0.62
40	Treatment	10	14	14	6	1.60	0.27	0.08	0.21
41	Treatment	10	14	24	10	2.50	0.36	0.11	0.09
42	Treatment	10	14	21	8	1.50	0.30	0.06	0.27
43	Treatment	10	14	29	11	2.00	0.34	0.08	0.16
44	Treatment	10	14	25	10	2.20	0.35	0.09	0.13
45	Treatment	10	14	12	5	1.30	0.24	0.07	0.28
46	Treatment	10	14	17	6	0.70	0.24	0.03	0.44
47	Treatment	10	14	11	6	2.60	0.32	0.15	0.06
48	Treatment	10	14	15	4	0.70	0.16	0.04	0.78
49	Treatment	10	14	18	7	1.40	0.28	0.06	0.28

50	Treatment	10	14	15	6	1.30	0.26	0.07	0.28
51	Treatment	10	14	15	4	0.70	0.16	0.04	0.78
52	Treatment	10	14	12	6	2.30	0.30	0.13	0.10
53	Treatment	10	14	10	1	2.10	0.04	0.11	0.99
54	Treatment	10	14	11	6	2.60	0.32	0.15	0.06
55	Treatment	10	14	29	10	1.00	0.30	0.04	0.38
56	Treatment	10	14	14	2	2.40	0.08	0.11	0.98
57	Treatment	10	14	14	5	0.60	0.22	0.03	0.45
58	Treatment	10	14	15	8	3.30	0.38	0.19	0.03
59	Treatment	10	14	16	4	1.00	0.15	0.05	0.84
60	Treatment	10	14	13	4	0.00	0.17	0.01	0.64
61	Treatment	10	14	14	6	1.60	0.27	0.08	0.21
62	Treatment	10	14	10	4	0.90	0.20	0.05	0.37
63	Treatment	10	14	16	6	1.00	0.25	0.05	0.36
64	Treatment	10	14	22	6	0.80	0.20	0.04	0.81
65	Treatment	10	14	12	3	0.70	0.13	0.04	0.81
66	Treatment	10	14	14	4	0.40	0.17	0.02	0.72
67	Treatment	10	14	9	2	0.80	0.10	0.05	0.85
68	Treatment	10	14	21	8	1.50	0.30	0.06	0.27
69	Treatment	10	14	31	8	1.60	0.22	0.06	0.93
70	Treatment	10	14	18	5	0.60	0.19	0.03	0.76
71	Treatment	10	14	11	4	0.60	0.19	0.03	0.47
72	Treatment	10	14	22	6	0.80	0.20	0.04	0.81
73	Treatment	10	14	14	7	2.60	0.33	0.15	0.07
74	Treatment	10	14	18	6	0.40	0.23	0.01	0.52
75	Treatment	10	14	30	12	2.70	0.38	0.10	0.07
76	Treatment	10	14	45	14	0.00	0.31	0.00	1.00
77	Treatment	10	14	12	6	2.30	0.30	0.13	0.10
78	Treatment	10	14	11	5	1.60	0.25	0.09	0.21
79	Treatment	10	14	16	6	1.00	0.25	0.05	0.36
80	Treatment	10	14	13	6	2.00	0.29	0.11	0.15
81	Treatment	10	14	10	4	0.90	0.20	0.05	0.37
82	Treatment	10	14	27	10	1.60	0.32	0.06	0.24
83	Treatment	10	14	17	5	0.30	0.19	0.02	0.70
84	Treatment	10	14	25	7	0.80	0.22	0.03	0.80
85	Treatment	10	14	17	8	2.70	0.35	0.14	0.07
86	Treatment	10	14	13	2	2.00	0.08	0.10	0.97
87	Treatment	10	14	13	4	0.00	0.17	0.01	0.64
88	Treatment	10	14	22	6	0.80	0.20	0.04	0.81
89	Treatment	10	14	25	9	1.20	0.30	0.05	0.32
90	Treatment	10	14	16	7	2.00	0.30	0.10	0.15
91	Treatment	10	14	14	4	0.40	0.17	0.02	0.72
92	Treatment	10	14	11	3	0.40	0.14	0.03	0.75
93	Treatment	10	14	14	7	2.60	0.33	0.15	0.07
94	Treatment	10	14	12	7	3.30	0.37	0.20	0.02
95	Treatment	10	14	12	5	1.30	0.24	0.07	0.28
96	Treatment	10	14	24	7	0.50	0.23	0.02	0.73
97	Treatment	10	14	28	6	2.70	0.17	0.10	0.98
98	Treatment	10	14	18	7	1.40	0.28	0.06	0.28
99	Treatment	10	14	45	14	0.00	0.31	0.00	1.00
100	Treatment	10	14	22	8	1.20	0.29	0.05	0.34
101	Treatment	10	14	18	6	0.40	0.23	0.01	0.52
102	Treatment	10	14	16	7	2.00	0.30	0.10	0.15

