Reflective Redo Within a Three-Dimensional Simulation and its Influence on Student Metacognition, Reflection, and Learning

Jon M. Scoresby
Utah State University

Follow this and additional works at: https://digitalcommons.usu.edu/etd

Part of the Education Commons

Recommended Citation
Scoresby, Jon M., "Reflective Redo Within a Three-Dimensional Simulation and its Influence on Student Metacognition, Reflection, and Learning" (2011). All Graduate Theses and Dissertations. 983. https://digitalcommons.usu.edu/etd/983

This Dissertation is brought to you for free and open access by the Graduate Studies at DigitalCommons@USU. It has been accepted for inclusion in All Graduate Theses and Dissertations by an authorized administrator of DigitalCommons@USU. For more information, please contact digitalcommons@usu.edu.
REFLECTIVE REDO WITHIN A THREE-DIMENSIONAL SIMULATION AND ITS INFLUENCE ON STUDENT METACOGNITION, REFLECTION, AND LEARNING

by

Jon M. Scoresby

A dissertation submitted in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in Instructional Technology and Learning Sciences

Approved:

Brett E. Shelton, Ph.D. Mimi Recker, Ph.D.  
Major Professor Committee Member

Andrew Walker, Ph.D. Douglas L. Holton, Ph.D.  
Committee Member Committee Member

Kerry Jordan, Ph.D. Byron R. Burnham, Ed.D.  
Committee Member Dean of Graduate Studies

UTAH STATE UNIVERSITY  
Logan, Utah

2011
ABSTRACT

Reflective Redo Within a Three-Dimensional Simulation and its Influence on Student Metacognition, Reflection, and Learning

by

Jon M. Scoresby, Doctor of Philosophy
Utah State University, 2011

The objective of this study was to investigate the effects on a student’s metacognition, reflection, and learning in a specifically designed educational simulation supported by unique technology. The simulation allows players’ actions to be recorded for the purpose of review to identify mistakes. The simulation also allows students to start at and redo actions while fixing previous mistakes instead of starting over at the beginning of a new scenario. When starting at the mistake or point of failure, as identified by a facilitator, during the redo of the initial saved scenario, students reflect on the actions performed during the initial scenario. Student thinking during a redo of a scenario, after the initial scenario reflection, may be called reflective redo when the simulation technology can support starting from the point of failure. This research investigated how metacognition, reflection, and learning were affected by reflective redo.

Two key findings were identified when analyzing reflective redo in how students
learn the content and how they learn about their own use of metacognition and reflection. The first key finding relating to the influence of reflective redo on learning was that participants used reflection at levels that matched their need as a support mechanism. The second key finding was that the students’ abilities to place themselves in the problem space contributed to the amount of contextual information they needed to be successful—in this case, either starting from the beginning or from the point of failure.
ACKNOWLEDGMENTS

There are many people who have helped make this dissertation and degree possible. Brett Shelton as my chair has been the one who has been patient and led me through this process. He has always shown that my best interest was very important to him, for which I am truly grateful. The rest of my committee, Mimi Recker, Andy Walker, Doug Holton, and Kerry Jordan, also deserve much credit for providing the necessary feedback and guidance along the way. The students who participated in this study who remain nameless deserve my thanks, for without them, I could not have conducted this study.

My parents have been very supportive of my efforts from the beginning. I especially want to thank my dad who spent a lot of time on the phone with me and reading my papers in an effort to help and guide me with his vast knowledge and experience. I appreciate my immediate brothers and sisters and in-laws who showed both interest and concern for my work and well-being.

I am grateful to a point that cannot adequately be expressed in words to my most wonderful wife who helped, supported, and cried with me through this long process. My children who grew so much over these few years have supported me in ways that I may never know. They sustained me and prayed for me, that “daddy may finish his big paper soon” and loved me through it all. My family is the most important thing in my life and I share this accomplishment with them because without their love, patience, and support, I would not have finished.

Jon M. Scoresby
# CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Background</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Purpose of the Study</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Research Questions</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Assumptions</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Overview</td>
<td>12</td>
</tr>
<tr>
<td>II.</td>
<td>LITERATURE REVIEW</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Metacognition</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Reflection</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Learning</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Framing Technology-Supported Reflection and Metacognition</td>
<td>25</td>
</tr>
<tr>
<td>III.</td>
<td>METHOD</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Research Design</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Participants (Sample)</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Instruments</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Procedures</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Data Collection</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Data Analysis</td>
<td>41</td>
</tr>
<tr>
<td>IV.</td>
<td>FINDINGS</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Review of Terms</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Student Examples</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Participant Experience Summary</td>
<td>78</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Metacognitive Knowledge and Regulation Questions from the MAI</td>
<td>39</td>
</tr>
<tr>
<td>2. Conversation with Jack about Give a Command During the Simulation</td>
<td>55</td>
</tr>
<tr>
<td>3. An Excerpt from Jack’s Interview Transcript Showing the Level of His Metacognitive Awareness</td>
<td>58</td>
</tr>
<tr>
<td>4. Summary Table of Participants’ Age, Mai Scores in Ascending Order and Checklist Scores for Each Scenario</td>
<td>83</td>
</tr>
<tr>
<td>5. Summary Table of Claim 1 and How It Relates to Research Question 1</td>
<td>93</td>
</tr>
<tr>
<td>6. Summary Table of Claim 2 and How It Relates to Research Question 2</td>
<td>103</td>
</tr>
<tr>
<td>7. Summary Table of Claim 3 and How It Relates to Research Question 3</td>
<td>113</td>
</tr>
</tbody>
</table>
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A visual representation of the regen tool. New scenarios were regenerated at points C and E.</td>
<td>9</td>
</tr>
<tr>
<td>2. Research design summary showing how the objectives of areas of investigation, research questions, data collection, and proposed analysis are connected</td>
<td>32</td>
</tr>
<tr>
<td>3. A screenshot of the playback functionality within the simulation that contains the DVR-like controls for playback.</td>
<td>35</td>
</tr>
<tr>
<td>4. The proposed data collection procedures for this study.</td>
<td>38</td>
</tr>
<tr>
<td>5. An example of categorizing related interview answers.</td>
<td>45</td>
</tr>
<tr>
<td>6. Mental processes of participants.</td>
<td>105</td>
</tr>
<tr>
<td>C-1. A screenshot of the fire in the kitchen of scenario 1.</td>
<td>144</td>
</tr>
<tr>
<td>C-2. A screenshot of the house used in both scenarios.</td>
<td>145</td>
</tr>
<tr>
<td>C-3. A screenshot of the bedroom fire in scenario 2.</td>
<td>145</td>
</tr>
<tr>
<td>C-4. Brad watching the playback of his actions performed during scenario 1.</td>
<td>147</td>
</tr>
<tr>
<td>C-5. A screenshot of loading scenario 1 so Brad could watch his actions performed during scenario 1.</td>
<td>147</td>
</tr>
<tr>
<td>C-6. The playback of scenario 1 that Brad watched during the debrief session.</td>
<td>148</td>
</tr>
<tr>
<td>C-7. Creating a new scenario at the point of failure for Brad so he could redo scenario 1 and fix the mistakes he made starting at 2:24:68.</td>
<td>149</td>
</tr>
</tbody>
</table>
There have been many attempts to improve how students learn with educational simulations designed to facilitate metacognition and reflection (Lin, 2001; Shang et al., 2006; Vincent, Aleven, & Koedinger, 2002; Wang & Reeves, 2007). One implemented method that helps facilitate metacognition and reflection when learning with simulations has been termed an After Action Review (AAR). During an AAR, a facilitator leads a discussion to help students identify mistakes and possible solutions. Once the discussion is completed, the students can then practice or redo their actions and try to fix their mistake by starting from the beginning within the simulation. For example, a student is training on a flight simulation that lasts 10 minutes and during the AAR a mistake was identified at the 8-minute mark. The problem, then, is that to fix that mistake, the student would have to (a) start from the beginning of the simulation and redo actions that he has already performed correctly for 8 minutes until he would even have the chance to fix the previous mistake and (b) try to recreate the exact situation where the mistake took place.

Because there is little known about how students’ learning is affected when starting at the point of failure when redoing actions within a simulation, we can ask what would it mean in terms of learning if it were possible to redo actions and focus student attention on the mistake by starting at the mistake or point of failure instead of starting from the beginning? And, if it were possible to start at the point of failure, is it possible to overcome those obstacles of performing already mastered skills and recreating the same situation where the mistake took place? The objective of this study is to answer these
questions by (a) investigating the use of technology-supported metacognition and reflection and (b) gain a better understanding of how participants’ metacognitive awareness, reflection, and learning are influenced when starting at the point of failure within a first-responders open-ended complex multi-player educational simulation. I concentrated on student experience using an educational 3D simulation that was designed with specific instructional functionalities that support student learning and the role of a facilitator. I concentrated on what the students did (actions) during each scenario (use of the simulation), why they did what they did, what they were thinking when performing, and why they thought those thoughts. Specifically, I concentrated on what students were thinking and doing when they started at the point of failure during the redo of previously performed actions rather than from the beginning of their educational scenario.

One of the above-mentioned functionalities of the simulation is that each scenario can be saved and replayed in much the same way as with a recorded movie, by pressing the play, pause, and stop buttons. At any time during the playback of a saved scenario, a participant can restart the scenario and redo the previously performed scenario, specifically focusing on the point of failure. This redo functionality enabled me to focus on participants’ reflections during the redo of the previously saved scenario and on how their metacognitive and reflective abilities were affected.

Based on the analysis of the participants’ interactions with this simulation, I present an overview of how their learning of this new content was influenced when using the simulation and how this technology supports metacognitive and reflective activities. The participants memorized the tasks that needed to be performed and at the same time
learned the purpose of each task. I implemented a debriefing session between scenarios to help participants identify their mistakes and give them the opportunity to ask questions. Participating in this debriefing session and using this technology helped participants use and learn about metacognitive and reflective activities. However, metacognitive and reflective activities were not discussed or taught during the debriefing session. Participants reviewed their actions and discussed the tasks they either missed or performed incorrectly. I describe two participants’ experiences to highlight, in a broad sense, how this technology supports metacognitive and reflective activities for different types of learners, those with high and low metacognitive awareness. Afterward, using data from all participants, I discuss in specific terms how reflective redo influenced learning. Student thinking during a redo of a scenario, after the initial scenario reflection, may be called reflective redo when the simulation technology can support starting from the point of failure. Currently, a facilitator is necessary to identify the mistake or point of failure that may occur doing a scenario. The reflective redo process is facilitated by the use of this technology that allows users to start at the point of failure, identified by a facilitator. Therefore, whenever reflective redo is referenced, it should be understood that reflective redo is the process of thinking during the redo of a scenario after the initial scenario reflection when starting at the point of failure as identified by a facilitator.

**Background**

In redoing some kind of activity during an educational experience, it is important to consider everything that is involved in the redo process. Not only are actions being
redone but thoughts are being considered or reflected upon to ensure that the same mistakes are not made again. These actions and thoughts have been researched to discover how learning can be improved. I define reflection and metacognition and discuss how both are used to improve learning of new content in the context of this technology and a facilitator-led debriefing session. I then explain the purpose of this research, discussing how I studied the effects of reflective redo on reflection and metacognition.

Thinking about our thoughts or cognition is termed metacognition, which is defined as “the deliberate conscious control of one’s own cognitive actions” (Brown, 1980, p. 453); in other words, how learners think about their thoughts. Past research has indicated that students need to become more aware of their own metacognitive and reflective abilities and learn to apply those abilities (Schraw, 1998; Young & Fry, 2008).

Learners need environments that promote metacognitive awareness or, in other words, a way to practice metacognitive skills (Schraw, 1998). Students can use reflection and metacognitive skills to improve learning during any learning exercise because “extended practice and reflection play crucial roles in the construction of metacognitive knowledge and regulatory skills” (Schraw, 1998, p. 118). Therefore, to improve existing student learning environments beyond their current state, it is important to question what kinds of environments exist and afford the practice of reflection and metacognitive skills.

The military uses a reflection process called After-Action Review (AAR) that is led by a facilitator and helps to identify, fix, and learn from recent mistakes during training or actual missions (Baird, 1999; Johnson, 2000; Salmons, 2008; Seglie & Selby-Cole, 2000). The military has also implemented AAR into simulated training
environments (Hill et al., 2006; van Lent, Fisher, & Mancuso, 2004).

Although military and academic researchers have already implemented and studied educational tools such as simulations that support metacognition and reflection (Azevedo, 2005; Hill et al., 2006; Lin & Lehman, 1999; Seale & Cann, 2000; van Lent et al., 2004; Vincent et al., 2002), more can be learned. Military simulations that incorporate AAR, as with other similar nonmilitary simulations, have been designed so that students can redo or practice actions by starting from the beginning. This means students are practicing both correctly and incorrectly performed actions during their learning activity. Redoing correctly performed actions may be redundant during a student’s learning process. There is little known about the effects on learning when a student redoes a learning activity from the point of failure rather than from the beginning. Therefore, there is a need to know what the effects on reflection and metacognition and ultimately on learning are when starting from the point of failure.

I propose to identify if and how students use reflection and metacognitive processes when starting from the point of failure during the redo of a saved scenario. I examine the effects this activity has on students when learning new content with the HEAT technology that supports starting from the point of failure. Because little is known about the process of reflective redo, this study was designed based on previous research about learning with AARs, learning with technology that supports metacognition and reflection, and learning with simulations and facilitators (Hill et al., 2006; Lajoie, 1993; Seale & Cann, 2000; Windschitl & Andre, 1998). Also, this study was designed by using elements of both grounded theory and design-based research (DBR) in the process of
identifying and understanding how starting at the point of failure and the process of reflective redo affects student metacognitive awareness, reflection, and learning.

Elements of grounded theory were chosen because this method is meant to provide researchers a perspective on behavior, in this case, reflective redo (Corbin & Strauss, 1990; Glaser & Strauss, 1968). One element of grounded theory is that data collection and analysis are interrelated processes where the data should be analyzed from the beginning to help direct the next interview and observation (Corbin & Strauss, 1990; Glaser & Strauss, 1968). As understanding of the effects of reflective redo grew through the initial analysis of the interview question and observations of the first few participants, this analysis was performed to help ensure that future questions were more specific and to strengthen current understandings. Another element of grounded theory used is that “sampling in grounded theory proceeds not in terms of drawing samples of specific groups of individuals, units of time, and so on, but in terms of concepts, their properties, dimensions, and variations” (Corbin & Strauss, 1990). The context of students learning new content with a 3D simulation was chosen to study the process of reflective redo and how this process affects students’ learning of that new content. For this purpose, students were chosen who had no knowledge of the content presented to them during the study and had never had the experience of learning from the point of failure within this context. The final element of grounded theory chosen to help guide the design of this study is that analysis makes use of constant comparisons (Corbin & Strauss, 1990; Glaser & Strauss, 1968). When an incident was noted it was compared to other incidents and helped identify and account for the patterns and themes that emerged from the data.
Design-based research or design experiments allow researchers to study and apply theory in a specific context that then can be used to advance that theory (Barab & Squire, 2004; A. L. Brown, 1992; Collins, Joseph, & Bielaczyc, 2004). There is also a need to understand learning in real-world contexts rather than in a lab situation (Barab & Squire, 2004; Collins et al., 2004). Many iterations and implementations of a theory within specifically designed contexts are normally performed to advance that theory with DBR. This study can be recognized as one implementation of an iteration to gain understanding of reflective redo within the context of learning new content with a 3D simulation when having a facilitator identify the point of failure for the redo of previously performed actions. DBR methods are helpful for understanding the experiences of students learning within this context and can be used to enhance future design efforts as well as the learning process.

Framing this research by implementing these elements of grounded theory and DBR to help identify how students’ understandings of this new content changes through their actions, their reflections on those actions, and their redoing of those actions. I use data collection and analysis methods similar to those in other studies that have investigated student learning and metacognitive activities using simulations. The implications from this research may show the benefits and applications for starting at the point of failure rather than from the beginning of an educational activity within a virtual simulated environment.

**Purpose of the Study**

This study used software that simulates a virtual 3D multiplayer environment to
train firefighter Incident Commanders (IC). The HEAT software (Stowell & Coats, 2009) records all simulation team members’ actions, voices, and how long the recorded scenario lasted (Shelton et al., 2010; Stowell, Scoresby, Coates, Capell, & Shelton, 2009). The playback system is a functionality that plays back the recorded actions, and can be fast-forwarded, rewound, and paused, much like a digital video recorder (DVR). This function can be used as a discussion point during the debriefing session to trigger reflection on past actions. An additional functionality built into the simulation is the regen tool.

Shelton, Scoresby, and Parlin (2010) described how the regen tool works, which is visually represented in Figure 1.

A saved scenario can be regenerated (regen for short) at any point along the saved timeline. The regen can be used to create multiple outcomes based on any single scenario. To illustrate, consider Figure 1 in which a key decision was made during the simulation at 2 minutes, represented at point “C”. During the playback review of a saved scenario, the facilitator (instructor) can start recording a new scenario at the key decision “C” time creating a new saved scenario, leading to a new outcome. All the while, the new scenario 2 contains exactly the same saved actions in scenario 1 from the time 00:00 to 2:00. Said another way, scenario 1 at time A-C contains the same saved actions as in scenario 2 at A-C. To further illustrate how regen works, during playback of scenario 2, another key decision was made at point E along the timeline now named scenario 2. A new regen from point E could generate yet another completely new scenario, designated scenario 3. Note that all saved behaviors and actions in the 3D environment are identical from points A-C-E within scenarios 2 and 3. All three scenarios look the exact same between points A-C. Yet all three scenarios diverge from each other, having completely different outcomes. Points B, D, and F are the arbitrary “end” points in the simulation, dictated by completion of the activities or when the facilitator stops the recording of the scenario. This regen feature is unique because 1) it gives learners the opportunity to immediately learn from their mistakes without having to repeat already correctly performed actions and 2) it allows the key learning aspects of review and replay, controlled by an instructor or a student, to assist in identifying alternatives during critical points of a simulation. No other engine employs this functionality within open-ended 3D learning environments.

At any point in a saved scenario, a facilitator can restart the recording, giving the
participant a chance to redo the same scenario and fix a mistake that may have occurred.

For example, as shown in Figure 1, at the 2-minute point of a 5-minute saved scenario, an incident commander directed a firefighter to go to the back of the house instead of checking for victims. At that point in this saved scenario, the simulation can be regenerated employing an alternate decision that ultimately creates a new outcome. Note that each new scenario includes the exact actions that occur before a new “branch” is generated in a completely new, separate file. In addition, an infinite number of new
scenarios can be generated from any of the regenerated scenarios.