103	Treatment	10	14	26	7	1.10	0.21	0.04	0.85
104	Treatment	10	14	15	5	0.30	0.21	0.01	0.54
105	Treatment	10	14	17	6	0.70	0.24	0.03	0.44
106	Treatment	10	14	13	6	2.00	0.29	0.11	0.15
107	Treatment	10	14	17	4	1.30	0.15	0.06	0.88
108	Treatment	10	14	20	9	2.80	0.36	0.13	0.07
109	Treatment	10	14	45	14	0.00	0.31	0.00	1.00
110	Treatment	10	14	17	5	0.30	0.19	0.02	0.70
111	Treatment	10	14	15	5	0.30	0.21	0.01	0.54
112	Treatment	10	14	45	14	0.00	0.31	0.00	1.00
113	Treatment	10	14	14	3	1.40	0.12	0.07	0.90
114	Treatment	10	14	37	13	1.50	0.34	0.05	0.21
115	Treatment	10	14	16	6	1.00	0.25	0.05	0.36
116	Treatment	10	14	16	4	1.00	0.15	0.05	0.84
117	Treatment	10	14	34	11	0.40	0.30	0.01	0.53
118	Treatment	10	14	9	5	2.20	0.28	0.14	0.09
119	Treatment	10	14	26	11	2.90	0.38	0.12	0.06
120	Treatment	10	14	23	8	0.80	0.28	0.03	0.41
121	Treatment	10	14	18	6	0.40	0.23	0.01	0.52
122	Treatment	10	14	25	8	0.20	0.26	0.01	0.57
123	Treatment	10	14	30	8	1.30	0.22	0.05	0.89
124	Treatment	10	14	13	3	1.00	0.13	0.06	0.86
125	Treatment	10	14	21	6	0.50	0.21	0.03	0.75
126	Treatment	10	14	18	6	0.40	0.23	0.01	0.52
127	Treatment	10	14	14	4	0.40	0.17	0.02	0.72
128	Treatment	10	14	21	6	0.50	0.21	0.03	0.75
129	Treatment	10	14	11	4	0.60	0.19	0.03	0.47
130	Treatment	10	14	16	7	2.00	0.30	0.10	0.15
131	Treatment	10	14	42	14	0.90	0.33	0.03	0.32
132	Treatment	10	14	17	6	0.70	0.24	0.03	0.44
133	Treatment	10	14	24	7	0.50	0.23	0.02	0.73
134	Treatment	10	14	23	6	1.20	0.19	0.05	0.86
135	Treatment	10	14	10	5	1.90	0.26	0.11	0.14
136	Treatment	10	14	28	7	1.70	0.20	0.06	0.93
137	Treatment	10	14	19	8	2.10	0.32	0.10	0.15
1	Control	10	14	21	5	1.50	0.17	0.07	0.91
2	Control	10	14	16	7	2.00	0.30	0.10	0.15
3	Control	10	14	18	7	1.40	0.28	0.06	0.28
4	Control	10	14	21	7	0.50	0.25	0.02	0.51
5	Control	10	14	14	5	0.60	0.22	0.03	0.45
6	Control	10	14	11	4	0.60	0.19	0.03	0.47
7	Control	10	14	28	9	0.30	0.27	0.01	0.56
8	Control	10	14	14	6	1.60	0.27	0.08	0.21
9	Control	10	14	19	4	1.90	0.14	0.08	0.94
10	Control	10	14	18	9	3.40	0.39	0.18	0.03
11	Control	10	14	16	4	1.00	0.15	0.05	0.84
12	Control	10	14	19	6	0.10	0.22	0.00	0.60
13	Control	10	14	13	6	2.00	0.29	0.11	0.15
14	Control	10	14	21	6	0.50	0.21	0.03	0.75
15	Control	10	14	13	4	0.00	0.17	0.01	0.64
16	Control	10	14	25	8	0.20	0.26	0.01	0.57
17	Control	10	14	24	7	0.50	0.23	0.02	0.73
18	Control	10	14	16	7	2.00	0.30	0.10	0.15