Because little is known about the effects of redoing an educational activity from the point of failure rather than from the beginning, as in AAR simulations, there is a need to understand the reflection and metacognition that take place during this type of learning activity. In other words, there is a need to understand how participants use reflection and what they are reflecting on when redoing an educational activity from the point of failure. Student thinking during the redo of the scenario, after the initial scenario reflection, may be called reflective redo when the simulation technology can support starting from the point of failure as identified by the facilitator.

The purpose or objective of this research is to (a) better understand the use of technology-supported metacognition and reflection by investigating how HEAT supports metacognition and reflection, and (b) specifically understand how reflective redo affects learning in terms of metacognition and reflection. To investigate how HEAT supports metacognition and reflection and how reflective redo influences learning, the intervention consisted of Scenario 1, the debriefing of Scenario 1, and reflective redo during the redo of Scenario 1.

**Research Questions**

The following questions guided this research.

1. How does the intervention that includes reflective redo influence metacognitive knowledge and regulation? How are participants thinking about their thinking?

2. During the reflective redo aspect of the intervention, how are participants
thinking about their actions?

3. What evidence exists that reflective redo activity alone creates a change in learning in relation to metacognition and reflection?

Assumptions

Reflection and metacognition and their influence on learning have been the subjects of past and current research (Brown, 1980; Flavell, 1979; Hannafin & Land, 2000; Ke, 2008; Lajoie, 1993; Schon, 1983). Reflection during or after a learning experience is called reflection-in-action and reflection-on-action (Schon, 1983). Metacognitive knowledge and regulation are two subcategories of metacognition. By making students aware of these subcategories, educators can show them where weaknesses may exist in their learning (Schraw, 1998; Schraw & Dennison, 1994; Young & Fry, 2008). Even though research has found that technology can facilitate reflection and metacognition and improve learning (Lin & Lehman, 1999; Seale & Cann, 2000; Wang & Reeves, 2007), there is still a need to understand how reflection and metacognition are influenced during reflective redo and how learning can be improved.

The HEAT software provides a method of redoing past actions to fix past mistakes when implementing reflective redo. Instead of redoing the activity, HEAT allows users to redo specific mistakes made during the activity. Focusing on fixing the mistakes allows users to think about what went wrong and how to fix it. They will not have to reflect upon the correct choices made before the mistake, and this may help increase learning speed and the understanding of reflection.
Reflective redo could be a new way of researching and understanding the role of reflection in learning. The results may help researchers and educators better understand how to use reflection in learning, especially with reflection-supported technology, by changing the way students are taught to reflect on their actions and thoughts. However, the results from this study come from only one content area, and further research is necessary in other content areas with technology that supports reflective redo. The findings add to the existing literature on reflection and how it affects learning practices, and they can be compared with current literature in order to identify the differences between reflection and reflective redo. However, this is only one study and there may be more to learn about reflective redo and the technology that facilitates it. A new and better understanding of how reflection is used and affected by this kind of reflective redo activity may influence new educational software design.

**Overview**

This dissertation is organized into five chapters. Chapter II contains the literature review. Chapter III contains the method and data collections. Chapter IV contains the research findings, which are broken down into broad and specific findings. The broad findings are presented by highlighting two participant experiences, and the specific findings are presented by describing the findings from the analysis of all combined participant data. Chapter V offers a discussion of the implications of the findings and claims described in Chapter IV.
CHAPTER II
LITERATURE REVIEW

The first section provides a broad perspective of both metacognition and reflection, followed by more specific sections on learning within virtual computer environments that support aspects of metacognition and reflection. In the first two sections, there is discussion about what metacognition is and how to help students become aware of their own metacognitive knowledge and regulation. In the reflection section, reflection is defined and examples are given that discuss how reflection can be supported or facilitated.

Subsequent sections define learning for this study and pertain to learning in specific situations and how students can be taught to reflect upon their thoughts within these situations. For example, authentic learning environments can be created for students to participate in specific learning situations. Simulations and games can provide these authentic learning environments and give students opportunities to learn in virtual environments that emulate the real world.

Metacognition

Metacognition has been defined as the knowledge that people have about their own thoughts (Bruning, Schraw, Norby, & Ronning, 2003; Ormrod, 2007) or the way that people monitor their thoughts and activities (Cary & Reder, 2002). Alternatively, it is “the deliberate conscious control of one’s own cognitive actions” (Brown, 1980, p. 453). Brown added to the definition of metacognition by identifying multiple components
such as “predicting, checking, monitoring, reality testing, and coordination and control of deliberate attempts to study, learn, or solve problems” (p. 454). Others have narrowed the definition of metacognition by stating that subcomponents of metacognition are planning, monitoring, and evaluation (Flavell, 1979; Schraw, 1998; Young & Fry, 2008). From these definitions, one may conclude that metacognition could be defined as thinking about thinking. Even though there are different definitions of metacognition, a common theme exists within each definition. Hacker (1998) stated that the related themes consist of “knowledge of one’s knowledge, processes, and cognitive and affective states, and the ability to consciously and deliberately monitor and regulates one’s knowledge, processes, and cognitive and affective states” (p. 11).

Researchers have studied metacognition in an effort to better understand how it influences knowledge and learning (Brown, 1988; Palinscar & Brown, 1984). Researchers who study metacognitive activity in classroom situations have identified two perspectives: (a) knowledge about cognition, and (b) regulation of cognition or, in other terms, metacognitive knowledge and metacognitive regulation (Schraw, 1998). Flavell (1979) added to these perspectives in his metacognitive monitoring model that includes five areas: (a) metacognitive knowledge, (b) metacognitive experiences, (c) goals (or tasks), and (d) actions (or strategies). Metacognitive knowledge consists of knowledge or beliefs about the variables that act or interact in ways that affect cognitive activity or what we know about our own cognitive processes (Flavell, 1979; Schraw, 1998; Young & Fry, 2008). Metacognitive experiences are the cognitive or affective experiences that accompany an intellectual activity. Goals or tasks are the objectives of a cognitive
activity and actions or strategies refer to the thoughts or behaviors that are used to reach those goals (Flavell, 1979). Flavell also wrote that improving monitoring of these five areas would help learning strategies. Schraw (1998) supported Flavell in stating that learners need to be made aware of their own thoughts by monitoring cognitive processes, and their awareness can be improved by practice. It is important for educators to understand what metacognitive strategies are and also to help students learn about these skills (Baker & Brown, 1984). For example, some metacognitive strategies that teachers can teach their students consist of explaining the instructional material to themselves (Vincent et al., 2002), monitoring (Flavell, 1979; Haller, Child, & Walberg, 1988), asking questions, regulating (Haller et al., 1988), and being how to be aware of the cognitive process (Baker & Brown, 1984; Haller et al., 1988). It is important to understand what happens to students when they are learning to become aware of metacognitive strategies because teachers can then include these strategies in their own teaching. It is also important to understand what types of environments best facilitate improvements in these skills.

Schraw and Dennison (1994) created a 52-question Metacognitive Awareness Inventory (MAI) to test and score an individual’s metacognitive knowledge and regulation. They tested the validity of the MAI by comparing the MAI scores with other scores possibly related to metacognition such as pretest monitoring skills, test-taking skills, or test-taking performance. Schraw and Dennison found that having metacognitive knowledge awareness was related to higher test performance whereas metacognitive regulation was not. Furthermore, they found that metacognitive knowledge as measured
by judging pretest scores was related to the MAI and the pretest judgments were related to test performance. Finally, they found that there was no significant relation between monitoring accuracy and the MAI.

Even though Schraw and Dennison (1994) did not find validation of metacognitive regulation in their study, other researchers did validate metacognitive regulation by comparing test-taking skills with grades (Sperling, Howard, Staley, & DuBois, 2004; Young & Fry, 2008). Sperling et al. (2004) used the MAI to measure college student metacognitive awareness and found a correlation between metacognitive knowledge and regulation. They were also interested in finding a relationship between MAI scores and academic scores such as the Scholastic Aptitude Test (SAT).

Young and Fry (2008) used the MAI to find relationships between metacognitive knowledge and regulation and academic achievement such as GPA and final semester grades. They went so far as to test a subgroup of the initial group to examine relationships between MAI scores and individual test scores. They found a correlation between the MAI, both metacognitive and regulation scores, and GPA and course-end grades. These findings support the validity of the MAI and how it relates to academic measures (Young & Fry, 2008). Young and Fry looked for differences between graduate and undergraduate students in their level of metacognitive knowledge and regulation, and they did find a difference between graduate and undergraduate students and their metacognitive regulation scores. These differences support the finding by Schraw (1994) that adult learners differ in metacognitive regulation ability and not in metacognitive knowledge skills. Young and Fry stated that their findings could be promising for
professors who want to screen their students to find those who need specific instruction in metacognitive skills. A student’s low MAI score could be flagged and then used to determine what types of learning skills that student uses. These metacognitive strategies could then be taught or improved and could help increase the student’s final semester grade. Recognizing the level of student metacognitive knowledge and regulation may allow researchers to help educators in their teaching ability and ultimately students with their learning ability.

Teaching metacognitive strategies has been shown to have positive effects on achievement and learning (Haller et al., 1988; Paras & Bizzocchi, 2005). When these strategies are learned and implemented correctly by a student, that student’s learning improves. Metacognition has also been shown to direct and affect learning and study behaviors (Baker & Brown, 1984). Pintrich (1999) stated that “students’ metacognitive knowledge and use of metacognitive strategies can have an important influence upon their achievement” (p. 460). Pintrich’s statement supports the goal and activities aspects of Flavell’s (1979) cognitive monitoring model. Students need to practice and have opportunities to reflect upon the their metacognitive knowledge and regulatory skills in order to improve learning (Schraw, 1998), and computer-generated authentic learning environments can provide a place for such practice.

**Reflection**

Atkins and Murphy (1993) reviewed the literature on reflection and found that researchers have had difficulty defining reflection. However, Atkins and Murphy stated
from multiple definitions that the process of reflection involves the self and the results of reflection are due to some type of conceptual change. Their literature review revealed three stages in the reflective process that have been shared among authors. Stage one of the reflective process is triggered by being aware of uncomfortable feelings about thoughts or knowledge (Atkins & Murphy, 1993). Schon (1983) called this the experience of surprise. Stage two is the critical analysis of the situation, which involves examining the feelings and knowledge, and stage three is the development of new perspectives on the situation, and the outcome of reflection is therefore learning (Atkins & Murphy, 1993). As when students are aware of metacognitive skills, when they are made aware of reflection and what to reflect upon, it may help their learning processes.

Reflection has been defined by one researcher as a process in “problem solving, reconstruction of meaning, and subsequent reflective judgments while persons are engaged in significant new activity” (Reiman, 1999, p. 598). Reflection or self-monitoring is a method that some have implemented to enhance metacognitive activities and learning (Brown, 1988; Schraw, 1998; Vincent et al., 2002). Reflection can take the form of reflecting on the processes or activities and the usable knowledge levels during a learning scenario (Vincent et al., 2002). It should be noted that those with less knowledge find it difficult to reflect and regulate the skills needed for learning (R. Glaser & Bassok, 1989). However, researchers are trying to understand how to improve reflective skills even though students are not experts in a particular content area (Mathan & Koedinger, 2005; Quintana, Zhang, & Krajcik, 2005). Therefore, students need to be made aware of how reflection can help their learning and how to properly reflect upon
what they are trying to learn.

Reiman (1999) wrote that educators and psychologists have had difficulties trying to determine how people learn from their experiences because of the complicated and subtle problem of how people obtain meaning from experience. He continued by stating that “a current challenge and question for educators and psychologists interested in promoting learning and intellectual development is the identification of relevant theory and the creation and testing of interventions that can appropriately guide the development of reflection” (p. 599). Reiman theorized that role taking can be used to help students learn. Role taking is the action that precedes and forms the intellectual thoughts (reflection) that come from it. Reiman also suggested that participating in social situations helps initiate the reflective actions that lead to learning. A. L. Brown (1988) also supported the idea of having students work in social groups by indicating that deep understanding is most likely to happen when students are required to reflect upon, explain, elaborate, or even define their ideas to others.

**Practice Through Replay Versus Redo**

Practicing or redoing an educational task can be repeated many times to ensure that students learn and understand what they are meant to learn. Expertise is gained most often through practice (Ericsson, Krampe, & Tesch-Romer, 1993) or redoing an action until it is done right. According to Ericsson and colleagues (1993), for effective practice, task design needs to take students’ preexisting knowledge into account so that they understand a task after receiving instruction. To improve performance, Ericsson and colleagues said that teachers or experts must give immediate feedback on students’
performance and students must continue to practice.

The information about practice from Ericsson et al. (1993) can apply to learning or practicing something using educational games or simulations, which can have built-in feedback that can help improve a student’s knowledge and skills. Possible methods of computer-simulated practice are hypothesis testing (DeJong & Jooligen, 1998) and drill and practice (Garris, Ahlers, & Driskell, 2002). However, Garris and colleagues stated that one’s learning is limited from drill and practice and results will be predictable. This learning limitation could result from students practicing or performing actions that they already know. One problem with continual practice of this kind is the time lost in applying knowledge that is already mastered that could have been spent in gaining new knowledge.

Researchers are trying to enhance practice with simulations by implementing a playback system that records the actions of the user into the simulations. Review of the action via a playback system can be used to focus discussion during the debriefing and to identify areas of knowledge or skills that need improvement or practice (Freeman, Salter, & Hoch, 2004; Shang et al., 2006). Students can view actions through the playback system and practice simulated activities repeatedly to improve their knowledge and skills. Shang and colleagues stated that by continually evaluating and revising activities, students can learn and apply new knowledge in a shorter amount of time. However, some questions remain to be answered, such as: At what point during the learning activity with the simulation are students practicing and revising their activities, and is it important to know when this occurs? Now that technology such as HEAT supports recording and
saving actions and has the redo functionality that allows the user to practice or redo an action anywhere along the timeline of the saved simulation, researching users’ metacognition and reflection may help identify the effects of focused practice within a simulation and determine whether learning can be improved.

**After-Action Review**

The military has implemented a technique referred to as After-Action Review (AAR) since the Vietnam War (Seglie & Selby-Cole, 2000). An AAR is a team-building exercise in which soldiers come together after performing a training exercise or actual mission to reflect upon and identify both mistakes and good decisions, discuss possible alternatives, and talk about how to implement solutions (Baird, 1999; Scott, 1984). The AAR gives soldiers an opportunity to reflect upon past actions learned while performing (Baird, 1999) and also provides a method for soldiers to monitor and discuss their own actions and those of their team members (Salmons, 2008). The AAR has been adopted by businesses (e.g., British Petroleum) to enhance organizational learning as well (Schindler & Eppler, 2003). The purpose of the AAR is to learn from doing and while doing (Baird, 1999; Scott, 1984; Seglie & Selby-Cole, 2000). The actions implemented in an AAR allow all involved to discover for themselves what they need to learn and how to improve (Seglie & Selby-Cole, 2000). The military has also implemented the AAR into virtual simulation training (Hill et al., 2006; van Lent et al., 2004). The simulated actions of each soldier can be recorded for review and critique during the AAR. The recorded actions can also be compared with the intended learning objectives that have been programmed into the training software (van Lent et al., 2004), and in some cases the software can generate
Learning more about AARs and how they are performed can help researchers better understand how reflection on past actions helps learning in teams. However, the AAR is designed and meant more for group learning rather than individual learning. There is a need for a better understanding of reflection on the individual level as well as a better understanding of reflection from the point of failure rather than from the beginning of an educational activity. Currently it is not known how AARs within military contexts might be applicable across more common class-based contexts. However, the AAR literature indicates that reflection plays a large role in learning and should be researched in other educational contexts beyond the military. AARs fail to address the redo from the point of failure and its effects on learning. Therefore, research is needed on reflection during the redoing of an activity from the point of failure to find its effects on learning.

Learning

Learning has been defined as “a long-term change in mental representations or associations as a result of experience” (Ormrod, 2007). Over time, researchers have developed theories when trying to understand how people learn. Some of these theories are behaviorism, constructivism, and cognitivism (Bruner, 2004; Ormrod, 2007). Other researchers take these theories and apply them to see how people learn under certain conditions or in certain situations (Brown, Collins, & Duguid, 1989; Brown, 1990). For example, Brown et al. discuss learning in an apprenticeship situation, pairing a novice with an expert in hopes of turning that novice into an expert. Pairing is similar to
Vygotsky’s zone of proximal development where a student is instructed or guided by someone more capable who helps the student change the current development level to a potential development level (Kozulin, 1986). During a guided learning situation, the novice students learn new concepts (Brown et al., 1989). Concepts are both situated and developed through activity or, in other words, learning by doing (Glaser & Bassok, 1989). What this means is that those who use a tool have a much deeper understanding about that tool and the world where that tool is used than those who just obtain the tool. A learning situation can be enhanced when learning in authentic situations.

Situated learning has been linked to learning through experience and experience can be shaped by hypothesis testing (Bruner, 1985). Hypotheses are developed and tested in controlled situations and it is within these situations that students gain experience and learn. Bruner mentions Piaget’s constructivism as another way or style of learning. In constructivism, self-propelled learning is bound by the rules of the situation. These situations allow students to test their hypotheses, gain experience, and learn.

Learning can also take the form of gaining intellectual skill or procedural knowledge. The skill is shown when a person can turn the concepts learned into action in a situation (Gagne, 1984). As people gain knowledge or facts, they are gaining what is known as declarative knowledge, a subcomponent of metacognition. Declaritive knowledge is used to learn how knowledge connects with other facts and how knowledge is organized. People can take these two types of knowledge and learn how to use them by creating strategies that will help them remember and retain newfound knowledge.

Simulations and games as learning environments have also been used for training
and education (DeJong & Jooligen, 1998; Garris et al., 2002; Rieber, Smith, & Noah, 1998). Simulations and games claim many benefits, such as portraying processes that are lengthy (e.g., population growth), happen quickly (e.g., car crashes), or are otherwise expensive, dangerous, or difficult processes (Harper, Squires, & McDougall, 2000). Simulations and games can give a student opportunities to play an authentic role in performing complex tasks (Harper, Hedberg, Corderoy, & Wright, 2000). Simulations and games provide learners with a way to solve problems at a deeper level through the testing of their own “what-if” scenarios (Harper, Hedberg, et al., 2000). These “what-if” scenarios mean that the learners can, in a way, ask the computer or the simulation “what if I change these variables, what will happen next?” Also, simulated what-if scenarios can be used to test hypotheses and have been found to be successful (B.E.C.T.A., 2001; Harper, Squires, et al., 2000). To test a hypothesis, students need to reflect on what they are doing and what they already know. Thinking about what they know when using games and simulations can be helpful in hypothesis testing and learning about the process of learning.

Designing games and simulations that have built-in functionality or planned activities that facilitate reflective and metacognitive activities may increase opportunities for and improve the process of learning, as well as the learning of new content. For this study, learning is identified by the participants’ modifications of their behaviors and their explanations of those modifications. Within this explanation, students described how they became more aware of their own metacognitive and reflective abilities.
**Framing Technology-Supported Reflection and Metacognition**

Various tools and methods, such as journal writing (Richardson & Maltby, 1995), role taking (Reiman, 1999), reflection on action (Kreber, 2005), and AARs (Darling & Parry, 2001) have been implemented to study the influences of reflection on learning. Using these tools or methods for reflection has also led to improved learning.

Such reflective tools or methods can be used in what Brown and colleagues (1989) described as an apprenticeship learning situation. Brown and colleagues and Collins, Brown, and Holum (1991) discussed how pairing a novice with an expert in an apprenticeship situation is designed to transform the novice into an expert. The expert guides the novice during the learning situation by modeling, scaffolding, and coaching (asking reflective questions). This guidance is similar to how technology can help the student reflect by prompting with reflective questions. During learning tasks, experts can show students control processes or strategies to carry out the tasks. Control processes are the mental or cognitive strategies used when learning (e.g., reflecting by self-questioning). These control processes are metacognitive strategies that ensure that a learning or cognitive goal is reached (e.g., understanding something read; Palinscar & Brown, 1984). Educational simulations can give students the opportunity to reflect upon what was taught and to use the learned control processes in a specific context. The process of reflection can be enhanced by using different methods for reproducing or redoing the performance of the student (Collins et al., 1991). The apprenticeship model as described by Brown and colleagues and Collins and colleagues can be used to guide students’ learning of reflective and metacognitive skills. It is also important to understand
the situation in which these skills are being learned. Brown and colleagues noted that knowledge can be thought of as a tool and “can only be fully understood through use” (p. 33). However, true understanding of a concept comes only after understanding its use within an activity or the culture in which that activity exists (Brown et al., 1989). It can then be assumed that to fully understand how students use the knowledge or skill of reflection and metacognition, researchers first need to understand the context in which such knowledge and skills are applied. Brown and colleagues stated that for one to learn, there must be an understanding of the activity, the concepts involved, and the culture in which the learning takes place. Therefore, it is important to understand the activities, concepts, and context of the learning environment. This consists of learning with a subject-matter expert and, in the case of this research, a computer simulation that facilitates reflection, metacognition, and redo. However, within the context of student learning with a subject-matter expert or with technology-supported reflection and metacognition, there is little known about the effects of redo.

Seale and Cann (2000) performed two case studies in which students had the opportunity to reflect upon what they had learned. The first study focused on reflection in online environments such as chat rooms, and the second study focused on offline environments such as classroom settings. The purpose of these studies was to better understand the role of technology in encouraging students to reflect upon what they were learning. One case study used a web-based tutorial and online forums for discussion. The second study used online discussion forums for reflection after an in-class lecture. The findings from this second study lacked support because a questionnaire was the only data
collection method. However, Seale and Cann’s findings are in line with what Schon (1983) described as reflection-in-action and reflection-on-action. Seale and Cann indicated that in the cases of both online learning and in-class lectures with technology to facilitate reflection, a tutor or teacher plays a large role in aiding student reflection. Teachers can help make connections between learning content and learning goals and they can also bring attention to the process by which reflective practices can be carried out.

White and Frederiksen (2005) stated that for students to learn about metacognition, they need to be able to “talk about the different cognitive, social, and metacognitive capabilities that are needed” (p. 211) in that learning community. They suggested that after learning in a technology-supported metacognition environment, students should be able to participate in metacognitive activities outside of the software environment as a way solidifying what they have learned. White and Frederiksen designed virtual subject-matter experts into the learning environment. They also wanted to identify the kinds of metacognitive knowledge and skills needed in order to be successful when learning with technology that supports metacognition. Their research is in line with understanding the context in this learning situation.

In summary, metacognitive strategies that include reflection can be prompted and facilitated by technology and supporting software. These tools can give students the opportunity, or even force them, to reflect upon their thought processes while participating in learning activities. Often, these tools are accompanied by a subject-matter expert, such as a teacher, who can help make connections between the content and the
metacognitive skills learned. Technology can also give students the chance to practice and redo what they have previously performed and then reflect upon those actions. Researchers have stated that there is a need for practicing metacognitive and reflection skills when using technology for learning (Schraw, 1998; Seale & Cann, 2000). This practice, termed reflective redo, needs to be researched to understand how it affects current learning experiences and how it can be implemented for future teachers and learners.
CHAPTER III

METHOD

Research Design

Multiple students were studied within the context of a simulated computer environment that facilitates reflective redo. This research studied the influences of reflective redo on metacognitive and reflective activities as well as learning within a specifically designed computer-simulated environment. For this study, learning is identified by the participants’ modifications of their behaviors and their explanations of those modifications. Within this explanation, students described how they became more aware of their own metacognitive and reflective abilities. The research design used elements related to an observational study (Creswell, 2003) which is implemented in research using either grounded theory and DBR (Barab & Squire, 2004; Collins et al., 2004; Corbin & Strauss, 1990). Data were gathered through observation as well as other methods (e.g., interviews) and were then analyzed to make connections between the simulation and the effects on the participants. It was assumed that understanding the makeup of the learning environment in this study, which consisted of an expert (SME) and computer simulation, would generate improvement in awareness of metacognitive and reflective activity. The role of the SME in this study was to facilitate the debriefing session by pointing out mistakes and areas that needed improvement, and deciding at what point along the time line of Scenario 1 the “firefighter” was going to start the redo scenario. A mistake could consist of forgetting to perform a task, such as giving an
incomplete initial report (see Appendix B), or failing to give commands to other firefighters. However, the influence of the reflective redo aspect of this computer-simulated environment was not clear. Gathering data from multiple participants in this study helped uncover the effects of reflective redo on metacognition, reflection, and learning.

Metacognition has been defined as having knowledge of your own knowledge and regulating that knowledge or, in other words, thinking about the way you think and how you regulate that thinking (Hacker, 1998). For this study, metacognition was operationalized by how participants thought and what they thought about during a scenario, as well as how they regulated their thinking (a) during a scenario, (b) when they were reflecting on that scenario, and (c) when they were redoing that scenario. The interview questions were designed to measure whether participants learned to be aware of their own thoughts and to discover how they regulated those thoughts during the intervention. Gathering this data from multiple participants and using constant comparisons, aided in identifying whether reflective redo helped them learn about their own thoughts and whether metacognitive knowledge and regulation helped them succeed when learning with this type of simulation.

During the reflective redo aspect of the intervention, it was expected that the participants would reflect both in-action and on-action (post-action) and use that reflection to help them improve their actions and learning. Observation data and interview questions measured how the use of reflection both in-action and on-action was influenced by reflective redo. Learning was measured by changes in performance as well
as changes in reported self-awareness (metacognitive knowledge and regulation) and in the use of reflection. The study as designed provided the best chance of discovering how metacognition and reflection are influenced. Insights from this research help to show how reflection affected learning and how students were made aware of metacognitive skills when using specifically designed tools that supported reflective redo. The influence of reflective redo was investigated by using qualitative techniques described by previous researchers, such as categorizing, synthesizing, and searching for patterns from gathered data (Glesne, 2005; Guba & Lincoln, 1982). This design is useful in exploring research problems in new areas (Isaac & Michael, 1995) and can be used in laying the groundwork for future research.

Figure 2 shows the research design for this study. The objective was to understand how technology supports metacognition and reflection, and specifically to understand how reflective redo affects learning as a result of metacognitive and reflective activity. I used the following research questions to help attain the broad and specific objectives of this study.

1. How does the intervention that includes reflective redo influence metacognitive knowledge and regulation? How are participants thinking about their thinking?

2. During the reflective redo aspect of the intervention, how are participants thinking about their actions?

3. What evidence exists that the reflective redo activity alone creates change in learning in relation to metacognition and reflection?
### Objectives

**Theoretical areas of investigation**

**Research questions**

**Data sources**

**Planned analysis**

**Operationalized**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Theoretical areas of investigation</th>
<th>Research questions</th>
<th>Data sources</th>
<th>Planned analysis</th>
<th>Operationalized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad: to better understand how technology supports aspects of metacognition and reflection.</td>
<td>Metacognition</td>
<td>Q1</td>
<td>MAI Scores</td>
<td>Score rank/IQR</td>
<td>Thinking about their thinking pertaining to do, reflect, redo</td>
</tr>
<tr>
<td></td>
<td>Reflection</td>
<td>Q2</td>
<td>Participant observations, Video observation</td>
<td>Categorical comparison using benchmarks of • Metacognitive knowledge and regulation</td>
<td>Thinking about their actions pertaining to do, reflect, redo</td>
</tr>
<tr>
<td>Specific: to understand how reflective redo affects learning.</td>
<td></td>
<td>Q3</td>
<td>Change in checklist score (performance), Participant observations, Video observation, Notes, Interview/email</td>
<td>Categorical comparison using benchmarks of • Reflection-on-action • Reflection-in-action • Metacognitive knowledge/ regulation reflective redo alone</td>
<td>Change in checklist score (performance), Change in reported self-awareness, Change in use of reflection</td>
</tr>
</tbody>
</table>

*Figure 2.* Research design summary showing how the objectives of areas of investigation, research questions, data collection, and proposed analysis are connected.

This research had two basic methods of data collection. The primary components were interviews, observations (both participant and video-recorded), and sessions of recorded simulation play (Lin, 2001; Lin & Lehman, 1999; Richardson & Maltby, 1995). The secondary component was an online survey (MAI) to measure participants’ metacognitive awareness. The MAI data were used to identify the two individuals with the highest and lowest scores. These two individuals became a focus of the data analysis in an effort to identify how using this technology, which supports reflective redo, may affect those who have high or low metacognitive awareness. Once these two individuals were identified and their experience analyzed, the findings from the data corpus were then compared to the findings from these two individuals. This comparison was performed in an effort to identify whether the participants implemented metacognitive
knowledge and regulations and reflective activities and if so, to determine how metacognition and reflection may have been affected.

Participants (Sample)

Participants for this research were between 18 and 24 years old. I was interested in post-secondary learners based on the type and nature of the material (emergency response training), whose target audience is legal adults. The participants were self-selected college students at Utah State University (USU) who were attending introductory psychology classes within the department of psychology. The students fulfilled a class requirement by participating in the study. I tried to schedule seven females and eight males, but because more males than females contacted me to participate in this study, I scheduled six females and nine males. I chose 15 participants based on previous research that (a) had a least 15 participants, and (b) used similar data collection and analysis methods (Ke, 2008; Scoresby & Shelton, 2010; Squire, Barnett, Grant, & Higginbotham, 2004). Comparing the collected data from all 15 participants helped to identify the influence of reflective redo on metacognition and reflective activities as well as learning.

Instruments

Metacognitive Awareness Inventory

The Metacognitive Awareness Inventory (MAI) is used to assess metacognitive knowledge and regulation. The MAI consists of 52 Likert scale questions aimed at
measuring awareness of how metacognitive knowledge and regulation exist within an individual’s thinking. The purpose of the MAI in this study was to identify the two individuals with the highest and lowest scores. These two individuals’ experiences with the simulation are presented in Chapter IV describing how learning and metacognition and reflection were affected by this software. Comparing the range of the participants’ scores allowed an assessment of their metacognitive awareness.

Software

The HEAT simulation allows a team of firefighters to train in the necessary protocols using a simulated incident scenario. This study consisted of two scenarios. Scenario 1 consisted of a fire in the kitchen of a two-story house and an unconscious victim in a bedroom just above the fire. Scenario 2 consisted of a fire in an upstairs bedroom with an unconscious victim in the adjacent room. More detail about the scenarios can be found in Appendix C. Within the HEAT scenarios, the simulated actions of all team participants could be recorded and played back for review. During the playback portion of the intervention, the participants had the opportunity to reflect upon their efforts and thoughts. All participant and team member actions were saved to a database during the scenario. During the playback of a scenario, the saved data was loaded and displayed on the computer screen much like a video recording. By using DVR-like controls, as seen in Figure 3, students could play, pause, fast forward, and rewind their actions during the review.

The redo functionality gave the participants the opportunity to reflect upon past actions and help them fix any mistakes in the previously recorded scenario. For example,
one participant forgot to give the command to search the house because he focused completely on the fire. This mistake meant that the team never found the unconscious victim in the upstairs bedroom which was identified during the debriefing. I then facilitated the redo of Scenario 1. It is important to understand how this software influenced the reflection and learning of the users. Because the participants performed a redo of the saved scenario, they had the opportunity to reflect upon the actions performed in Scenario 1 and also to reflect upon their actions during reflective redo. The interviews were used to assess whether and how the participants reflected during the redo of Scenario 1.

Figure 3. A screenshot of the playback functionality within the simulation that contains the DVR-like controls for playback.
Checklist

Professional firefighters and firefighter trainers provided a checklist to mark off task items performed or given as commands by the Incident Commander (IC) during each scenario within the simulation. A task item consisted of actions the IC performed such as describing the fire, the building, or his current position, or giving commands such as telling firefighters to investigate the premises or prepare the hose. During the intervention, items on the list were checked off as the participant performed them (see Appendix B).

Procedures

During the simulated scenario and as part of this intervention, three users participated in the environment at one time. However, one of the three users was designated as the Incident Commander (IC), and it was from this study participant that data were gathered. The other two helper participants’ sole purpose was to participate in the scenario and perform the simulated actions as commanded by the IC that related to the actions that needed to be performed on the checklist. These two helper participants were chosen for convenience because they were familiar with the simulation. They were instructed to act solely on the commands given by the IC study participant to ensure a similar experience for all IC study participants. An intervention timeline experienced by participants can be found in Appendix A.

Each scenario lasted anywhere from 5 to 10 minutes. A few participants required more time to complete their scenarios. A full description of what the participants
experienced during each scenario is provided in Appendix C. The procedures of the study intervention followed these steps.

1. Study participants completed the MAI 5-point Likert scale survey as seen in Appendix D.

2. Study participants were instructed on the protocol items on the checklist. They were informed that these checklist items would be the basis for their score during the simulation scenario.

3. Study participants started Scenario 1.

4. Study participants used the scenario regeneration tool and playback system during the debriefing of their first scenario. I led a debriefing session after the first scenario, which included the playback of Scenario 1 as well as discussion of and questions about actions performed in Scenario 1. After the debriefing session, the participant performed a redo of Scenario 1 to have a chance to fix any mistakes made during Scenario 1.

5. Study participants started Scenario 2 and new data were collected.

6. I interviewed the study participants using open-ended, semistructured interview questions.

Data Collection

Figure 4 represents the proposed data collection procedures for this study. Data were gathered in the following ways.
<table>
<thead>
<tr>
<th>Time</th>
<th>Participants</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 (~10mins)</td>
<td>MAI</td>
<td>MAI score collected upon completion</td>
</tr>
<tr>
<td>T2 (~10mins)</td>
<td>Scenario 1</td>
<td>S1 checklist</td>
</tr>
<tr>
<td>T3 (~20mins)</td>
<td>Intervention: debriefing S1 • Discussion lead by SME/researcher • Redo S1</td>
<td>Participant observations/notes taken and video during S1, debriefing, S1 redo, S2</td>
</tr>
<tr>
<td>T4 (~10mins)</td>
<td>Scenario 2</td>
<td>S2 checklist</td>
</tr>
<tr>
<td>T5 (~30–60mins)</td>
<td>Participant interview</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 4.* The proposed data collection procedures for this study.

**Saving Scenarios**

Each scenario was saved and played back on the computer screen much like a DVR. These recordings also included audio recordings of the IC that were used to listen for correct commands.

**Checklist**

The checklist contained the correct items that an IC had to follow to be successful. These items consisted of the verbal commands the IC gave to the other participants. I explained the items on the checklist to the individual participants, and during the intervention I recorded the correctly mentioned items from the checklist.

**MAI**

To help assess the effects of the redo reflection on metacognitive awareness, MAI
scores were gathered before the intervention. Research has shown that the two metacognitive components of knowledge and regulation are embodied within the survey and the survey has been found valid (Schraw & Dennison, 1994; Young & Fry, 2008). In the inventory survey, there were 35 questions relating to regulation and 17 relating to knowledge. With the five-point Likert scale, there was a possible maximum score of 175 for metacognitive regulation and a maximum score of 85 for metacognitive knowledge.

Table 1 shows sample questions from the MAI that the participants answered relating to metacognitive knowledge and regulation.

**Observations**

During each scenario and the debriefing session, I took notes and made observations and video recordings of participant actions to gather data related to reflection and metacognition. The data consisted of visual cues, such as pausing to think before talking and restating something already said.

Table 1

*Metacognitive Knowledge and Regulation Questions from the MAI*

<table>
<thead>
<tr>
<th>Item</th>
<th>SD</th>
<th>D</th>
<th>N</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metacognitive knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I try to use strategies that have worked in the past.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I understand my intellectual strengths and weaknesses.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I learn best when I know something about the topic.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metacognitive regulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I ask myself periodically if I am meeting my goals.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I pace myself while learning in order to have enough time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I slow down when I encounter important information.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly agree (SA).
Interviews

After participants completed both scenarios, they took part in a one-on-one, semi-structured interview. The interview questions were designed to elicit information that can be difficult to observe (Glesne, 2005) regarding participants’ opinion of the tools built into the training simulation. Additionally, questions were asked to obtain demographic information, make connections between the simulation and reflection-on-action, and give support to metacognitive subcategories (planning, monitoring, and evaluation). Scoresby and Shelton (2010) interviewed their study participants for anywhere between 15 minutes and one hour, with an average time of around 40 minutes. The interviews in this study averaged about the same. The following are some sample interview questions (a complete list of questions can be found in Appendix E):

Reflection-in-action:

- During the simulation, how do you use reflection?
- In your opinion, how does reflecting during the simulation affect you?

Reflection-on-action:

- How do you think you did?
- Is there anything that you think would have helped you improve your performance?

Planning:

- Did you make any predictions about how you were going to include all of the items on the checklist?

Monitoring:
• Did you think about what you already knew about the topics?

Evaluation/Regulation:

• During the simulation were you thinking about what you wanted to gain/goals?

Emails

Emails were sent to all the participants to gather data that clarified their interview answers. Even though all the participants stated in the interviews that they would respond to any further questions via email, only a few responded to follow-up questions. However, one participant had a difficult time clarifying his answers during the interviews and had decided he needed more time to think about his answers. In the days following the interview, I emailed this participant and he responded with clarifying answers to the interview questions.

Data Analysis

Overview

During each scenario, I took observational notes of each participant’s actions within the context of the simulation, in particular how they used the redo and playback tools (Glesne, 2005; Jordan & Henderson, 1995). Each participant was observed and video recorded to look for connections to participant reflection and metacognition while using the tools. In particular, verbal cues such as pauses or reiterations could signify that the student was reflecting and using metacognition.