19	Control	10	14	17	5	0.30	0.19	0.02	0.70
20	Control	10	14	14	5	0.60	0.22	0.03	0.45
21	Control	10	14	17	4	1.30	0.15	0.06	0.88
22	Control	10	14	13	3	1.00	0.13	0.06	0.86
23	Control	10	14	23	7	0.20	0.23	0.01	0.66
24	Control	10	14	15	5	0.30	0.21	0.01	0.54
25	Control	10	14	12	2	1.70	0.08	0.09	0.95
26	Control	10	14	12	5	1.30	0.24	0.07	0.28
27	Control	10	14	13	6	2.00	0.29	0.11	0.15
28	Control	10	14	20	7	0.80	0.26	0.03	0.43
29	Control	10	14	21	6	0.50	0.21	0.03	0.75
30	Control	10	14	13	2	2.00	0.08	0.10	0.97
31	Control	10	14	14	8	3.60	0.40	0.21	0.02
32	Control	10	14	23	5	2.20	0.16	0.09	0.96
33	Control	10	14	22	8	1.20	0.29	0.05	0.34
34	Control	10	14	17	7	1.70	0.29	0.08	0.21
35	Control	10	14	11	2	1.40	0.09	0.08	0.93
36	Control	10	14	30	11	1.70	0.33	0.06	0.22
37	Control	10	14	13	4	0.00	0.17	0.01	0.64
38	Control	10	14	28	6	2.70	0.17	0.10	0.98
39	Control	10	14	12	5	1.30	0.24	0.07	0.28
40	Control	10	14	10	3	0.10	0.14	0.01	0.67
41	Control	10	14	18	6	0.40	0.23	0.01	0.52
42	Control	10	14	33	12	1.70	0.34	0.06	0.19
43	Control	10	14	24	7	0.50	0.23	0.02	0.73
44	Control	10	14	31	10	0.40	0.29	0.01	0.55
45	Control	10	14	21	7	0.50	0.25	0.02	0.51
46	Control	10	14	25	9	1.20	0.30	0.05	0.32
47	Control	10	14	11	5	1.60	0.25	0.09	0.21
48	Control	10	14	17	5	0.30	0.19	0.02	0.70
49	Control	10	14	24	8	0.50	0.27	0.02	0.49
50	Control	10	14	20	9	2.80	0.36	0.13	0.07
51	Control	10	14	23	6	1.20	0.19	0.05	0.86
52	Control	10	14	23	10	2.80	0.37	0.13	0.06
53	Control	10	14	19	4	1.90	0.14	0.08	0.94
54	Control	10	14	18	5	0.60	0.19	0.03	0.76
55	Control	10	14	16	3	2.00	0.11	0.09	0.96
56	Control	10	14	23	10	2.80	0.37	0.13	0.06
57	Control	10	14	13	5	1.00	0.23	0.05	0.37
58	Control	10	14	14	4	0.40	0.17	0.02	0.72
59	Control	10	14	11	2	1.40	0.09	0.08	0.93
60	Control	10	14	19	5	0.90	0.18	0.04	0.82
61	Control	10	14	12	4	0.30	0.18	0.01	0.56
62	Control	10	14	14	4	0.40	0.17	0.02	0.72
63	Control	10	14	9	2	0.80	0.10	0.05	0.85
64	Control	10	14	17	5	0.30	0.19	0.02	0.70
65	Control	10	14	21	8	1.50	0.30	0.06	0.27
66	Control	10	14	16	3	2.00	0.11	0.09	0.96
67	Control	10	14	12	5	1.30	0.24	0.07	0.28
68	Control	10	14	18	7	1.40	0.28	0.06	0.28
69	Control	10	14	19	6	0.10	0.22	0.00	0.60
70	Control	10	14	29	7	2.00	0.19	0.07	0.95
71	Control	10	14	17	6	0.70	0.24	0.03	0.44

72	Control	10	14	17	7	1.70	0.29	0.08	0.21
73	Control	10	14	15	2	2.70	0.07	0.12	0.99
74	Control	10	14	21	8	1.50	0.30	0.06	0.27
75	Control	10	14	15	6	1.30	0.26	0.07	0.28
76	Control	10	14	33	11	0.70	0.31	0.02	0.44
77	Control	10	14	17	6	0.70	0.24	0.03	0.44
78	Control	10	14	15	5	0.30	0.21	0.01	0.54
79	Control	10	14	11	5	1.60	0.25	0.09	0.21
80	Control	10	14	33	11	0.70	0.31	0.02	0.44
81	Control	10	14	13	4	0.00	0.17	0.01	0.64
82	Control	10	14	20	7	0.80	0.26	0.03	0.43
83	Control	10	14	31	10	0.40	0.29	0.01	0.55
84	Control	10	14	17	6	0.70	0.24	0.03	0.44
85	Control	10	14	12	5	1.30	0.24	0.07	0.28
86	Control	10	14	13	4	0.00	0.17	0.01	0.64
87	Control	10	14	17	9	3.70	0.41	0.20	0.02
88	Control	10	14	13	5	1.00	0.23	0.05	0.37
89	Control	10	14	18	5	0.60	0.19	0.03	0.76
90	Control	10	14	14	5	0.60	0.22	0.03	0.45
91	Control	10	14	18	6	0.40	0.23	0.01	0.52
92	Control	10	14	16	5	0.00	0.20	0.00	0.62
93	Control	10	14	23	9	1.80	0.32	0.08	0.19
94	Control	10	14	12	3	0.70	0.13	0.04	0.81
95	Control	10	14	27	8	0.40	0.24	0.02	0.72
96	Control	10	14	11	5	1.60	0.25	0.09	0.21
97	Control	10	14	27	7	1.40	0.21	0.06	0.89
98	Control	10	14	21	7	0.50	0.25	0.02	0.51
99	Control	10	14	15	6	1.30	0.26	0.07	0.28
100	Control	10	14	22	8	1.20	0.29	0.05	0.34
101	Control	10	14	35	10	0.90	0.26	0.03	0.86
102	Control	10	14	15	6	1.30	0.26	0.07	0.28
103	Control	10	14	19	5	0.90	0.18	0.04	0.82
104	Control	10	14	12	3	0.70	0.13	0.04	0.81
105	Control	10	14	26	6	2.10	0.18	0.08	0.95
106	Control	10	14	19	4	1.90	0.14	0.08	0.94
107	Control	10	14	15	3	1.70	0.12	0.08	0.93
108	Control	10	14	25	8	0.20	0.26	0.01	0.57
109	Control	10	14	15	4	0.70	0.16	0.04	0.78
110	Control	10	14	13	5	1.00	0.23	0.05	0.37
111	Control	10	14	14	4	0.40	0.17	0.02	0.72
112	Control	10	14	22	7	0.20	0.24	0.00	0.59
113	Control	10	14	24	8	0.50	0.27	0.02	0.49
114	Control	10	14	17	7	1.70	0.29	0.08	0.21
115	Control	10	14	27	7	1.40	0.21	0.06	0.89
116	Control	10	14	27	10	1.60	0.32	0.06	0.24
117	Control	10	14	14	4	0.40	0.17	0.02	0.72
118	Control	10	14	17	8	2.70	0.35	0.14	0.07
119	Control	10	14	21	8	1.50	0.30	0.06	0.27
120	Control	10	14	15	2	2.70	0.07	0.12	0.99
121	Control	10	14	15	2	2.70	0.07	0.12	0.99

Appendix E – UNIX and R Code

5) To read the knowledge structure file

- > library (XLConnect)   # load XLConnect package to read a excel file
- wk = loadWorkbook ("file_name.xls")
- df = readWorksheet (wk, sheet="Sheet1")
- # df is the data frame holding knowledge structure
- # Each row in df represents a vector belonging to a specific participants

6) Convert each row in data frame to a symmetric matrix

- library (corpcor)   # load corpcor package for matrix manipulation
- m <- list() # Define m as a list object
- # covert all vectors into matrix and store in list ‘m’
- for (i in 1:nrow(df)) {m[[i]]<-vec2sm(unname(unlist(df[i,])),diag=FALSE)}

7) Print the each lower matrix from a list object m containing symmetric matrices

- library (psych) # load pysch package for matrix printing
- z <- list() # Define z as a list object
- i = 1
- for (i in seq_along(m))
- + {z[[i]]<-capture.output(lowerMat(m[[i]]))
- +write.table(z[[i]],paste("filename",i,".txt",sep=""),col.names=FALSE,row.names=FALSE,sep=" ",quote=FALSE)}

8) UNIX commands to make the file suitable for pathfinder analysis

- for f in filename*.txt ; do cut -d " " -f 3- "$f" > "${f}".tmp && mv "${f}".tmp "$f"; done
- for f in filename*.txt ; do tail -n+2 "$f" > "${f}".tmp && mv "${f}".tmp "$f"; done
- for f in filename*.txt ; do cat trianing.txt "$f" > "${f}".tmp && mv "${f}".tmp "$f"; done

Further, notepad++ was used for batch formatting.

Appendix F- Measurement Items

Construct	Items	
Ability to program	ABL1	As a result of On-line training, I have the ability to declare a variable in computer program in Python language
	ABL2	As a result of On-line training, I have the ability to use string in a Python computer program
	ABL3	As a result of On-line training, I have the ability to write a simple Python computer program
	ABL4	As a result of On-line training, I have the ability to understand general programming language practices
	ABL5	As a result of On-line training, I have the ability to understand other programming languages similar to Python
	ABL6	As a result of On-line training, I feel confident in my ability to apply the skills learned in a different context
Training Experience	EXP1	I enjoyed this training program
	EXP2	I am satisfied with the training program
	EXP3	I would recommend this training program to others
	EXP4	Overall, I am satisfied with the quality of the training program that I have just received
Generalized Computing Knowledge	GCK1	On-line Python training increased my knowledge of terminology used in computer programming
	GCK2	On-line Python training increased my knowledge of String usage
	GCK3	On-line Python training increased my knowledge of Backus-Naur Form (BNF)
	GCK4	On-line Python training increased my awareness about Syntax errors
	GCK5	On-line Python training increased my awareness about Semantic errors
	GPK6	**On-line Python training increased my knowledge of computer programming in general**
Learning Orientation	LO1	The opportunity to learn new things is important to me
	LO2	The opportunity to do challenging work is important to me
	LO3	**If I don't succeed on a difficult task, I plan to try harder next time**
	LO4	In learning situations, I tend to set fairly challenging goals for myself
	LO5	I am always challenging myself to learn new concepts
	LO6	The opportunity to extend my range of abilities is important to me
Extraneous Load	EL1	The instructions and/or explanations during the activity were very unclear
	EL2	The instructions and/or explanations were, in terms of learning, very ineffective
	EL3	The instructions and/or explanations were full of unclear language
Intrinsic Load	IL1	The topic/topics covered in the training activity were complex
	IL2	The training activity covered programming concepts that I perceived as complex
	IL3	The training activity covered concepts and examples that I perceived as complex
Germane Load	GL1	The training activities really enhanced my understanding of the topic(s) covered
	GL2	The training activities really enhanced my knowledge of terminology used Python programming language