During the review of Scenario 1 (the debriefing session), there were opportunities
for discussion and for participants to ask questions. I noted anything asked or discussed that related to reflection and metacognitive knowledge and regulation. Participants had the opportunity to learn a lot more through interacting with me as the facilitator because they could ask questions to clarify and further review the task items. These interactions had the potential to be highly variable, depending on what happened during the simulation. However, there were very few differences among the participants’ debriefing sessions. After reviewing the actions performed during Scenario 1, few participants asked questions when given the opportunity. The questions that were asked pertained to task clarification. Therefore, comparing the debriefing sessions was not difficult due to the lack of variability among the participants.

After participants finished the survey, the scores were automatically saved and were later totaled. The range of scores was used to identify those with the highest and lowest scores for focused analysis. The different components that make up metacognitive knowledge (e.g., declarative and procedural knowledge) and regulation (e.g., planning and monitoring) were used to categorize the data when analyzing each participant. The participants’ answers to the MAI questions relating to metacognitive knowledge and regulation were compared with other data such as answers to interview questions. These comparisons were made to help identify possible emergent themes during the ongoing data analysis.

Gathering and analyzing data from one group allowed the identification of key words, phrases, and patterns from each participant’s answers that were related to the interview questions. Using one group allowed for the comparison of data among the
participants while enhancing the possibilities of answering the research questions. The key words were then summarized and analyzed to find different aspects or themes relating to metacognitive knowledge, regulation, and reflective activity. After interviewing each participant, I reviewed the data collected, including observational notes, video observations, interview transcriptions, and saved simulated scenarios, to draw conclusions about the interview. I specifically attempted to identify how the participants thought about their thinking and how they thought about or reflected on their actions during and after the activity. At the conclusion of this research, I identified themes among the participants that related to the research questions in order to draw conclusions from the research findings (Creswell, 2003; Yin, 2003).

An additional analysis was performed to compare the number of correct decisions made from the checklist within the group. The comparison was used to see if the reflective tools did, in fact, have an effect on the participants’ actions and learning. Schon (1983) stated that reflection-on-action and reflection-in-action are the two types of reflection that can be used to improve learning. These types of reflection were used as benchmarks to analyze the interview questions that were designed to elicit answers pertaining to the participants’ reflective activities. Interview questions were created that related to metacognitive knowledge and regulation. Metacognitive knowledge and regulation were used as the benchmark analysis tool for the research questions. The analysis revealed the effects the combined simulation and SME had on metacognition and reflection, specifically what kinds of effects reflective redo had on learning when using metacognition and reflection.
Phases of Analysis

After all data were collected from the 15 participants, I transcribed the interviews into text documents, which provided easy access to this data and organized it by related answers. I then created new text documents that contained matching interview questions and answers that pertained to the different subcomponents of reflection and metacognition. Next I placed participant-specific interview answers under the related research question. Once all the related answers were organized and matched to the research questions, I analyzed these sections by searching for matching terms or phrases given by each participant during the interview. Figure 5 shows how I categorized related interview answers that pertained to metacognitive regulation, more specifically the subcategory of planning. The vertical red lines show how I aligned the related interview answers and the horizontal blue lines separate the participants’ answers. An image with clearer text can be seen in Appendix F. Identifying these terms and phrases was important because it helped to elucidate emergent patterns and themes among participants’ interview answers that related to the research questions.

The next phase in the data analysis consisted of reviewing the video recordings of each participant during the simulated scenarios, replaying their saved scenarios, and reviewing the recorded debriefing sessions, the checklist items, and my personal observations. I reviewed the video recording of a scenario while watching the replay of that saved scenario within the technology. This review gave me the chance to double-check my original scoring of the checklist items as well as my observations from each scenario. While reviewing the videos, I also added to my previous observations by taking
Figure 5. An example of categorizing related interview answers.
new notes of participant actions and statements during Scenario 1, the redo of Scenario 1, and Scenario 2. Reviewing and adding to previously made observations provided more insight into the actions of the participants and what that insight might mean in terms of using this technology for learning. I also identified where the participants made mistakes during Scenario 1 and whether they fixed their mistakes during the redo of Scenario 1.

The last phase of my data analysis consisted of identifying those who scored highest and lowest in the MAI survey. The MAI survey was made up of 52 questions that could be scored on a five-point Likert scale. The purpose of this survey was to score a student’s awareness of metacognition. I performed a small statistical analysis on the scores by identifying the range of the scores. The range scores were used to identify the individuals who had the lowest and highest scores. However, during the analysis of the complete data set, two distinct groups or outcomes emerged in relation to the participants’ experience with reflective redo. This emergent outcome is discussed later in the chapter. One outcome was represented by the participants who used reflective redo to focus their efforts on fixing the mistakes made during Scenario 1, and the second outcome was represented by the participants who could not focus on the mistake or start at the point of failure because they could not place themselves at that point within the problem space. It so happened that the participants with the lowest and highest MAI scores were in the same group and had the same opinion of reflective redo. For this reason, I chose to use the participant who had the second highest MAI score and whose reflective redo outcome was different from that of the participant with the lowest score. This switch allowed me to discuss the experiences and outcomes that represented all
participants of this study. The data from these two chosen participants were used for a more detailed analysis to identify the relationship between metacognitive awareness and learning while using this technology.
CHAPTER IV

FINDINGS

This chapter illustrates my method for determining how students were influenced in terms of their metacognition and reflection when using the HEAT simulation. I provide an in-depth example of my analysis using two students to show how I identified the effects this simulation had on metacognition, reflection, and learning. I summarize the results of the analysis for these two students and then summarize the results of the analysis for all of the participants by addressing the research questions. I conclude with a discussion of the material presented in this chapter.

This chapter describes the findings of this study and I use those findings to answer the research questions.

1. How does the intervention that includes reflective redo influence metacognitive knowledge and regulation? How are participants thinking about their thinking?

2. During the reflective redo aspect of the intervention, how are participants thinking about their actions?

3. What evidence exists that the reflective redo activity alone creates change in learning in relation to metacognition and reflection?

In the previous chapter, I described my methods of data collection and analysis. The data consisted of information gathered from the MAI, observations of the participants, video recordings of the participants during the simulation and debriefing sessions, saved simulation scenarios, and interviews. The broad objective of this study
was to better understand how technology supports aspects of metacognition and reflection; the specific objective was to understand how reflective redo affects learning. To analyze the data pertaining to metacognition, I used categorical comparisons with the benchmarks of metacognitive knowledge and regulation. To analyze the data pertaining to reflection, I used a categorical comparison with the benchmarks of reflection-in-action and reflection-on-action. By categorical comparison, I mean I categorized related data from each participant in terms of metacognition, reflection, and learning, and then compared the data in those categories.

**Review of Terms**

To review, metacognition has been defined as the “the deliberate conscious control of one’s own cognitive actions” (Brown, 1980, p. 453). Other researchers have identified and defined common components of metacognitive knowledge such as declarative, procedural, and conditional knowledge, and the components of metacognitive regulation such as planning, monitoring, and evaluation (Flavell, 1979; Schraw, 1998; Young & Fry, 2008). I used these six subcomponents of metacognitive knowledge and regulation as benchmarks for the data analysis.

Declarative knowledge consists of knowledge about oneself as a learner and the factors that influence one’s performance (Schraw, 1998; Young & Fry, 2008). For example, good learners are aware of their memory limitations. Procedural knowledge means one has knowledge about the different learning and memory strategies that work best for oneself. A typical example of procedural knowledge is knowing how to chunk information when learning something new. Conditional knowledge means having
knowledge and understanding of when to implement different learning strategies (Schraw, 1998; Young & Fry, 2008).

Metacognitive regulation consists of planning, monitoring, and evaluation. Planning means learners plan out a cognitive task by choosing the best learning strategies during learning experiences. Monitoring means the awareness of one’s progress through the learning or cognitive task. Evaluation means determining if the learning outcomes are matching the learning goals (Schraw, 1998; Young & Fry, 2008). For this study, planning is defined as choosing a particular learning strategy for this learning experience. Monitoring is defined as the participants’ awareness of their progress in completing checklist task items and how they used or thought about their learning strategy during the scenario. Evaluation is defined in two parts: first, the number of task items the participants completed and second, the effectiveness of their learning strategy.

I often refer to the participants’ metacognition throughout this chapter. When I make such a reference, it should be understood that I mean their implementation of metacognition within the context of this study, which consists of learning with this technology, and the support of the facilitator.

For this study, learning is identified by the participants’ modifications of their behaviors and their explanations of those modifications. Within this explanation, students described how they became more aware of their own metacognition and reflection.

**Student Examples**

In this section, I describe the experience of two participants selected by their MAI
scores. I first describe their individual experiences during each scenario and debriefing session by explaining what they did and what I observed during each scenario.

Describing their experience lays the foundation for understanding how this technology facilitates metacognition and reflection, which is the broad objective of this research study. After I describe their experience with the technology, I discuss the findings from the analysis of their data and how the findings relate to the research questions in a general or broad sense. Finally, I report in a new section the findings from all of the participants to explain how reflective redo influences metacognition, reflection, and learning.

**Jack’s Example**

Out of a possible 280 points, Jack had the lowest MAI score, 169. He was 24 years old and a junior at Utah State University. Jack reported that in the past he had played sports games on Xbox or Playstation, but he felt that playing those games had very little influence on him during this simulation. Like all of the participants, Jack filled out the MAI survey and then sat down to receive instructions for this study, which were the same as those received by all the other participants. He then had time to review and memorize the task items on the checklist. When he felt ready, we started Scenario 1.

Analyzing Jack’s data was difficult at times because Jack often gave contradicting answers during the interview. For example he stated that he did not organize the information in any particular order, but then also stated that he tried to think about the task items in an order of what would happen at the beginning, middle, and end of the scenario. To help overcome any problems that arose because of the contradictions, I searched for and compared the answers he gave to the interview questions that were
related. This method of analysis helped me gain insight into Jack’s experience and also helped me understand some of the answers he gave later in the interview that may have contradicted previous answers to interview questions. For example, even though he contradicted himself about not thinking about the task items in any particular order, he stated more than once that he did mentally put the task items in a beginning, middle, and end. Based on this example, I chose to record that he actually did think about an order of task items and how they should be performed.

**Scenario 1.** During Scenario 1, Jack reported that he felt timid and showed that he was unsure of the actions he was supposed to perform during the scenario. One indication that he lacked confidence was the “ums” and “ahs” he uttered when trying to give commands to the other firefighters within the simulation. He also had a difficult time playing the role of a commander. Jack would ask, rather than command, the other firefighters to perform actions, as in, “Will you please go in and assess the fire?” Each participant was instructed to be as specific as possible when giving commands, but Jack had a problem with this also. He would often give a command and not indicate who was supposed to perform that command. For example, he gave the command, “Go get the hose and put the fire out.” At this point, the firefighters did not do anything because neither of them knew who was supposed to get the hose. Not only did Jack have a difficult time remembering some of the tasks and giving commands in a direct and specific manner, he also took longer than all the other participants to complete the scenario. His first scenario took approximately nine minutes; the rest of the participants took between 5 and 6 minutes on average. During Scenario 1, Jack performed 9 of the 17
tasks on the checklist.

**Debriefing session.** After Jack completed Scenario 1, we sat together at the facilitator’s computer and watched the replay of the scenario. Jack sat still, watched, and listened while giving the occasional nod or “uh-huh” to show that he understood what we were discussing. He made the mistakes of not being specific and direct when giving commands and not completing the initial report after arriving on scene. The initial report consisted of tasks such as giving a building description, describing smoke and fire conditions, giving initial actions or assignments, calling command as the IC, naming the incident, and reporting the location. Our discussion focused on his mistakes, which involved failing to describe the building, name the incident, or report his location. I asked him if he had any questions or concerns and he asked only one question, saying he wanted more clarification on the task item called Rapid Intervention Team (RIT). This command is given if other firefighters are in an emergency situation and need help getting out of a burning building. He was satisfied with the explanation given and had no further questions.

**Redo scenario.** During the redo scenario, Jack showed some signs of change and improvement. He improved his task item score by one from Scenario 1 (9 items) to the redo (10 items), and he improved his commands by being more specific and not asking. However, he did not completely stop asking the other firefighters to perform commands. On multiple occasions, he caught himself starting to ask but then gave the command instead. Catching himself during the redo showed that he was cognizant of what he was trying to fix, which means he was monitoring his actions while performing. Jack also did
not perform some of the tasks or, in other words, give some of the commands during the redo that he performed during Scenario 1. For example, he gave the command for RIT during Scenario 1 and did not give the command during the redo or subsequently during Scenario 2. It is not clear why Jack did not call for the RIT command during the redo scenario. However, I observed that he performed two other tasks during the redo and Scenario 2 that he did not perform during Scenario 1.

Realizing that Jack received clarification of the RIT command during the debriefing session may help in understanding why he did not use this command during the preceding scenarios. This understanding is an example of Jack evaluating his performance during the debriefing session and then adjusting his learning strategy to match his learning goal of doing the best he could by performing the tasks needed to get the job done correctly. Other notable actions performed by Jack during the redo scenario were calling for an ambulance once he was informed there was a victim recovered and calling for utilities to be shut off as one of his final commands. These actions were notable because (a) there was not a task item on the checklist that related to calling an ambulance, and (b) normally, shutting off or at least checking utilities is one of the first task items that are performed once the initial report is given. My conversation with Jack, as shown in Table 2, follows Jack’s command for the ambulance.

These questions and answers illustrate how Jack was thinking during the scenario. He attributed the call for an ambulance to human nature. I claim that Jack can actually attribute calling for an ambulance to past experience. As stated, Jack often contradicted himself and in one statement after being ask what he reflected on during scenario 1, he
Table 2

*Conversation with Jack about Give a Command During the Simulation*

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Verbal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviewer</td>
<td>Why did you call for an ambulance even though it wasn’t on the list?</td>
</tr>
<tr>
<td>Jack</td>
<td>I just saw a guy on the ground so I thought he needed assistance that we can provide so I decided to call.</td>
</tr>
<tr>
<td>Interviewer</td>
<td>What experience did you use or what knowledge goes into the reasoning that he’s hurt and that means he needs an ambulance?</td>
</tr>
<tr>
<td>Jack</td>
<td>Well usually I guess that at the scene of a fire, I’m not too sure, I think this is how it works, that there would always be an ambulance and with a fire truck and with the police department and stuff and I just looked around and didn’t see anybody that was there and I just saw the guy on the ground and assumed that he needed help.</td>
</tr>
<tr>
<td>Interviewer</td>
<td>I mean, you’ve had past experience where you’ve seen a movie or you’ve seen a TV show or maybe you’ve even seen the real thing, so what of that has gone into this assumption that an ambulance should be there?</td>
</tr>
<tr>
<td>Jack</td>
<td>Well a fire is a dangerous thing so you’d just assume that an ambulance would be on its way.</td>
</tr>
<tr>
<td>Interviewer</td>
<td>Have you seen a real-life fire? Have you seen it in a movie and did that come into play at all during the scenario?</td>
</tr>
<tr>
<td>Jack</td>
<td>I don’t think so, no. It was just kind of my human nature, you see someone in trouble and you just go in with that, and I wasn’t really thinking of any examples or anything like that.</td>
</tr>
</tbody>
</table>

stated, “Probably past knowledge, I mean, I would lean towards obviously probably something I’ve seen on TV or in a movie or something like that.” Calling for an ambulance during the scenario was also a sign that Jack was thinking or monitoring his thoughts while performing. The command to call for an ambulance was beyond what he had studied using his learning strategy.

I asked Jack why he called for the utilities to be turned off right at the end of this scenario and he said;

I just forgot, just simply forgot. It just came to mind afterwards and then I guess, but not too sure how it would work, but I just assumed that with the fire being out
I wouldn’t want the fire to start again with electricity and gas so I thought it best to put it out.

In all three scenarios, I observed Jack taking a little extra time to pause and think. He would command the other firefighters to perform multiple searches, and while waiting for the reports he would think about the checklist in his head. Jack’s statement that “it just came to mind” is evidence that he was continually checking his learning strategy by determining whether he had missed any tasks and assessing or evaluating his success.

**Scenario 2.** During Scenario 2, Jack improved slightly on the mistakes he made during Scenario 1. I observed that he was better at being more specific when giving commands, but was still unclear on a few commands. He even asked the other firefighters to perform some tasks on a couple of occasions during Scenario 2. Jack improved his checklist score from 10 during the redo to 13 for Scenario 2. Some of the task items that Jack performed during Scenario 2 were skipped during Scenario 1, the redo, or both. As he had done in the previous scenarios, Jack spent a little extra time toward the end of the scenario thinking about his actions and trying to remember anything else from the checklist. He performed the same actions during Scenario 2 as he did during the redo in that he sent the other firefighters to perform multiple searches in and around the house. He reported that he felt more confident during Scenario 2 and that with more practice and repetition he would continue to improve his performance.

**Jack’s metacognitive experience.** How did the technology affect Jack’s thinking in terms of metacognitive knowledge and regulation? By analyzing the interview questions, I determined that Jack used metacognition, but he was not aware, nor did he apply metacognition well. When I asked Jack what he was thinking about during the
different scenarios, he often gave contradicting answers. For example, he reported that he tried to organize the tasks into what had to happen at the beginning, middle, and end of the scenario. He also stated that when he was doing this mental organization, he did not apply any ranking or order to the task items, meaning that nothing needed to be performed before anything else outside of the original ordering. He later reported the exact opposite, that he applied an order of importance. The many conflicting answers that Jack gave throughout his interview supported his MAI scores and indicated that he was not very metacognitively aware or, in other words, had lower metacognitive awareness than the rest of the participants.

The metacognitive subcategories identified through the interview pertained to declarative, procedural, and conditional knowledge. Jack reported that he knew about chunking related terms and used chunking as his learning strategy. He had used this learning strategy in the past and he knew that chunking could be applied to this learning situation. However, due to his conflicting answers, it is unclear if Jack’s efforts with chunking were the same or different from those of most of the other participants. I will discuss later how the rest of the participants used chunking as a learning strategy and how they put the task items in an order of importance or ranked the tasks to help them remember the tasks better.