	GL3	The training activities really enhanced my understanding of the concepts covered in the Python programming language
	GL4	The training activities really engaged me in learning Python programming language
Computer Playfulness	CPL1	I am spontaneous when I interact with the application
	CPL2	I am playful when I interact with the application
	CPL3	I am flexible when I interact with the application
	CPL4	I am creative when I Interact with the application
	CPL5	**I am unimaginative when I Interact with the application (Reverse coded)**
	CPL6	I am original when I Interact with the application
	CPL7	I am inventive when I Interact with the application
Motivation to Learn	MVL1	I will exert considerable effort in learning the material on Python computer programming language,
	MVL2	I am motivated to learn the material on Python Programming language presented in this session
	MVL3	I am trying to learn as much as I can about Python Programming language from this session
	MVL4	I am very much interested in attending this introductory Python language session
	MVL5	I am excited about various Python skill that I will learn from this session
Perceived Ease of Use	PEOU 1	My interaction with the instructional materials was clear
	PEOU 2	I found instructional material easy to use
	PEOU 3	It would be easy for me to become skillful at Python programming using the type instructional material presented to me
	PEOU 4	Learning to work with instructional material was easy for me
Personal Innovativenes s	PINT1	If I heard about a new IT application, I would look for ways to experiment with it
	PINT2	**In general, I am hesitant to try out new IT applications**
	PINT3	Among my peers, I am usually the first to try out new IT applications
	PINT4	I like to experiment with new IT applications
Perceived Usefulness	PU1	I find on-line training to be useful in my job
	PU2	On-line training would increase my productivity
	PU3	On-line training would enable me to accomplish programming tasks more quickly
	PU4	If I keep myself updated using on-line training, my chances of getting a promotion will increase
Self-Efficacy	**SEC1**	**I believe I have the ability to use the Python programming language even if there is no one around to tell me what to do**
	SEC2	**I believe I have the ability to use the Python programming language even if have never programmed in a similar language before**
	SEC3	I believe I have the ability to use Python language if I can have access to technical manuals

	SEC4	I believe I have the ability to use the Python programming language if I observe someone else using it before I try
	SEC5	I believe I have the ability to use the Python programming language if I have used similar programming languages before
	SEC6	I believe I have the ability to use the Python programming language if I have access to Python's inbuilt help facility
	SEC7	I believe I have the ability to use the Python programming language if I have adequate time to explore it
	SEC8	I believe I have the ability to use the Python programming language if I can get help when I am stuck
	SEC9	**I believe I have the ability to use the Python programming language if someone guides me**

Note: The emboldened items were dropped from the analysis as they showed low loading values on respective constructs and high cross loadings.

Quiz at the End of Training

1) Starting with the sentence, which of the following are valid?

    Sentence---> Subject verb object where
    Subject --> Noun
    Object --> Noun
    Verb ---> Smoke
    Verb ----> Ride
    Noun ----> I
    Noun ----> Cigar
    Noun ----> Bicycle

    ☐ I ride Smoke
    ☐ I Bicycle Cigar
    ☐ I Cigar Bicycle
    ☐ I ride Bicycle
    ☐ Cigar smoke Bicycle
    ☐ Bicycle ride I

2) Starting with the sentence, which of the following are valid?

    Sentence---> Subject verb object where
    Subject --> Noun
    Object --> Noun
    Verb ---> Fly
    Verb ----> like
    Noun ----> I
    Noun ----> Food
    Noun ----> Python

    ☐ Python fly food
    ☐ Fly python I
    ☐ Food like food

☐ Fly python fly

3) Expression in Python is seen and evaluated as follows.

Expression --> Expression Operator Expression
Expression --> Number
Operators --> +, *, - and so on (i.e. arithmetic operators)
Number --> 0, 1,..
Expression --> (Expression)

Note: The sign "-->" means "can be replaced by"

Which of the following is a valid expression in Python?
- ☐ (13*(26*(41*(41)))
- ☐ (312)
- ☐ +563
- ☐ (((7))

4) Expression in Python is seen and evaluated as follows.
Expression --> Expression Operator Expression
Expression --> Number
Operators --> +, *, - and so on (i.e. arithmetic operators)
Number --> 0, 1,...
Expression --> (Expression)

Note: The sign "-->" means "can be replaced by"
- ☐ (3
- ☐ (1*(2)*(3*(4))
- ☐ (33))
- ☐ ((3 3))

5) Which of the following string valid?
- ☐ "Siberia"
- ☐ "Siberia
- ☐ 'Siberia"
- ☐ 'Siberia'

6) If I run following code in Python
print "Python is" + 1234

Will it result in an error? If so, what kind of error?
- Synthetic error
- Syntax error
- Systematic error
- None of the above

7) If I run following code in Python
inch = centimeters*2.54

foot = 12*inch

Will it result in an error? If so, what kind of error?

- Systematic error
- Semantic error
- All of the above
- None of the above

8) What kind of grammar does Python have?
    - Context-based grammar
    - Recursively enumerable grammar
    - Finite State grammar
    - All of the above
    - None of the above

Attention Check for Videos

True/False Statements
1) John Backus invented the Backus-Naur Form.
2) Backus-Naur Form (BNF) is the grammar used in Python Language.
3) Expression in Python following Backus-Naur Form (BNF) is the grammar is evaluated from left to right.
4) Python uses an interpreter to run programming statements.
5) Syntax error in Python occurs as a result of not conforming to its grammar.
6) Semantic error in Python results from having an expression or statement that does not have logical meaning i.e. the expression may be grammatically right but it does not make logical sense.

Chapter 5

Conclusion

The following sections outlines the summary of research findings of each essay, the contributions and directions for future studies.

Summary of Findings

Essay1 establishes the need for TML research, its relevance to stakeholders, as well as the suitability of IS field to investigate this phenomenon. Prior studies on information technology-based training have referred to it as e-Learning, technology-mediated learning (TML), virtual learning, and technology-based training (TBT). A variety of terms used in this field refers to information technology-assisted training. This varied terminology has the potential to create confusion for a researcher interested in extending this stream of work. In essay 1, the nomenclature used in the IT-assisted training literature is refined, so that the future researchers have a clear understanding of the terms used in this domains. A literature review is conducted to find out theoretical frameworks that can help IS researchers to investigate technology-mediated learning contexts. As a result of this literature review, social cognitive theory (SCT) and cognitive load theory (CLT) are discovered as the most prominent theoretical paradigms. Further, this essay details on how technology-mediated contexts can be used to espouse problem -based learning (PBL). It explores two contexts where PBL is enabled by information technology (1) ERP simulation (2) In-browser programming environment to learn basic computer programming with MOOC videos. For subsequent two essays, behavior modeling (BMT) was chosen as the training method as it was found to be most prevalent, and successful training technique. BMT is rooted in SCT's observational learning processes. In terms of intervention, mental rehearsal was chosen as it had been used in IS training in prior research and found to be effective in the fields ranging from music, neurology to sports training. Essay 2 research had two research objectives: (1) Examine relationships between OL processes (2) Examine the effectiveness of training intervention which combines vicarious learning, enactive learning, and mental rehearsal. A between-subjects quasi-experiment with n= 150 was conducted, where the control group received training which espoused vicarious learning as well as enactive to form the baseline. The treatment group was exposed to additional mental rehearsal activity. Study findings explain observational learning in terms of the theory of mind (ToM). It also suggests the possibility of designing a theory-based training intervention. Specifically, ERP training that affords rehearsal showed better outcomes in terms of business process knowledge, and integration knowledge. This finding is of significant importance, as the primary goal of ERP training is to make a trainee aware of the various business process, and their integration. Findings can potentially extend to other enactive training contexts. Rehearsal also led to the formation of knowledge structures that share greater similarity to experts' knowledge structure.

Essay 3 investigated mechanism underlying mental rehearsal using Cognitive load theory (CLT) as a theoretical lens. The study hypothesized that the effectiveness of mental rehearsal stems from the manner in which it relates to the human cognitive architecture. It can guide and focus a participant's attention on the learning material, thus increasing the perception of learning (i.e., germane load) while minimizing noise (i.e., extraneous load). Mental rehearsal's effectiveness was also captured in the schema/knowledge structure formation. A randomized two-group post-test online experiment was conducted with a sample size of 258. Results supported the notion that mental rehearsal leads to knowledge structures that share greater similarity to experts' knowledge structures. Generalized computing knowledge, ability to program, training experience, and post-training self-efficacy were also collected as training outcomes. Rehearsal significantly improved post-training self-efficacy. The impact of mental rehearsal was not consistent on training outcomes across the two studies as explained in following paragraphs.

In Essay 2, the training intervention had a significant impact on of business process knowledge, integration knowledge, ERP quiz, and knowledge structure similarity (KSS) compared to the control group. However, it did not have a significant impact on simulation experience, transaction knowledge, and post-training self-efficacy. Instead, these outcomes were driven by TAM variables. In Essay 3, the intervention had a significant impact on of extraneous load reduction, germane load increase, programming quiz score, post-training self-efficacy, and knowledge structure similarity (KSS) compared to the control group. However, it did not have a significant impact on generalized programming knowledge, training experience, and ability to program knowledge. Instead, these outcomes were driven by TAM variables.