Jack’s lack of metacognitive awareness was more apparent when assessing his interview questions pertaining to metacognitive regulation (planning, monitoring, and evaluation). To better explain Jack’s metacognitive regulation, I use transcript excerpts of his interview. In Table 3, the speaker is identified in the far left column: “Jack” refers to
Table 3

An Excerpt from Jack’s Interview Transcript Showing the Level of His Metacognitive Awareness

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Verbal</th>
<th>Descriptive comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviewer</td>
<td>Did you make any predictions about how you were going to include all of the items on the checklist?</td>
<td>Jack’s answer revealed that he was aware of planning. His plan was to put the different tasks into beginning, middle, and end stages of the scenario.</td>
</tr>
<tr>
<td>Jack</td>
<td>A little bit I just basically, just cut it down into different sections at first like the initial observation. I kind of put that in my head from there I just… I just basically broke things down to the beginning middle and end more or less.</td>
<td></td>
</tr>
<tr>
<td>Interviewer</td>
<td>Did you think about the content matter before you got started, in the sense of what things mean and how they are used?</td>
<td>This question was asked to further assess his planning awareness.</td>
</tr>
<tr>
<td>Jack</td>
<td>Not necessarily, but I knew kind of what they all meant. I was more or less trying to remember the exact order of the procedures I guess.</td>
<td>Even though Jack used planning which is a subcategory of metacognition, he was not aware of the full potential of how planning can help him learn.</td>
</tr>
<tr>
<td>Interviewer</td>
<td>So you put them in a procedure even though I told you there was no order of procedures, why did you do that?</td>
<td></td>
</tr>
<tr>
<td>Jack</td>
<td>I kind of did it because I was kind of going from the point of what I thought would be most relevant to the situation like which thing goes where. I tried to break it down in order, what you do first, what you do second, what you do third. Yeah so basically what was most relevant at that particular time….</td>
<td>Similar to other participants, Jack created a mental procedure of ordering the task items even though there was no correct order in which to perform the task items. Creating an order of how the tasks should be performed seemed to help students remember those tasks better.</td>
</tr>
<tr>
<td>Interviewer</td>
<td>What went into putting the task items into parts?</td>
<td></td>
</tr>
<tr>
<td>Jack</td>
<td>Just past experience is why I put into parts.</td>
<td>Thinking about past experience helped Jack create a plan for learning about this content.</td>
</tr>
<tr>
<td>Interviewer</td>
<td>Did you think about what you were going to do or how you were going to succeed for the second scenario?</td>
<td></td>
</tr>
<tr>
<td>Speaker</td>
<td>Verbal</td>
<td>Descriptive comments</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Jack</td>
<td>Yes I think so in retrospect, like the proper things I was going to do to succeed, like I think I did want to make sure although I didn’t do it in an aggressive manner I wanted to take the authoritative approach. I was more confident going into it so I was kind of already . . . had some . . . I had confidence going through my head so just went with that. That’s the main thing I wanted to do, I was just going to be more confident and be more authoritative and make sure they do what I tell them.</td>
<td>Jack discussed what he wanted to do to be successful for the second and final scenario. Being aggressive and taking an authoritative approach was one of the items we discussed during the debriefing session.</td>
</tr>
<tr>
<td>Interviewer</td>
<td>What triggered those thoughts going into the second scenario?</td>
<td>At this point, Jack evaluated his actions and his plan or learning strategy and realized that adjustments were necessary for him to be successful in the future.</td>
</tr>
<tr>
<td>Jack</td>
<td>Probably realizing that the first approach was the one that I shouldn’t have gone with.</td>
<td></td>
</tr>
</tbody>
</table>

From these interview questions, I assessed that Jack was using planning; however, I argue that he was not very aware of this or any other aspect of metacognition.

As stated, monitoring is defined as the participant’s awareness of progress during the scenario and using or thinking about the learning strategy while performing. Jack monitored his progress by mentally checking off the task items as he performed them. I previously mentioned that Jack would take time to perform extra searches toward the end...
of all three scenarios. Taking this extra time was a way for Jack to monitor his progress. He spent extra time within the simulation trying to remember any tasks he might have forgotten. However, Jack was not aware of his ability to monitor his thoughts about his learning strategy during the scenarios. I asked if he thought about and used any mental procedures or learning strategies during the scenario to help him remember the task items and he answered no. Jack said that he used the learning strategy of chunking related items into tasks that should be performed in the beginning, middle, and end of the scenario. I reminded him of his learning strategy after he said no, and he immediately stated;

I think the approach I took was “I did this, OK I’ve done this.” Basically checklisted...while I was trying to remember the checklist, basically checking it off of my checklist in my brain right. I would look around and use that approach and then think “what can I do next” and going on with that. I still had my own checklist not necessarily for the exact same things, I mean, pretty much for the same things but kind of in my own words in my head if that makes sense.

Jack’s answer demonstrates another example of how he used the skill of monitoring, creating his own mental checklist, but was not aware that he was using this skill until I reminded him.

Jack evaluated his progress by stating that he felt he improved on the number of task items performed from scenario to scenario. When he evaluated the efficacy of his learning strategy, he started to talk about how he tried to remember the things in general. He stated, “I think the first couple times I was just trying remember things and not forget them.” When evaluating his learning strategy for the redo and for Scenario 2, he stated;

And then the second time only trying to remember the things I’d forgotten from the first one. So, the second time I did all the things that I knew from the first one, they were just coming with me and I wasn’t worried about those ones, I was worried about the things that I wasn’t doing.
Jack’s answers show that he is evaluating his thoughts and what he was thinking about during the scenarios. But, when I asked if he was thinking about how he was using his learning strategy or even thinking about it at all during the scenarios, he stated, “Well I’m doing it, not thinking about thinking. Maybe afterwards, but I am definitely not while it’s happening. I’m not taking that approach to it at all.” This statement is another example of how Jack was contradicting himself throughout the interview. He had previously stated that he was thinking about what he had forgotten and the task items that he was not performing during the second scenario, and then immediately stated that he was not thinking about thinking during the scenarios. His statement, “Maybe afterwards, but I am definitely not while it’s happening,” is a correct evaluation method; however, he is not aware that he is actually monitoring and evaluating while he is performing.

Jack has the ability to use metacognition to help improve his learning, but he is not aware of how to properly use those skills to their full potential. Using this technology while learning new content forced Jack to think about his thoughts even though he was not aware that he was doing it. If Jack had had experience or, in other words, if he had been taught about these different aspects of metacognition, he probably would not have contradicted himself multiple times and would have had a clearer mental picture of his experience and the thought process he used for learning.

**Jack’s reflective experience.** How was Jack reflecting on his actions during the scenarios? Identifying how and on what Jack reflected during the scenarios was easier and created a clearer picture than was possible for metacognition. To help explain how Jack reflected on his actions during the redo, I describe how his reflective process
changed from scenario to scenario.

**Scenario 1.** Because Jack had no actions to reflect upon during Scenario 1, he reflected on the sheet that contained the task items in an effort to remember what needed to be done. He also reflected on past experiences in the form of what he had seen in movies and on TV. He stated;

Probably past knowledge, I mean, I would lean towards obviously probably something I’ve seen on TV or in a movie or something like that. I mean it’s not really something you would think about but I mean I’ve got a visual picture of it so that probably would mean that I did see on TV or from a movie or something like that. And then like I was saying earlier, I kind of remember...I took that course. I tried to remember something from that. That was kind of the initial thing like that but I think for the most part, it was probably just subconscious thinking about a movie or something that I had seen on TV prior.

Jack reflected on anything he could that related to this content. He used images he had seen in a movie or something he had seen on TV. He had taken a class that related to firefighting and he also used that experience for reflection. This example of what Jack reflected on during Scenario 1 is a prime example of what the rest of the participants did during their own experiences. As I will discuss later, when learning something new, students will reflect upon anything they can that possibly relates to the current topic in to further their understanding of that topic.

**Redo scenario.** After completing Scenario 1, Jack had actions to reflect upon that he used to help him during the redo scenario. These actions were recorded and reviewed using the playback system within the simulation. The review of the actions also gave Jack something to reflect upon. I asked if he reflected on our discussion during the debriefing session and he stated:

Yeah definitely, the things you told me...I think right away...initially I tried to get
done, um the things done than you first told me to get those things out of the way and then from that I just kind of tried to draw off again...just tried to picture the sheet in my head and tried to go from there.

Jack is referring to the mistakes that were identified during the debriefing session. He forgot to perform some of the initial report tasks during Scenario 1, so during the redo scenario he focused on those actions. When asked about the playback tool and whether he used the experience of watching his recorded actions for reflection he said, “I don’t think I knew while I was doing it that I did it wrong. So I mean without being told about that, I think I would have just done it again or else forgot about it like I did the first time.” Not only did Jack now have something to reflect upon, he had something specific to reflect upon, i.e., his mistakes. In other words, he focused on and tried to fix his mistakes by reflecting on what was identified during the debriefing session.

**Scenario 2.** Jack reported that the reflection process was different for Scenario 2 than for the redo scenario. He stated that because of seeing his actions on the playback and working on the mistakes during the redo, his reflection during Scenario 2 was not as intense, meaning that he did not put as much effort into reflection as he had before.

I started to reflect on what you told me again, but it stuck in there a lot better. I went with a little more of an aggressive approach and I think I kind of knew what I was going to get out right away. I didn’t really think about everything as much.

The redo scenario helped Jack learn about and memorize the task items better. Jack did not have to think about the task items as much and performed them without having to spend time thinking or reflecting on his mistakes.

**Jack’s learning.** Does this technology influence learning in terms of metacognition and reflection? Jack was identified as being less aware of his own
metacognition. He gave conflicting answers during the interview that supported this claim. Even though he was less aware of his own abilities, he had moments when he performed metacognition that, if identified, could have been used to improve his awareness. For example, I asked Jack if this experience, particularly redoing a scenario from the point of failure, influenced the way he thinks about his thinking. His answer was:

Yeah because I mean, you are not going to want to screw up again, so for the next time and all the times following that I guess it would probably make me think of just a better approach to go about the situation. Like if I couldn’t remember it the first time, I’m going to look back and think of why I did those things. So I think that would give me the motivation I guess to look towards new ways of attacking the situation.

Jack’s answer is the exact definition of evaluation. He is thinking about how he approached the situation and how he could adjust his approach to that situation if problems arose. Some of Jack’s interview answers about metacognition were contradictory and could be taken as a sign of a lack of awareness. With guidance, Jack may learn to identify and become aware of these thoughts as metacognition and improve his learning. In this case, because of his contradictory answers, it is unclear if Jack actually adjusted his learning strategy. Some answers reveal that he may have adjusted his learning strategy to improve his learning, but without further testing, I cannot know if he did. Contradictions aside, in terms of metacognition, some of Jack’s answers reveal that his learning was influenced. When asked if he thought this technology influenced the way he thought about his thinking and how that influence could improve his learning, he stated:

I think those were the things...that right away that I don’t think I was..."K, start
from here and then just kind of redo it.” I was basically just thinking ‘K, do these things first, the things I messed up on from last time, the things I didn’t remember from last time.’ I do those first and then move forward from there. I think that’s the approach I took on it...I think those are the things that would help things just because it’s something I think you’re just focusing on those things that you did wrong again, going back to that, you are just focusing on those and not really focusing on those other ones that you know you are going to do right or the ones you already did. It’s just going to come to you again so I think...that reflective redo would I think would almost help towards your learning because yeah, you really focus on those things that you know you didn’t do the first time.

Jack’s answer reveals what he was thinking about during the scenarios, namely, focusing on his mistakes. Focusing on mistakes during learning activities may lessen the time required to learn new content. Jack’s answer is supported by the work of Shang and colleagues (2006), who indicated that by continuously evaluating and revising activities within simulated environments, students can learn in a shorter time. Jack thought about what he had not done and, as he stated, the redo scenario helped to “really focus on those things that you know you didn’t do the first time.” Focusing on what he had not done during the previous scenarios gave him the opportunity to evaluate his learning strategy and adjust if necessary.

Jack’s change in learning when using reflection is similar to his change in learning in terms of metacognition. When asked about how reflection influenced his learning he stated;

Like I just kind of go with what I know and then once I find out what I don’t know, then just reflect on the things I don’t know and just focus in on those. I mean I think that is something I use for a lot of things, but I mean that’s something now that I know I think would lead towards more success in remembering things.

Jack used the redo scenario and reflection to focus in on his mistakes. He said he focused on things he did not know the first time around, and that helped him remember things.
Cory’s Example

Cory, a 24-year-old junior, scored 209 on the MAI. He had played some computer sports games in the past, but nothing in the role-playing genre. Cory felt that his past playing experience had no effect on his experience with the simulation. As mentioned, Cory’s MAI score was the second highest. His experience is presented because his resulting opinion of reflective redo was different from that of the participant with the highest score. There were two resulting groups or outcomes related to reflective redo that came out of the data analysis, and by highlighting Cory, I can illustrate the differences between the two groups. The participant with the highest MAI score fell into the same group as Jack, who had the lowest score, and highlighting this participant would therefore not allow a complete comparison.

Scenario 1. Cory performed pretty well during Scenario 1. He performed 11 of the 17 tasks on the checklist. The commands he gave to the other firefighters were a little slow and unsure during this scenario. Other than forgetting to perform a few of the tasks, his main mistake was not being direct in his commands. For example, he told both firefighters to prepare the hose and then to enter the house to extinguish the fire. Once inside, the firefighters reported the status of the fire and he gave the command, “Let’s perform a horizontal ventilation.” He did not direct the command to either firefighter, so neither one reacted to the command. After a minute had passed, he asked who had the hose, and once he received the answer, he commanded that firefighter to douse the fire.

Debriefing session. Cory’s debriefing session focused on being more direct and specifying which firefighter should perform which task. He forgot to perform some tasks,
so we discussed and reviewed those task items. Cory watched his playback and did not ask any questions. He sat and listened to what I was saying with an occasional nod or “uh-huh” to show understanding. Beyond being more specific and direct, the mistake identified to fix was the investigation step. Cory sent the firefighters in during Scenario 1 without investigating anything. An investigation can (a) locate the fire and other hazards, and (b) locate possible victims. We discussed how dangerous this could be and what it could mean to leave a victim inside.

Redo scenario. Cory did not improve on the number of task items performed during the redo scenario. He scored 11 out of 17 again. However, as identified through my personal observations and after reviewing the video recording of his experience, he showed more confidence during the redo scenario. He gave specific commands and identified which firefighter was to perform the given task. To fix his mistake, Cory gave a specific and direct command to one firefighter to investigate the rest of the house beyond the fire. This investigation turned up a victim that was not found during Scenario 1. The rest of his commands throughout the redo scenario were very direct, and each firefighter knew what he was supposed to do.

Another example of how Cory showed improved confidence as well as understanding was giving two commands at once. I observed Cory giving commands to a particular firefighter to shut off the utilities and once that was completed, to ventilate the house. This observation was noted while reviewing the video recordings of Cory’s scenarios. He showed that he not only remembered the task items but also understood their meaning well enough to give multiple commands that could be performed by one
During the redo, Cory also seemed more aware of his actions. After giving a command to one particular firefighter, Cory immediately realized that command could not be performed because he had previously given that firefighter something else to do. He quickly corrected himself and gave the command to another firefighter who could perform it. During Scenario 1, Cory often mixed the commands or gave multiple commands to one firefighter while forgetting to give commands to another firefighter.

**Scenario 2.** I also observed that Cory continued to show confidence during Scenario 2. I attribute this finding to what I observed during the initial scenarios and to what I observed during the review of the video recordings of each scenario. I observed that from Scenario 1 to Scenario 2 Cory sat up and leaned forward in his chair and he spoke with clarity when giving commands. In Scenario 2, he immediately completed the initial report and gave clear commands to the firefighters. He was much faster in giving the commands and therefore finished Scenario 2 more quickly than he finished either Scenario 1 or the redo scenario. When asked during the interview how he felt he did he stated “I did progress obviously as I went on. I knew the first part pretty well. I went through that part pretty well.” The mistake he made in Scenario 1 was that he forgot to call for an investigation of the premises to search for possible victims. As soon as he had completed the initial report, he called for an investigation of the fire and a search for possible victims. I believe he reflected on his mistake while performing during Scenario 2 and quickly carried out the steps necessary to avoid repeating the mistake.

A final observational note about Cory’s actions during Scenario 2 is that he
paused or seemed to drag out the scenario in an effort to try to remember any last tasks to perform. Once he had completed giving the commands to extinguish the fire and extricate the victim, Cory gave the command for all firefighters to exit the house and report on the front lawn. As the firefighters were exiting the house, he called for a Personal Accountability Report (PAR). I found this slightly odd because all of the firefighters had just reported on their last task and were exiting the house. He gave one firefighter one last command to search the entire house while the other firefighters sat and waited. When asked why he sent the firefighter on a final search, he stated it was meant to give him time to remember more tasks.

Cory’s metacognitive experience. How did the technology affect Cory’s thinking in terms of metacognitive knowledge and regulation? Cory scored fairly high on the MAI survey. His interview answers supported his score in that his answers revealed an awareness of his thoughts and how he used that awareness during the scenarios. Unlike Jack, Cory knew about a learning strategy and how it could be used for this type of learning. He was aware of how the learning strategy was working for him, and while performing he made mental adjustments to improve his performance.

In terms of declarative knowledge, Cory was aware of his ability to learn. When asked how he felt about learning new content and whether he was able to control how he learned that content he stated;

To an extent, I think if I’m able to give myself plenty of time, and organize it well, I can control it really well how to do it, but if I just cram, it just becomes overwhelming at certain steps.

The analysis of Cory’s interview questions showed that he was exactly right about
his ability to learn this content. I will describe this later in more detail, but Cory was aware of how to learn and his ability to learn. When applying his learning ability, he experienced some trouble learning this content because he did not have the time he felt he needed to be completely successful.

Cory’s procedural knowledge was revealed when he described the learning strategy he chose for this experience. He organized the information into groups, or used chunking. He even went a step further and used acronyms and association methods to help learn about and remember the task items within each chunked group. One more level of information organization was putting the task items in a specific order within the chunked groups.

Cory’s conditional knowledge consisted of his ability to apply what he learned to the situation. I asked Cory what he thought about learning this new content and he answered:

I mean it was interesting to me to see how the different steps that you have to go through to see how to actually do something. It’s not just going in and shouting commands and putting out the fire. There’s a bunch of different things that you have to go through. It was interesting to me at a point that I did try to learn it and try to focus on improving my ability on knowing what’s on the lists and stuff.

Cory knew that the tasks had to be performed in a way that allowed the team to put the fire out. As he said, “It’s not just going in and shouting commands”; there are multiple things that need to be done to ensure success. Cory learned about and memorized the content that he felt best suited his abilities. He applied what he had learned and focused on improving his ability to know what the task items meant and how they were used.

Cory’s learning strategy was chunking mixed with using an acronym to help
remember the task items. He planned on using this strategy while memorizing the content and while participating in the scenarios to help recall. As part of his learning strategy, Cory created an order of operations to be performed during the scenarios, which many of the other participants did as well. As mentioned, there was not a specific order in which the task items needed to be performed. However, the initial report was to be given once the firefighters arrived on scene. Beyond the report, any task item could be performed in any order the Incident Commander wanted. So, as part of his planning, Cory created an order that made sense to him using a made-up acronym. To support his learning strategy, he continually tried to think about all of the parts and what they meant. When asked how he used the different parts or how he thought about the different parts of the task items, he stated;

Well, I tried to think about all of the items, because I kind of knew what I was going to do at first. Then I was trying to think about all the parts that went on after that...like where the gas was at, the ventilation, and water and if it was hooked up and do a few things like that and try to go over each individual point.