The differences in results across two studies can be potentially attributed to different samples and duration of the respective study. In Essay 2, data was collected during a semester-long ERP introduction class with an extra credit incentive. Also, the practice/simulation sessions were not continuous and were conducted over multiple class periods. Given that student subjects were using ERP for the first time coupled with the discontinuous nature of the training, the training may have been perceived to be inadequate. In fact, a recent study investigating the impact of training duration on learning outcomes showed that training a long-term training program broken down over various sessions led to no significant increase in trainees' self-efficacy. However, actual/objective technology skills were enhanced (Brinkerhoff, 2006). A similar pattern was observed in the results of Essay 2. Mental rehearsal led to a significant increase in objective knowledge of ERP (as evidenced by KSS similarity and ERP quiz score) but not in the perceptions of self-efficacy, and transaction knowledge, and simulation experience. Given that extra credit was based on participation and not on the performance, it could also be a factor behind results observed in Essay 2.

In Essay 3, the training intervention had an impact on improving post-training self-efficacy. This could be attributed to the type of sample in the study. The study was conducted in the context of MOOC videos. Arguably, students who enroll in MOOCs have higher levels of intrinsic motivation and possess individual traits related to exploration of technology-mediated learning contexts (Tschofen & Mackness, 2012). Computer playfulness had a significant effect on post-training self-efficacy in Essay 3 (Table 13 in Essay 3, p. 183) while it had no effect on post-training self-efficacy in Essay 2 (Table 16 in Essay 2, p. 102). The study in Essay 3 had a total duration of 90 minutes and participants were paid $12 to complete the study. The monetary compensation and the study duration could be factors leading to the observed results.

In sum, the differences in the results between two studies can be attributed to a combination of variations in intrinsic motivation, study duration, computer playfulness, and compensation across two samples.

Contributions

Given the pace and magnitude of investments IT-assisted training, IT-based training has become important research topic for academics and practitioners alike. In spite of rapid adoption and increase in popularity, information technology/computer-based training have not delivered expected returns. Scientific literature in this area has acknowledged this discrepancy and stressed the need to develop effective training interventions in the technology-mediated context. My dissertation is an attempt to explore this area and in the process develops three essays. Together these essays make several contributions to research and practice. I have outlined the contribution of each of the essays is in the following paragraphs.

Essay 1 is the survey of research on information technology-assisted training. Prior research has referred to information technology/computer-based training using a variety of labels, and nomenclature is scattered at best. Specifically, this study clarifies the terminology employed in IT-assisted training, so future researchers have a clear understanding of the terms used in this domain. Further, it explains how a class of learning called problem-based learning (PBL) can be instantiated by technology-mediated learning, and describes two particular contexts utilized in this dissertation. Behavior modeling (BMT) rooted in SCT's observational learning processes was chosen as the training method as it was found to be the most prevalent, and successful training technique. In terms of intervention, mental rehearsal was selected as it has been used widely in IS training in prior research. Also, it has been found to be effective in the fields ranging from music, neurology to sports training.

Essay 2 extends previous training literature by operationalizing observational learning in accordance with the theory (Bandura, 1986; Renkl, 2014). To my knowledge, it is one of the first studies to explore the efficacy of theory-based training interventions in real-world enactive settings such as an ERP simulation. It also provides insights into workings social cognitive theory's (SCT) by integrating literature on the theory of mind (ToM) and mirror neurons. Training professionals researchers who employ behavior modeling can consider designing training intervention in accordance the principles of ToM.

Essay 3 makes several contributions to the literature in two domains: (1) Education (2) Information Systems. Education research has recently investigated mental rehearsal with cognitive load (Leahy & Sweller, 2004). This study builds on the cognitive load theory empirically examines the components of cognitive load contributing to the effectiveness of mental rehearsal. Thus, advancing our knowledge of mental rehearsal mechanism.

The idea of schemas and knowledge structures is paramount in training research (Badura 1969, Sweller 1998). It has received attention in IS research (Davis & Yi 2004) and needs to be explored further. As a next step, and this study investigates mental rehearsal, cognitive load, and knowledge structures together. It also answers the recent calls in IS to develop effective training methods for technology training (Alavi & Leidner, 2001; Gupta & Bostrom, 2013). Essay contributes back to education and IS literature by providing a more nuanced understanding of the learning process.

Both essay 2 and essay 3 have significant practical implications. Essay 2 shows that mental rehearsal can be combined with an ERP simulation to increase its efficacy. It is especially important as corporations look to train their workforce in ERP. Also, educational institutes who deliver ERP training can benefit from this finding. Further, designers of simulation can formulate novel ways to integrate mental rehearsal in their software/simulation.

Essay 3 goes further than essay 2 in examining the effectiveness of a training intervention. Ultimately, all learning depends on bottlenecks of human processing capacity. It has been a long and ongoing quest for training professionals and designers to develop an intervention that would work in accordance with the information processing tendencies of humans. Although, mental rehearsal was found to be effective in the ERP context in essay 2, the manner in which human cognitive architecture processes the rehearsal remained unclear. Essay 3 investigated this issue using cognitive load theory as a framework. Findings suggest that mental rehearsal works in tandem with natural information processing tendencies of participants. Essay 3 applies mental rehearsal to a TML context of MOOC videos; the results indicate the effectiveness of mental rehearsal in this setting as well. As the need for technology-savvy workforce increases, education delivered by MOOCs play an ever-increasing role in satisfying the demand. MOOC developers (i.e. educational institutes, and corporations) can use this finding to optimize their MOOC offerings.

Future Research

There are several opportunities for future research to build on the essays in this dissertation and they are discussed as follows. First in both essay 2 and essay 3, knowledge structures are treated as "collection of concepts". Explain. There is considerable neuroscience literature suggests that knowledge structures or mental schemas are hierarchical structures that encode sequential actions (Botvinik, 2007; Grafton & Hamilton, 2007). Langston et al. (1998) point out the nature of mental schema is "quintessentially semantic" (i.e., meaning in them is inherent). It implies a sense of hierarchy or sequence in which these concepts are connected. Also, there is a consensus that that actual action performance is mediated by roughly hierarchical internal representations (Cooper & Shallice, 2000; Cooper & Shallice, 2006). When trainees are instructed to mentally rehearse the modeling behavior or imitate the model, actions are broken down sequentially to form mental representation. The trainees use this representation as the basis for reproducing action (Chiavarino et al., 2012) raising an obvious question about the nature schemas: How are mental schemas organized in a hierarchy? According to recent research in neuroscience, a mental schema is encoded as a series of action sequences (Grafton & Hamilton, 2007). The action sequences themselves are based on a goal (Thill et al., 2013). The notion of the goal is akin to the higher level function that trainee wants to achieve, i.e. in the case of BMT, this goal would be to reproduce the modeled behavior. Given this higher level goal is fixed, there may be many action sequences that can lead to the desired result. Each action that the trainee performs lead to end-state and so on. At the end of the training session, schemas of trainees resemble a directed graph. Note that difference between “action” and “goal state” is subtle and syntactic. For example, let us imagine that we are training a novice to perform a regression analysis using the business analytic software. When trying to reproduce the modeled behavior, if intermediate steps require that he/she clean the data. This step of “clean the data” can be seen as a goal/end state that this trainee may want to reach, but it may also be seen as action sequence arising from current stage. This example, illustrates that goal or action follow the same general semantic principles (Kruglanski 1996; Kruglanski, Shah, Fishbach, Friedman, Chun, & Sleeth-Keppler, 2002). The concepts in a mental schema can be viewed as goal state if one engages in modifying his/her by backward learning or as action sequence if behavior is modified by forward learning. The hierarchical and sequential relationship between the components of knowledge structures (be it seen as goal state or as action sequences) is of greater importance than the purported nature of sub-components. In this view, knowledge structures can be seen as directed relationship between concepts. Future research can focus on measuring the hierarchical knowledge structures.

The second area that can be explored deals with team knowledge structures. Given that teams heavily use enactive learning contexts, future research can potentially study team processes relevant to learning. For example, how do individual team member’s knowledge structures lead to the formation of team mental model over the duration of training? This research promises to be of significance to corporations who employ large, and distributed teams.

Third, essay 2 was a quasi-experiment and essay 3 was an on-line experiment, they can be modified to be conducted in actual corporate settings. Results will either triangulate the ones found in this dissertation or give us deeper insights into the human learning process.

The fourth area that can be explored is related to cognitive load measurement. This dissertation used a recently developed perceptual measure of cognitive load. Results can be triangulated and further investigated by using a more objective measure such as response times, and heart rate variability. This investigation has the potential to advance IS research by understanding how a psychological construct translates into biological signals.

Finally, SCT can be better understood by employing insights from ToM and mirror neurons as explained in essay 2. Although, the nomological model developed in Essay 2 is based on implicit and explicit ToM, I do not measure it. A future extension this work could be in terms of measurement of ToM. Theory of mind measurements can be borrowed from neuroscience. EEG signal can be analyzed in terms of various frequency bands. The *mu* (μ) frequency band suppression is a biological marker of mirror neuron activation (Ulloa & Pineda, 2007). At rest (i.e. when the participants are not subjected to training), one can measure the power of the mu band of EEG. This power is at the highest as the brain is at rest. When trainees observe any action, it will be coded in the mirror neurons according to ToM. If so, then multiple brain areas required for priming the participant for action will be recruited. As a result, the amplitude or power of mu band will decrease (Oberman, Ramachandran, & Pineda, 2008). Similar techniques can be used when participants engage in explicit mentalizing. It has been shown that gamma band amplitude in (a) orbitofrontal cortex and; (b) dorsolateral prefrontal cortex increases as a result of an attempt to form cognitive representations (Heisel & Beatty, 2007) (i.e., when a trainee or a participant engages in explicit mentalizing). This increase can be measured as a biological marker of mentalizing.

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