This answer reveals how Cory had implemented his learning strategy. By thinking about all of the items individually, Cory could make connections or place the items in the order he had mentally created with the acronym.

It should be noted that Cory was aware enough of his thinking that he used his planned learning strategy as a monitoring tool as well. When asked how he planned to include all of the task items during the scenarios, he stated;

In the initial report strategy, operational mode and risk management, I made up a little kind of acronym for it just to make sure there was an order and make sure that I went through it. That’s one of the things that I use is making acronyms so that I can stay in that order and that usually helps me to find things in-between that and to remember where I’m at.
Cory combined his thinking processes or metacognition for this experience. It is easy to see from his answer how he used his learning strategy to remember the task items as well as to monitor himself. He used the acronym to help his recall, and at the same time he knew where he was in the process of giving task item commands. Even though Cory was aware of learning strategies and how to apply a chosen learning strategy to a situation, monitoring his progress during the scenarios revealed that he was not as prepared as he would have liked to be. I mentioned previously that Cory had some trouble learning this content, especially during the scenarios. When he was performing tasks during Scenario 1, he tried to monitor his progress by using the acronym he had created while studying. When asked if he thought about or monitored the mental procedures he had used to learn the content during the scenarios, he stated;

I did at first, but then once I got in the scenario it was all jumbled into one and I didn’t remember it after that. Just kind of trying to figure it out and looking and having the screen there and trying to look at the situation and see what was going on. I kind of lost focus on doing that mental procedure.

Cory monitored himself during the scenarios and realized that he could not use the learning strategy he had chosen. Even though he was aware and used metacognition to prepare for the scenario, those skills did not work.

When Cory evaluated his effort, he knew he had missed some of the tasks. He said he could not remember everything and sometimes could only remember a task now and again during the scenarios. He was evaluating his efforts because he knew he had not completed all of the tasks. I have already alluded to what Cory thought about his learning strategy when he evaluated his thoughts and found they became jumbled when he tried to think about and use the acronym. When asked what he would do to improve his
performance, he stated;

I think a little more preparation...I spent a lot of time on the first steps trying to go down the first steps. I think there was a lot I needed to go over, everything else a little bit more than just the first ones, kind of making sure I had those. I was too worried about going exactly in order and not like doing that, I only remember the first few and I’d lost count of a lot of the second or the following steps. Focusing more on everything as a whole in just the amount of time I was given might have helped out.

Cory completed 11 out of 17 tasks in all three scenarios. He stated that he needed more practice and maybe even an adjustment to his learning strategy by focusing more on the whole list of tasks instead of breaking it up into parts.

Cory is a good example of someone who is aware of his own metacognition and how he could apply it to this educational situation. Cory’s experience revealed that this technology does influence metacognition, but it does not necessarily mean that one’s scores will improve. As Cory stated, he felt he could have improved his performance with more time and practice. Because he is already aware of how he thinks about thinking and how his performance influenced that thinking, more cycles of using this technology could give Cory the chance to improve on the number of task items completed and lessen the time required to learn this content.

Cory’s reflective experience. How was Cory thinking about his actions during the scenarios? To answer this question, I will follow the same pattern I did with Jack in that I will explain what Cory reflected on during each of the different scenarios.

Scenario 1. Cory did not have any actions to reflect upon during Scenario 1, so he reflected on what he could: the list. When asked what he reflected on during Scenario 1, he answered, “The first scenario—just kind of go over what I’d memorized.” He also
said that while performing, the only time he reflected was when there was a pause in the action. The pauses occurred because he did not know what to do next, so he would reflect back on the list and try to remember what to do next. Cory also stated:

I kind of almost felt like trying to reflect on what I’d seen from firefighters before and movies or TV shows and how they kind of command and what they’re doing so reflecting on that to know what someone that actually does it and what things and strategies that they’d use in that situation.

Similar to Jack, Cory did not have much experience or actions to reflect upon during Scenario 1, so he used the sheet and what he had seen on TV or in movies.

**Redo scenario.** Cory’s change in reflection is similar to what Jack experienced. Cory did not reflect upon any actions during Scenario 1, but after he had completed Scenario 1, he had actions to reflect upon. Cory used the actions he performed during Scenario 1 as a reference point in his thought process, meaning that when he reflected on Scenario 1 during the redo scenario, he reflected on the point in time when the action was performed and tried to duplicate that action in the redo scenario. He also reflected on the actions seen in the replay and the actions identified during the debriefing session in which he either made a mistake or forgot to perform.

I think reflecting, like in the second situation [redo scenario]—reflecting on the first one, where I come to that pause where I pause on the first and try to figure out what was going on and the second one [redo scenario] I reflect on where at that specific moment, but now knowing that the information that I did miss on that [scenario 1] I was reflecting on what information that I did miss and where it was at so that I could apply in that time.

**Scenario 2.** Reflection during Scenario 2 for Cory was not as prevalent as in Scenario 1 or the redo scenario. This change in reflection over time was revealed when comparing two of Cory’s interview answers. I asked how he felt reflection affected his
experience, and he stated;

> It kind of slowed me down on the second one [redo] just trying to hurry and go back and figure out what was next. So it created me to pause for a little bit and think what I would do...but it definitely helped to get that mission accomplished.

When I asked him to describe his reflection for each scenario, he answered;

> The first scenario—just kind of go over what I’d memorized, second scenario—was more reflection to see where I was at, third scenario—just kind of what I’d done on the first and second one...wasn’t really reflecting, just going through the motions.

Cory’s reflective efforts lessened as he gained experience with this technology and content. In other words, during Scenario 2, Cory felt that he knew the content well enough that he did not have to reflect as much on previous actions.

**Cory’s learning.** Does this technology influence learning in terms of metacognition and reflection? Cory did not improve on the number of task items performed. However, he did perform some tasks in the redo and in Scenario 2 that he did not perform in Scenario 1. His score did not change because he forgot to perform some tasks in the redo and in Scenario 2 that he performed correctly in Scenario 1.

In terms of metacognition, Cory learned about his abilities and choice of learning strategy. He learned that he needed more time to prepare. Because this was his first experience with this content and this technology, he had very little foundation to build on. This experience helped Cory learn that his chosen learning strategy did not work when matched with the time and effort he put into memorizing this content. He felt he could have memorized the task items better if he had had more time.

> I think a little more preparation of maybe, I spent a lot of time on the first steps trying to go down the first steps. I think there was a lot I needed to go over everything else a little bit more than just the first ones kind of making sure I had
those. I was too worried about going exactly in order and not like doing that, I only remember the first few and I’d lost count of a lot of the second or the following steps and focusing more on everything as a whole in just the short about of time I was given might have helped out.

Being aware of his own metacognition allowed Cory to (a) choose a learning strategy, and (b) apply that learning strategy to an educational situation. Without this awareness, Cory could not have monitored and evaluated his efforts effectively. His awareness gave him the opportunity to evaluate and learn about his abilities and determine whether the learning strategy was a good fit for this learning situation. When asked how he thought he organized information with his chosen learning strategy, he stated;

I thought I did pretty well going through and creating the acronym and everything for it and then, I probably could have grouped them a little bit better and put more information with that acronym instead of just trying to do everything in a whole, I could have probably grouped things just a little better which would have made it easier for me to follow the steps.

Cory learned that he needed to adjust his strategy for learning this content by evaluating his efforts and how his learning strategy matched his learning goals.

How did this technology affect Cory’s learning when in relation to reflection? Cory learned about the way he learns and studies by using this technology to replay saved scenarios and also performed a redo of his actions to fix mistakes. When asked how he felt reflection-in-action affected his learning, he stated;

I think it creates a broader view of how to learn and how to study, just seeing the different techniques and different ways that people study. So putting that in action and seeing what works for me and what doesn’t work for me.

Cory stated that he reflected on what he had seen done in the past. He reflected on the different ways people studied and put that to use for this experience. He reflected on his study strategy and learned what worked and did not work for him.
Cory’s learning was also affected by reflection when it came to redoing the mistakes he made in Scenario 1. While fixing the mistakes during the redo scenario, Cory’s reflection and focus was centered on what he had missed and how he could apply that information at the appropriate time during the redo scenario.

I think reflecting, like the second situation reflecting on the first one, where I come to that pause where I pause on the first and try to figure out what was going on and the second one I reflect on where at that specific moment, but now knowing that the information that I did miss on that I was reflecting on what information that I did miss and where it was at so that I could apply in that time.

Jack’s and Cory’s learning experiences are similar when in relation to reflection in that both felt that this technology helped them identify their mistakes and that they could reflect upon those mistakes during the redo scenario in an effort to fix them. However, Cory went further than Jack in reflecting on his mistakes and how they influenced his learning. When asked what he thought about reviewing his saved actions and starting at the mistake instead of starting from the beginning, Cory stated;

I think it is a great technique to be able to see what you did and be able to correct it because with the reflection that way you are going to go back and see where you made mistakes and be able to correct them. I think that in the future if you are in that situation you will be able to reflect on the mistakes you made and how you corrected them which will better help you do the steps and what not correctly in the future.

When asked if he felt these tools (playback and redo) affected his learning, he stated;

Just because you’ve been in that situation before and you know what happens and you know when you did it wrong and when you did it right and what worked out better for you so that helps you to make the correct judgment, you could say, in the future. Just to go back and look at what happened and be able to know that and be able to apply that to the situation that you have.

Unlike Jack, Cory took reflection and its influence on learning beyond this
experience. It is unclear if Cory meant future learning with this technology or just future learning experiences in general. Either way, using this technology made Cory aware of how reflecting on and fixing mistakes can be applied beyond this learning experience. This realization is also supported by the work of Shang et al. (2006), who stated that the time it takes to learn new content can be lessened when applying reflection and fixing mistakes. The learning skills gained when learning new content by reflecting and fixing mistakes at the point of failure instead of from the beginning could feasibly be applied to other learning situations beyond this technology.

**Participant Experience Summary**

Jack was chosen and his experience was presented because he had the lowest MAI score of all the participants. His low score signified that he had a low awareness of metacognition. Jack gave conflicting answers throughout his interview when asked questions that related to metacognition. He would answer that he did not think about or use metacognitive skills, but then later answer that he did actually perform those skills. Even though Jack contradicted himself during the interview, some answers revealed that he did use metacognition throughout this experience but was unaware of doing so. In some cases he was unaware of using metacognition but was reminded or made aware when I asked another question or pointed out an answer that he had previously given.

Jack’s metacognitive knowledge or awareness of himself as a learner consisted of knowing that if he liked a topic he would put more effort into learning about that topic. However, he was not aware of what skills and abilities could be applied to that effort for
learning. As far as procedural knowledge, he knew about chunking and what it was. However, Jack was not aware that chunking was a learning strategy until I told him it was and that he had used it for learning this content. Even though he was not aware that chunking was a learning strategy, he still organized his thoughts in a way that is similar to chunking which showed conditional knowledge. Jack used chunking to organize the different task items on the sheet into what he thought should happen at the beginning, middle, and end of each scenario.

Recognizing Jack’s metacognitive regulation abilities was easier than identifying his metacognitive knowledge. Jack used planning by ordering the tasks that he thought should take place at the beginning, middle, and end of the scenario. However, he did not think about this strategy much while he was performing. Jack also gave conflicting answers when asked questions about his monitoring skills. He reported that he tried to think about what he had forgotten during Scenario 1 and apply that to his planning strategy, but later reported that while performing he was just acting and not thinking. Jack showed that he evaluated himself and his learning strategy when he reported that the efforts he made to prepare for Scenario 1 were not correct and needed to be changed.

During Scenario 1, Jack had no actions to reflect upon, so he reflected on what he had tried to memorize from the task item sheet as well as past experiences, which included a class and movies or TV shows that related to this content. During the redo scenario, Jack reflected on the actions he had performed during Scenario 1, what he had seen during the playback, and what was discussed during the debriefing. Jack’s reflecting changed during Scenario 2 in that he did not reflect as much because he felt he knew and
understood the items better.

The number of task items that Jack performed increased with each scenario, showing that he memorized more task items and learned how those task items were used. However, it is unclear if Jack learned in terms of metacognition. He gave multiple conflicting answers during his interview. However, he did show that he used aspects of metacognition, but was not aware of how to improve his learning with those aspects. Learning in terms of reflection can be seen when Jack reported that he reflected on the tasks that he did not know or had forgotten and tried to fix what he had done wrong.

Even though Cory had the second highest score on the MAI, he was chosen because he was in the group with the opposite opinion from Jack in terms of reflective redo. In general, Cory showed that he was aware of his metacognition and used reflection to help his performance and learning. He improved on or fixed the mistakes he made during Scenario 1 that were identified during the debriefing session.

Cory was cognitively aware or had knowledge of his own learning abilities. He knew that with enough time, he could memorize and learn what he needed to. He knew about learning strategies and chose one that he felt would work for this learning scenario. Cory chose to chunk related terms and create an acronym to help him memorize the task items that needed to be performed. He also created a mental procedure by placing the task items in order of importance. Cory showed his awareness of conditional knowledge by reporting that he focused on understanding the task items and how they applied to the scenarios or, in other words, how they were used to get the job done.

Cory used chunking as his planning strategy. As he was preparing for each
scenario, Cory went through the chunked groups in his mind in an effort to improve his learning and performance. He used his planning strategy to monitor his progress as well by making an effort to identify where he was along the path of the order of importance he had mentally created. However, his effort to monitor his progress was disrupted because his learning strategy, specifically the acronym, became jumbled during the scenarios. He reported that once he was finished, he evaluated his progress by thinking about how effective his learning strategy was. He felt with more time he could have used his learning strategy to full potential and done better by performing more task items.

Cory’s reflective abilities were similar to Jack’s. Cory had no actions to reflect upon during Scenario 1, so he reflected on the sheet and on movies and TV shows related to firefighting. During the redo scenario, Cory reflected on the actions he had performed during Scenario 1, what he had seen in the playback, and the mistakes identified during the debriefing session. Cory also reported that his reflection lessened during Scenario 2. He felt that he had learned the task items well enough that he did not have to reflect as much and could focus more on the actions that needed to be performed.

Cory’s task item performance did not improve between scenarios. Cory’s learning in terms of metacognition was identified by reviewing how he thought about his thoughts during and after the scenarios. Cory knew what learning strategy he had chosen for this exercise and believed that it might have worked if he had had more time, which matched his knowledge about himself as a learner. Cory’s learning in terms of reflection can be explained by how his reflection on his actions changed between scenarios. As he gained experience with the technology, he gained confidence not only with the simulation but
also with his ability to perform and learn about these task items. His increased confidence helped him perform the actions during Scenario 2 without having to think much or reflect upon what he had done previously.

To help show how these two students relate to the rest of the participants in this study, their names, ages, checklist scores, and MAI scores are shown in Table 2 which is organized by ascending MAI scores. Those participants who did not like or found it difficult to start at the point of failure are identified by an asterisk. This table is presented because the similarities that exist between these two participants and the whole group are important for the analysis that was performed on the collected data. Further description of findings is found in the next section where I describe the group as a whole. Table 4 shows the summary data from the MAI scores and the participants’ checklist scores from S1, redo of S1, and S2.

**Findings from the Data Corpus**

The following section describes the findings from the corpus of data gathered during this study. I use the findings from the participants’ experiences to fulfill the specific objective of this research or, in other words, to identify how reflective redo influences learning in relation to metacognition, reflection, and other possible factors. I quote multiple participants throughout this section as examples that support what I am describing. First, I describe the participants’ metacognitive knowledge or how aware they are of their own declarative, procedural, and conditional knowledge. Second, I describe the participants’ metacognitive regulation, which includes planning, monitoring, and
Table 4

Summary Table of Participants’ Age, MAI Scores in Ascending Order and Checklist Scores for Each Scenario

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>MAI scores</th>
<th>S1</th>
<th>S2</th>
<th>S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jack</td>
<td>24</td>
<td>169</td>
<td>9</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Karen</td>
<td>29</td>
<td>187</td>
<td>12</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Steve</td>
<td>18</td>
<td>188</td>
<td>6</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Autumn</td>
<td>23</td>
<td>189</td>
<td>13</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Amber</td>
<td>23</td>
<td>189</td>
<td>11</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Brandon</td>
<td>21</td>
<td>189</td>
<td>4</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>John</td>
<td>19</td>
<td>190</td>
<td>12</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Krystal</td>
<td>18</td>
<td>190</td>
<td>9</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Allan</td>
<td>18</td>
<td>203</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Brad</td>
<td>21</td>
<td>203</td>
<td>7</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Shannon</td>
<td>19</td>
<td>205</td>
<td>10</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Gary</td>
<td>21</td>
<td>206</td>
<td>14</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Charles</td>
<td>19</td>
<td>208</td>
<td>7</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Cory</td>
<td>24</td>
<td>209</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Melissa</td>
<td>19</td>
<td>231</td>
<td>9</td>
<td>9</td>
<td>12</td>
</tr>
</tbody>
</table>

aSignifies those who could not or disliked starting from the point of failure.

I make three claims throughout the description of each section (metacognition, reflection, and learning) pertaining to that particular section and how the claim relates to the research question. The first claim is that this technology, when accompanied by a facilitator, may help participants improve awareness of their metacognition. Even though the participants in this study had different levels of metacognitive awareness, each participant tended to show more awareness of their application of metacognition between each scenario. The second claim is that using this technology with support from a
The third and final claim is that reflective redo invites participants to think about their thoughts and supports their learning about their own use of metacognition and reflection.

**Metacognitive Knowledge**

*Claim 1: This technology, when accompanied by a facilitator, may help participants improve their awareness of their metacognition.* The first research questions, How does the intervention that includes reflective redo influence metacognitive knowledge and regulation? and, How are participants thinking about their thinking? are answered by identifying the participants’ level of metacognitive awareness and their ability to learn this new content, or how they were thinking about their thinking during the debriefing and redo of Scenario 1. I must point out that identifying and describing participants’ metacognitive knowledge creates the foundation for describing how they are regulating their thoughts. During the description of metacognitive regulation, I answer the research question, How does reflective redo influence students’ thinking?

In terms of declarative knowledge, participants’ interview answers revealed that most were aware, to varying degrees, of their ability to learn. Some felt that with the right learning strategy and enough time, they could learn almost anything. For example, when asked how he was able to control his own learning of this content, Charles said,

I kind of have my own technique, like I was just repeating, trying to make a relation with other things that I already know so that I could remember them...I just think that I needed more time.

However, there were others who felt that their only ability was to repeatedly review the content to get the information into their minds. Steve was an example of a
young participant who had very little awareness of how he learned. He was an 18-year-old freshman in his second semester of college. When I asked Steve if he was aware of his ability to learn this content and what he did to learn the content, he reported, “Yeah, just going over it, over and over again, until I felt kind of comfortable with it. ‘Cause I knew I wouldn’t be able to get 100% comfortable with it.” Those who only used repetition to review the information tended to be younger, had fewer years of experience in higher education, and were less aware of their metacognition. Identifying the participants’ declarative knowledge awareness creates the foundation for understanding how this technology supports the other aspects of metacognition.

Procedural knowledge or knowing about different learning strategies was represented by three main strategies: repetition, visualization, and chunking. Repetition was the predominant learning strategy used to understand and memorize this content. However, most of the participants mixed repetition with other learning strategies such as visualization or chunking. Brad chose visualization as a learning strategy, and when asked how visualization helped him learn or memorize this content, he answered, “As I was organizing the information, I tried to visualize it, I played it out in my mind as I was organizing it.” The participants reviewed and repeated the list, using some form of the aforementioned learning strategies until they felt comfortable with the content. When asked if and how they were thinking about their learning strategies during the debriefing and the redo session (reflective redo), most reported they reviewed the previously performed learning strategy in their minds as well as testing or judging its effectiveness (evaluation).
Those who used only repetition as a learning strategy thought mainly about the tasks they had forgotten to do during Scenario 1 that were identified during the debriefing session. These participants used the short time between the debriefing session and the redo to review the task items in their minds, in a way trying to reuse or even verify their learning strategy. This mental review of the task items was similar to how the rest of the participants verified their learning strategies; however, those who used a learning strategy beyond repetition had another level to think about. These participants thought about their learning strategy of choice during the redo to help them remember the task items as well as to verify their learning efforts.

Conditional knowledge, or knowing how and when to apply certain learning strategies was well represented in the interview answers. Some students applied the only learning strategy they knew (i.e., repetition of task items), but others applied a learning strategy that made sense to them. Those who implemented visualization as a learning strategy did so because of the nature of the experience. For example, Brad said, “Knowing beforehand it was going to be a simulation I figured it would be really helpful to run my own mental simulation as a primer.” Some stated that they chose chunking as a learning strategy because of the format in which the task items were presented. However, they made this decision because they felt it was the best learning strategy and it had worked for them in the past. For example, I asked Shannon how she organized the information presented to her and she stated;

Related terms, um grouping. I guess something I was thinking about was the format that it’s in on your paper kind of sticks in my head, but I kind of made up my own format to where it logically made sense to me.
Like Shannon, many of the participants chose chunking or grouping terms as a learning strategy because of the way the task items were presented on the paper. Even though the organization of the paper may have influenced the choice of chunking as a learning strategy, participants tended to group the task items in a way that made sense to them to help them better understand and memorize the task items.

**Metacognitive Regulation**

For this study, planning has been defined as choosing a particular learning strategy for this learning experience, monitoring is defined as the participants’ awareness of their progress in completing checklist task items, and evaluation is defined in two parts: first, evaluating how many task items the participants completed and second, evaluating the effectiveness of their learning strategy.

**Planning.** All participants made a plan to learn or memorize the content. It is interesting that some participants, such as Jack, used aspects of metacognition such as planning but were not aware of it. The participants were asked what learning strategies they chose to learn this content, and some stated that they just read through it and tried to memorize the task items. However, later in the interview, these participants mentioned that they tried to visualize themselves using the task items in their minds, or they implemented some other strategy. Autumn is an example of a participant who used the planning strategy of chunking related task items, but then when asked if she thought about this strategy to help her remember the checklist items, she stated, “Not at all.” Most of the participants were aware of their choice of which learning strategy to apply for this learning situation; however, there were a few who were not aware of what to do with
their choice of learning strategy beyond the initial usage. This lack of metacognitive awareness is supported by Schraw (1998) and Schraw and Dennison (1994).

Another planning strategy implemented by most of the participants was placing the task items in order of importance. Even though there was no real order in which to perform the task items, many participants created their own order of importance anyway. To help facilitate the creation of the ordered process, the participants identified the tasks they felt were most important by what they thought needed to be performed immediately. Those who used ordering of importance as a planning strategy tended to have a background in emergency training or actual emergency situations. For example, two participants who used this strategy were Certified Nursing Assistants (CNA), one was a lifeguard, and another participant had watched his grandmother’s house burn. In addition, one participant had had some emergency training because he was a leader in his fraternity house, while two other participants had either taken firefighting classes or spent time with firefighters to learn about their work.

Krystal stated that she used the order of importance strategy because of her CNA background. I asked her how she created this order and she stated, “Just the grouping first of all like putting certain related information together and . . . to compare to other things.” I then asked Krystal if she could give an example of how creating the order of importance for this content related to her past experience, and the example she gave was thinking about possible unconscious victims.

Well the unconscious thing I guess. We had to do a lot of training for my CNA and I’ve been with unconscious people before at a job I’ve had before. So you know you have to go perform CPR and you have to have an ambulance called first and then you perform while you wait for the ambulance.
Krystal’s example shows how she thought about order of importance. In a situation with an unconscious person, the order she created came from knowing she would have to perform CPR, but must first must call an ambulance and then perform CPR while waiting. If one is aware of metacognition, the order of importance described here as well as the participants’ other planning strategies can be used as a monitoring tool to measure progress while performing and learning.

**Monitoring.** Most participants had a difficult time monitoring their personal progress during Scenario 1. Many reported they felt they did not know how to best learn or memorize the task items on the list. They also added that learning what the items meant was hard because they did not know how the task items were to be applied. The participants found it difficult to learn about these tasks because they had no real context in which to apply the task items in a way that would help them understand how they were used in emergency situations. Because some participants had no context, or only a weak context, in which to apply the task items, many had to draw on past experience that related to this content as a context to help them learn about and memorize the task items. As soon as some participants had completed Scenario 1, and for some as soon as they started Scenario 1, they could apply the task items to a context and understand the meaning of the task items. Having a context in which to apply task items helped the participants monitor themselves during the simulation, added to their understanding during the debriefing session, and then allowed them to test and better monitor their understanding during the redo. When I asked Amber if she thought about the content and what it meant, she described how not having a context affected her thinking during
Scenario 1 and how her thinking changed during the redo scenario.

Um, not as much in the first one but more in the second simulation (redo). In the first simulation I was so worried about getting it and getting all the bullet points done. I wasn’t really worried about the why or how but in the second simulation I felt better about the simulation. I was like ‘oh yeah that makes sense, that there are no other victims or the fire hasn’t spread’ rather than being like ‘the fire’s out, sweet we’re done.’ In the second one [redo] I was more into it, into the situations versus trying to get the task checked off.

Like Amber, the other participants seemed to improve their monitoring abilities in stages throughout the simulation. Even though the participants had different levels of background experience and knowledge to draw upon, they seemed to improve their monitoring ability from scenario to scenario. This improvement may be attributed to practicing their monitoring skills as they applied their current knowledge to the context of the firefighting simulation in each scenario. However, as with planning, many participants initially had a difficult time monitoring their progress because they had no context to test or monitor themselves against.

I have alluded to two identified groups and their opinions of reflective redo. I will discuss these two groups in more detail, but their initial description is as follows. Reflective redo influenced participants’ monitoring skills because it forced them to think about where they were within their learning strategy, for example, where they were within their mentally created order of importance. This experience is different from practicing a task over and over because practice starts at the beginning and therefore monitoring starts at the beginning. With reflective redo, some participants could monitor their progress and start at the point of failure whereas others had a difficult time starting at the point of failure and wanted to start from the beginning of the scenario. In other
words, the latter group wanted to practice these tasks over and over.

The participants evaluated themselves in two ways: first, by checking the results, or how many task items they performed in each scenario, and second, by evaluating the effectiveness of their chosen learning strategies. It is important to recognize the two different components of evaluation, because without an evaluation of the end result, one cannot have a meaningful evaluation of the applied learning strategy. If the end result is what the learner wanted or expected, then the learner may evaluate the learning strategy positively because it worked well. If the end result is less than what was wanted, then something about the learning strategy needs to change.

There were 17 task items that could be performed on the checklist. All but one of the participants completed the same or a greater number of tasks during the redo than in Scenario 1. One participant dropped from 14 task items during Scenario 1 to 13 during the redo. Most of the participants increased their numbers by one or two, but there were three who increased their number of completed tasks by four, five, or six. Two of these three reported that the redo gave them the chance to verify the effort they had put into learning the content because they could see how their choice of visualization as a learning strategy worked for them.

Brad was one of the participants who used visualization as a learning strategy. The following discussion is a good example of how Brad evaluated his learning strategy specific to how playback and redo affected it.

Interviewer: Why do you think that visualization helped?

Brad: I think just because reading information and hearing it and seeing it, all those different things, information is processed differently depending on how it is
Interviewer: By using the simulation, how do you think it affected this learning strategy?

Brad: It took it from just a mental process to physical stimuli.

Interviewer: That did what for you?

Brad: It confirmed...it just helped confirm and deny certain specific elements [of the learning strategy].

Brad’s statement that “it just helped confirm and deny certain specific elements” was the evaluation of his chosen learning strategy. He now knew what worked from his learning strategy and could adjust it if he needed to. Those participants whose scores increased by one or two evaluated their learning strategy and reported feeling that the redo also verified their efforts and that with a little more time reviewing or just more experience with the simulation, they would improve their scores and learn this content well. Table 5 lists a summary of claim 1 and how the claim relates to research question 1.

Reflection

Claim 2: Use of this technology with support of a debriefing facilitator may help students focus their reflection and organize their thoughts. I used Schon’s (1983) work on reflection, namely reflection-in-action and reflection-on-action, as benchmarks for my analysis of the participants. I analyzed the participants’ reflection by reviewing what they were reflecting on during the intervention, which included reflection after Scenario 1, during the debriefing session, and during the redo scenario. This analysis guided my efforts in answering the second research question: During the reflective redo aspect of the intervention, how are participants thinking about their actions?
Table 5

**Summary Table of Claim 1 and How It Relates to Research Question 1**

<table>
<thead>
<tr>
<th>Students’ thoughts pertaining to metacognition</th>
<th>Relations to research question 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metacognitive knowledge</strong></td>
<td></td>
</tr>
<tr>
<td>Declarative knowledge</td>
<td>The student participants had varying degrees of awareness of their ability to learn</td>
</tr>
<tr>
<td>Procedural knowledge</td>
<td>• Represented by three main strategies: repetition, visualization, and chunking</td>
</tr>
<tr>
<td></td>
<td>• Those who used only repetition as a learning strategy thought mainly about the tasks they had forgotten to do during scenario 1</td>
</tr>
<tr>
<td></td>
<td>• A mental review of the task items was how some participants verified their learning strategies</td>
</tr>
<tr>
<td></td>
<td>• Participants thought about their learning strategy of choice during the redo to help them remember the task items as well as to verify their learning efforts</td>
</tr>
<tr>
<td>Conditional knowledge</td>
<td>Some students applied the only learning strategy they knew, i.e., repetition of task items, but others applied a learning strategy that made sense to them, like chunking</td>
</tr>
<tr>
<td><strong>Metacognitive regulation</strong></td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td>• All planned but some not aware of learning strategy or even knew what to do with their learning strategy</td>
</tr>
<tr>
<td></td>
<td>• Some participants’ planning strategy was to create order of importance, these tended to have emergency training or experienced an emergency</td>
</tr>
<tr>
<td></td>
<td>• Order of importance can be used as a monitoring tool</td>
</tr>
<tr>
<td>Monitoring</td>
<td>• Initially had could not or had a difficult time because had no experience or context to apply task items</td>
</tr>
<tr>
<td></td>
<td>• A context to apply the task items helped the participants monitor themselves during the simulation, added to their understanding during the debriefing session, and then allowed them to test and better monitor their understanding during the redo</td>
</tr>
<tr>
<td></td>
<td>• Improved ability from scenario to scenario</td>
</tr>
<tr>
<td></td>
<td>• Some could not monitor and start at point of failure</td>
</tr>
<tr>
<td>Evaluating</td>
<td>• Participants thought about how many task items they performed in each scenario</td>
</tr>
<tr>
<td></td>
<td>• Evaluated the effectiveness of their chosen learning strategies by thinking about how well they can done</td>
</tr>
<tr>
<td></td>
<td>• Redo gave a chance to evaluate their progress and the learning strategy</td>
</tr>
</tbody>
</table>

*Note. Claim 1: This technology, when accompanied by a facilitator, may help participants improve their awareness of their metacognition. Research question 1: How does the intervention that includes reflective redo influence metacognitive knowledge and regulation? How are participants thinking about their thinking?*
Reflection-on-action. The data analysis revealed two main foci of the participants’ reflection-on-action during the reflective redo portion of the intervention. The first main focus was the actions performed during Scenario 1. The second main focus was what took place during the debriefing session. There were other foci of reflection as well that helped support the participants’ reflection on the aforementioned two main foci. These were past experience and knowledge and how they related to the main foci of reflection.

To best understand the influence and importance of reflecting on the actions performed during Scenario 1 and how that reflection changed over time, I needed to identify what the participants were reflecting on before they gained experience with Scenario 1. Similar to the previous discussion about participants lacking a context in which to understand the meaning of the task items, before Scenario 1, the participants had very little knowledge or experience to reflect upon. The participants either found it difficult to reflect upon Scenario 1 or reflected on anything they could, for example, the task items on the paper they received. I asked Amber to describe what she reflected on during Scenario 1, and she stated, “Um, I think the reflection in Scenario 1 was just... again I was just trying to remember what was on the list.” I asked Autumn the same question and she stated, “I didn’t really reflect. I didn’t know what to expect at all. I think it was easier to reflect on the second time.”

Some participants tried to match their current actions with those they had seen in movies or on TV and others who had had emergency training reflected on actions related to that training. This finding is important because it reveals that these participants
reflected on any preexisting knowledge or experience they could that would help them create a context in which to apply the task items (Ericsson et al., 1993). Ericsson and colleagues stated that when learning, students must use preexisting knowledge to have an understanding of the tasks that need to be performed. Without preexisting knowledge, the student’s learning will most likely be hindered. Ericsson and colleagues also stated that if students received constant feedback and continued to practice, then they could enhance their learning.

During the interviews, the participants reported that reflecting on what they had done during Scenario 1 helped them know what to do in the redo scenario and Scenario 2. All 15 participants reported that they appreciated the playback tool because they could see and hear what they had done and now had something meaningful to reflect upon. I asked Brad what he thought of the playback tool and how that influenced his experience, and he stated:

Well especially watching the view of truck one and engine one, just watching them do, watching from their view, what I was commanding them to do, helped me understand a little better like where and how to make my commands more effective and what specifics to look for.

Brad’s experience with the playback tool helped him understand how to use the tasks and when to command a specific task. This knowledge was then put to use during reflective redo. Like Brad, the other participants felt that they now had an understanding of what it was they were supposed to do and felt better about performing these tasks. Along with experiencing their actions within a context and gaining an understanding of the task items, the participants also gained confidence in their actions.

Not only did the participants report during the interviews that they gained
confidence, but I observed increased confidence during both the actual scenarios and the reviews of the video recordings of the participants’ actions. I observed and noted from the video reviews that many of the participants no longer slouched in their seats, they gave commands more quickly and with more authority, and some, like Cory, even gave multiple commands at the same time during the redo scenario. The first experience with Scenario 1 was a little daunting for some of the participants because of their unfamiliarity with the content and the simulation. For example, John reported that “starting out as the commander I had no clue how to put out a fire. I was kinda like a complete newbie and I had no idea what I was doing.” As soon as John and the rest of the participants gained experience with the simulation and saw how to apply the task items to this context, their confidence improved and they felt better about their experience.

The majority of the participants felt that their increased confidence was attributable to their experience with the simulation coupled with reflection on their actions from the playback and discussion during the debriefing session. For example, when asked how the playback helped, Autumn reported;

Um, I think it’s good because when you see and hear yourself you can see what you need to do better and I think it makes you reflect about what you need to change or on other strategies that you could take.

Amber was asked the same question and she reported how the playback tool allowed her to see where she was not confident and where to fix mistakes.

I could hear my own voice and I could hear when I stuttered and I could hear when I didn’t know what I was saying.... I could see when I wasn’t as confident and then I could see the mistakes and I could hear the mistakes I had made.

So, during the reflective redo aspect of the intervention, the participants were
reflecting on the actions they had performed during Scenario 1 and on those same actions that they had seen with the playback tool. Reflecting on these actions helped the participants identify and focus on fixing their mistakes. The influence of reflecting on their actions during the reflective redo aspect of the intervention came through gaining experience with the simulation, which provided a context in which to apply the task items. This influence helped the participants gain confidence to perform actions for future scenarios.

**Reflection-in-action.** Reflection-in-action is what one reflects on during a learning activity. For example, when practicing soccer, one reflects on actions performed and skills learned during previous practices that can be used at that moment. The main foci of reflection-in-action identified during the reflective redo aspect of the intervention were the actions performed during Scenario 1, how those actions related to the order of importance the study participants had mentally created for themselves, and what was identified and discussed during the debriefing session.

All of the participants reported that during the redo session, they were reflecting on what they had done during Scenario 1. This provided a foundation for what to do during the redo scenario. The participants now knew what the task items meant and how they were supposed to be used to put out the fire. For example, when Allen was asked how he used reflection during the scenarios, he stated;

Like, in the first simulation, I felt like my voice was a little shaky, ummm, but after we went over it, and, you know, simulation one, I felt a lot more, like, confident in the second simulation. And in second simulation I was just reflecting on, like, what I had done in the first one. I was trying to get things done a lot more concisely, and be more specific with my calls.
During the redo session, participants also used reflection-in-action as a means of monitoring progress. Many reported that they checked their actions during the redo against those performed during Scenario 1 to help them know how they were doing and to know what else needed to be done. I asked Allen what he was reflecting on specifically during the redo scenario and he stated;

I reflected on my response time. So in Scenario 1, like, I had to think about what we were supposed to do. And so, by the time we did the redo and Simulation 2 it was kind of primed at that point. Umm, if I had done, like, a little more thinking, I probably would not have missed, like, the incident call. But I was just, like, running through the checklist.

During the scenarios, Allen reflected on his past actions and felt that during the redo he knew what to do. He also reflected on the checklist to test his progress in completing the task items.

The next focus of reflection-in-action was used by one of the two groups previously mentioned during the description of Jack’s and Cory’s experiences. The majority of the participants fell into this group, as did Cory. The focus of reflection-in-action in this group was how the actions performed in Scenario 1 matched the order of importance the participants had created for themselves. The participants used this reflection as a monitoring tool to assess their productivity. Many of the participants had mentally created an order of importance for the task items, and they applied the tasks in their desired order during the simulation. So, during the redo, the participants reflected on the actions they had performed during Scenario 1 while comparing those actions to their mentally created order of tasks. This comparison helped the participants feel on track because they were performing task items in an order they felt matched their
previously created mental order. For example, Brandon described how he felt reflection during a scenario helped him:

Umm, that it will, each time it happens, each scenario you go through, you have to think about different things. It helps you build upon what you have done. “I know I have done this before correctly, but I need to work on that.” It helps you slowly build up the kind of experience you need to do everything right.

The last focus of reflection-in-action during the redo was what was discussed during the debriefing session, or more specifically, the mistakes made during Scenario 1 and how to fix them. Many participants reported that the redo session helped them focus their efforts to fix the mistakes made during Scenario 1. When starting the redo scenario, these participants reflected momentarily on what needed to be fixed (as identified in the debriefing session) and then continued with the rest of task items. The analysis revealed that these participants, when preparing to fix their mistake, reflected on the actions they had performed during Scenario 1, and then matched those actions with their personal order of importance. Finally, these participants reflected on the mistakes identified during the debriefing session. This order of reflection helped these participants focus on fixing the mistake by planning their next action (fixing the mistake) in the correct order according to their mentally created order of procedures. Three participants demonstrated this order of reflection.

One of the “problems” Gary had during Scenario 1 was that he kept saying “please” when asking the firefighters to perform tasks. We talked about how a true Incident Commander would not be so polite and agreed he should try to fix that during the redo. The redo scenario was started at the point where he first said “please.” He described his reflection process at this point by stating:
Well, I was thinking about how we started about right where she was going to find the fire and so, I had to think what I did the first time, and, how I could make that better by not saying please and just making sure the whole house was checked.

Krystal described this reflective process when I asked her what triggered her use of reflection during the redo scenario. She stated, “Just thinking, like thinking about things that needed to be done after certain things were done if that makes sense.”

I asked Karen what she specifically reflected on during the redo scenario and she said;

I think I reflected a little bit more just because I knew now what I had done wrong. From my mistakes, I was able to know that, ‘oh I can do this now to make it better.’ I reflected on the previous experience and then since I did the first scenario I did have an understanding of how the scenario worked, so that made it easier to reflect on.

Not only did many of the participants have an order of importance they wanted to follow when giving commands, but they also tended to follow a reflective process to help them know where they were in that order of importance. By reflecting on actions performed incorrectly during Scenario 1, they knew what not to do and could match that knowledge against their personal mentally created order of importance. By reflecting on the actions seen and discussed during the debriefing session, they knew how to fix their mistakes and could then continue along in that order of procedures.

The following is a description of the second group identified during the data analysis. Jack and a few other participants fell into this group. The previously described reflective procedure did not work for all participants. Some had a difficult time starting at the mistake or point of failure during the redo scenario. These participants placed value on the idea of fixing the mistake by starting at the point of failure in the redo scenario,
but they preferred to start from the beginning. They reported that they too reflected on the actions that were performed during Scenario 1 and what was seen and discussed during the debriefing sessions; however, they found it difficult to place themselves in the order of importance they had created. They reported that they felt uncomfortable about starting at the mistake because they did not know where they were in their personal order of importance. When starting at the point of failure, they felt rushed and unsure of what to do next. For example, Jack stated;

By starting at two minutes I felt much more rushed to complete the activity and my confidence level was slightly lower in myself, because I knew that I had already messed it up once. At the two minute mark, I was also thinking a little too hard perhaps and I had felt a little more confused on what was supposed to be completed, I felt rushed even though I hadn’t completely started over.

These participants preferred to see or actually perform all the actions, and by not starting at the beginning, they had a difficult time seeing the whole process of the actions in their minds and thus could not reflect well on their personally created order of procedures. Both Autumn and Melissa found it difficult to start in the middle of their mentally created processes. When asked how she specifically reflected on her actions during the redo session, Autumn stated;

To be honest I thought it was almost harder because you had to think about where you left off and having to remember everything else that needs to be done for me. Because I thought of it when I was looking at papers and I thought, “I got to get this and this and this done” and then move on this part and it was not in the order that I had planned it to be I guess. And then I had to pick up at that point and try to remember to tell them to try to do this and this and this...other things are like in a process, bam bam bam, like a step process.

Melissa’s statement was similar in that she had a process in her mind and found it difficult to find her place in the problem space when not starting from the beginning.
I think I would prefer to do the whole thing over again. Because in my head I had a train or a chain of what I needed to do, like if they said this, than I would do this. But when I got put back in, I was like “oh yeah wait, where was I again? Like what did I already do and what do I need to do?” And so I forgot not that I forget but I was kind of like “I already said that” I wouldn’t remember if that was before we started.

Table 6 lists a summary of claim 2 and how that claim relates to research question 2. So, during the reflective redo aspect of the intervention, the participants were thinking about the actions they performed during Scenario 1 and what they had seen during the playback in the debriefing session. The participants thought about their actions in a way that allowed them to compare what they had done during Scenario 1 to the mentally created order of importance or procedures they used to learn or memorize the tasks. During the reflective redo aspect of the intervention, some participants could think about or reflect upon that order of importance and place themselves in the problem space when starting at the point of failure. Others tried to place themselves in the problem space but found it difficult and felt uncomfortable with this activity. These participants preferred to start from the beginning of the scenario and perform the actions that matched their order of importance. They thought about their actions differently than did the first group, in that they did not or could not follow the same reflective process as the rest of the participants.

Learning

Claim 3: Reflective redo invites participants to think about their thoughts and learn about their metacognitive and reflective skills. What evidence exists that the reflective redo activity alone creates change in learning in relation to metacognition and reflection? To assess learning, I analyzed the data to identify how the participants learned
Table 6

Summary Table of Claim 2 and How It Relates to Research Question 2

<table>
<thead>
<tr>
<th>Students’ reflection</th>
<th>Relations to research question 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflection-on-action</td>
<td></td>
</tr>
<tr>
<td>Before scenario 1</td>
<td>• Participants reflected on any past knowledge or experience (group 1 &amp; 2)</td>
</tr>
<tr>
<td></td>
<td>• Participants matched current actions with what they had seen in movies (group 1 &amp; 2)</td>
</tr>
<tr>
<td>During redo scenario</td>
<td>• Participants reflected on the actions they had performed during scenario 1 (group 1 &amp; 2)</td>
</tr>
<tr>
<td></td>
<td>• Participants reflected on the actions they had seen with the playback tool (group 1 &amp; 2)</td>
</tr>
<tr>
<td></td>
<td>• Reflecting on these actions helped the participants identify and focus or think about fixing their mistakes (group 1)</td>
</tr>
<tr>
<td>Reflection-in-action</td>
<td></td>
</tr>
<tr>
<td>Means to monitoring</td>
<td>• Participants reflected on past actions and felt that during the redo they knew what to do (group 1)</td>
</tr>
<tr>
<td></td>
<td>• Participants reflected on the checklist to test their progress in completing the task items (group 1)</td>
</tr>
<tr>
<td></td>
<td>• Participants reflected on the actions performed in scenario 1 and matched those action to the order of importance they had created for themselves (group 1)</td>
</tr>
<tr>
<td>During the debriefing session</td>
<td>• Participants focused their efforts and thought about how to fix the mistakes made during scenario 1 (group 1 &amp; 2)</td>
</tr>
<tr>
<td></td>
<td>• Reflection helped the participants know what not to do and could match that knowledge against their personal mentally created order of importance (group 1)</td>
</tr>
</tbody>
</table>

Note. Claim 2: Use of this technology with support of a debriefing facilitator may help students focus their reflection and organize their thoughts. Research question 2: During the reflective redo aspect of the intervention, how are participants thinking about their actions? Group 1: Could start at the point of failure without discomfort. Group 2: Could not start of the point of failure and feel comfortable.

when using this technology and how it affected their learning process. To measure or identify learning, I used changes in the checklist scores, changes in reported self-awareness (metacognition), and changes in the use of reflection as benchmarks during the analysis. In previous sections, I have alluded to some findings to be used as descriptions of these benchmarks. The following section describes these findings.
**Change in scores.** During each scenario, I marked each task item when the participant correctly performed it. All but one of the participants either improved or had the same checklist scores between Scenario 1 and the redo scenario. The one score that did not increase dropped by one between Scenario 1 and the redo. This participant reported that he felt that some of the items did not apply and therefore he did not use all the task items during the scenarios. When asked why he chose not to give some of the commands, Gary stated;

> Well, the RIT, that was the rescue...Rapid Intervention Team and it seemed like we had the situation fairly well under control, so I didn’t think we’d need that, and benchmark, I wasn’t really sure what the point of that was for. It was just to say that we’d gone to this point...so I didn’t use it.

Even though Gary’s score decreased by one point from Scenario 1 to the redo scenario, he still showed he understood and learned this content well enough to apply the commands that allowed his team to put out the fire. Like Gary, some participants reported that they did not perform a certain task because they felt that task did not apply to the current situation, whereas other participants simply forgot to apply some of the task items to the scenario. Even though memorizing through practice was not an aspect of my research design, I do not discount the possibility that the change in scores may be attributed to practicing and memorizing the task items. However, some participants showed a different level of learning when they reported they chose not to perform certain tasks because those tasks did not apply. Choosing not to perform a task that did not apply to the situation showed that participants had learned what the tasks were and how they should be used, which was more than just memorization.

In the following section, I explain the influence the redo scenario or the act of
reflective redo has on learning when analyzed in terms of self-awareness (metacognition) and reflection as it relates to the participants. The first key finding relating to reflective redo’s influence on learning was that participants used reflection at levels that matched their need as a support mechanism (Gibbons, 2001). The second key finding, which I alluded to in the reflection section, was that the students’ ability to place themselves in the problem space contributed to the amount of contextual information they needed to be successful, in this case, either starting from the beginning or from the point of failure.

**Change in metacognition and reflection.** Reflection and metacognition each have their respective individual characteristics, but to fully use and improve metacognition, one has to use reflection. As seen in Figure 6, metacognition and reflection are separate for the most part; however, there are times when they relate to each other or overlap, and it is in this area that I focus my report of the findings.

As stated, learners used reflection at levels that matched their need as a support mechanism. The following paragraphs describe the mental processes of the participants

![Figure 6. Mental processes of participants. The shaded area represents where metacognition and reflection relate.](image)
and how learning is influenced through the varying degrees of complexity of reflection.

The participants’ experience followed a process when it came to changing their self-awareness and their use of reflection. This process consisted of:

1. Choosing a learning strategy for this content.
2. Gaining experience using the simulation.
3. Identifying mistakes in their actions and reflecting on previous actions and thoughts while making adjustments to their learning strategy.
4. Redoing actions to fix mistakes while testing adjustments made to the learning strategy.
5. Doing, reflecting, redoing.

First: Participants choose a learning strategy to learn about and memorize the task items provided on the checklist. Learning strategies were representations of metacognitive knowledge in that the participants were aware of a type of learning strategy (procedural knowledge) and knew to apply that strategy to this situation (conditional knowledge). Before gaining experience with the simulation, the participants had very little knowledge that related to this content and had little way of knowing how effective their chosen learning strategy would be or if it would work at all. Without a foundation of knowledge of the content, the participants found it difficult to think about their thoughts and reflect upon their actions, meaning they found it difficult to use other aspects of metacognition such as monitoring and evaluation of their chosen learning strategy. As previously mentioned, Amber described how not having an understanding of the context affected her experience by leading her to try to perform tasks without really
understanding which tasks to use or what they meant.

In the first simulation I was so worried about getting it and getting all the bullet points done. I wasn’t really worried about the why or how but in the second simulation I felt better about the simulation. I was like ‘oh yeah that makes sense, that there are no other victims or the fire hasn’t spread’ rather than being like ‘the fire’s out, sweet we’re done.’ In the second one [redo] I was more into it, into the situations versus trying to get the task checked off.

Once Amber had experience and a context in which to apply this material, the tasks made sense and she knew how to use them. She now had a context in which she could adjust and test her learning strategy and improve her learning of this content, as well as a way to learn about the way she learns new content.

Second: Gaining experience using the simulation. The second step in participants’ changing self-awareness and use of reflection came after they had gained experience with the simulation. This experience not only gave the participants a context in which to apply the task items and learn how they were to be used, it also gave them confidence while performing within the simulation. Increased confidence supported the participants in their efforts to gain knowledge and understanding of the task items they performed during the scenarios. In many cases, the participants reported that their newfound confidence allowed them to try tasks during the scenarios in an effort to learn how the tasks were used as well as how to memorize them better. For example, when I asked Shannon how gaining experience influenced her, she stated;

Because I’ve been through the simulation once, and I knew what was expected of me and what to expect. I had more confidence in my calls I guess and I could remember what I was supposed to do easier.

Amber also mentioned how gaining experience and knowing that she could redo or fix her mistakes gave her confidence. She stated;
If you mess up on a test you are going to want, like if they let you go back to redo it, then sweet. Um I think it’s the same kind of thing, it made me more confident knowing that I hadn’t messed up from the second one [redo] and that I was able to go through and fix the mistakes before went into the second scenario. I think it was a huge confidence builder in this aspect. I mean like “OK I can fix this and I can remember it for the next time.”

Gaining experience, confidence, and a context in which to apply new knowledge created an environment in which the participants could practice aspects metacognition such as monitoring and evaluating their task-related and learning progress. The participants could learn about the way they learn when they applied monitoring and evaluation skills. During a scenario, participants paused to try to remember the next task to perform, and that pause also allowed monitoring or a self-check of progress. For example, Amber reported, “During Scenario 1, I thought to myself, OK, I see how this works, I’ve done this and now I can do this.” Amber monitored her thoughts and understanding while performing the task items. However, it is important to note, as previously stated, that meaningful monitoring and evaluation did not take place until the participants had completed Scenario 1 and had had mistakes identified during the debriefing session. Once the participants knew what needed to be fixed as identified in the debriefing session, they had something meaningful to reflect upon, namely, their actions and how those actions related to their learning strategy. Thus, they learned how effectively they performed the actions and how effectively they used their learning strategy to learn or memorize this content. The degree of complexity of their reflection-on-action and their thoughts about their learning strategy allowed the participants to adjust their thought process and learning strategy accordingly.

Third: Identifying mistakes in their actions and reflecting on previous actions and
thoughts while making adjustments to their learning strategy. Once the debriefing session was complete, the participants had something to focus on during the redo scenario.

Before starting the redo, the participants evaluated their thoughts and learning strategy in an effort to improve their performance. Those participants who mentally adjusted their learning strategy during the debriefing session reported that using reflective redo during the redo scenario helped cement the adjustments they had made after discovering the mistakes or areas that needed to be fixed. For example, when asked how the redo affected her learning strategy, Amber stated;

I think that repetition and focusing on mistakes is how I learn. So, if anything, it [redo] just solidifies that even more. Like you know, I’m going to focus on the things that I don’t understand vs. freaking out and making sure that I remember what I already understand. I think it just solidified in my head how I already learn and how it applies to other things.

Amber now had a mistake to focus on during the redo scenario. She applied reflective redo during the redo scenario and had the process of her learning strategy solidified and confirmed that it worked for her.

Fourth: Redoing actions to fix mistakes while testing adjustments made to the learning strategy. The fourth step in the learning process identified during the data analysis is redoing actions and testing adjustments to learning strategies through monitoring and evaluation. This is the point in the process where reflection begins to have varying degrees of complexity. For some, reflective redo provided a chance to test adjustments made to learning strategies through actions and reflection on those actions. For example, Amber reported that the reflective redo aspect of the intervention helped her learn this content better by focusing on her mistakes. Allen felt that having the
opportunity to fix the mistakes identified during the debriefing session improved his learning more than just practicing the scenario over and over would have done.

   Focusing on my mistake, and starting from there, I did not have to worry about the beginning, because, I feel like I had that down, obviously. And so I think... during the redo, like I was just like, running a systems check again, in my head, umm, now that I know how it was supposed to be done right.

   Other participants had a difficult time reflecting on past actions when starting at the point of failure. They could not place themselves in the problem space at the point of failure that was created for them when a mistake was identified during the debriefing session. In other words, these participants preferred to start from the beginning of the scenario so they could perform all the actions and not skip what they had previously performed correctly. These participants felt that the reflective redo did help focus on the mistake(s), but the main problem was that they felt unsure of what to do next after fixing the mistake because they could not remember what was next in their mentally created order of procedures.

   Through this experience, some participants became more aware of the effectiveness of their learning abilities via a particular learning strategy when they reflected on those actions and thought processes. These participants fixed their mistakes during the redo scenario, which added to their knowledge and understanding of the task items and also helped them adjust or verify their learning strategy. Other participants had a problem with starting at the point of failure. Even though these participants reflected on their previously performed actions and thought about their thought processes in a similar manner as the rest of the participants, they had a difficult time placing themselves in the problem space (i.e., at the point of failure) because they needed more contextual
information to be successful. The contextual information they needed came from starting from the beginning. They needed to see the process and perform the actions that led up to the mistake. By starting from the beginning, they felt confident they could fix the mistake and then move on with the rest of the process. Melissa had a “chain of what I needed to do,” and when starting at the point of failure, she forgot what she had done and what still needed to be done.

When these participants started at the point of failure, they felt hurried and unsure of what to do next. These feelings often led to becoming overwhelmed because in their minds, they were starting somewhere in the middle of the scenario. Jack said that when starting at the “2-minute mark, I was also thinking a little too hard perhaps, and I had felt a little more confused on what was supposed to be completed, I felt rushed.” Even reflecting on the actions they had performed in Scenario 1 and had seen during the playback of Scenario 1 was not enough to help these participants placing themselves within the process of tasks.

Fifth: Doing, reflecting, redoing. The last step in the process involves doing, reflecting, and redoing. Even though the participants performed three scenarios, or one cycle, many reported they would like to have had more experiences. They felt that if they had had the opportunity to go through more cycles, they could have gotten all of the task items on the checklist and would have done well if these had been applied to the same learning situation with new content. Continually following this process could help users revise their learning strategy and learning process to the point where revision was no longer necessary.
Learning Summary

During the data analysis, I used changes in score, changes in metacognitive awareness, and changes in reflection as benchmarks to identify participant learning. Different levels of learning were identified in that the scores of some participants seemed to change based on memorization of the tasks, while the scores of others changed because they chose not to perform certain tasks that they did not believe applied to the situation.

Identifying learning in relation to metacognition revealed two key findings. First, reflective redo’s influence on learning was that participants used reflection at levels that matched their need as a support mechanism. Second, the students’ ability to place themselves in the problem space contributed to the amount of contextual information they needed to be successful, in this case, either starting from the beginning or from the point of failure.

The participants’ experience followed a process when it came to changing their self-awareness and their use of reflection. First, participants chose a learning strategy to learn about and memorize the task items provided on the checklist. Second, participants learned about self-awareness and the use of reflection after they had gained experience with the simulation. This experience not only gave them a context in which to apply the task items and learn how they were used, it also gave them confidence while performing within the simulation. Third, once the debriefing session was complete, the participants had something to focus on during the redo scenario. Before starting the redo, the participants evaluated their thoughts and learning strategy in an effort to improve their performance. Fourth, participants redid actions and tested adjustments to their learning
strategies through monitoring and evaluation. At this point in the process, reflection began to have varying degrees of complexity. For some, reflective redo provided a chance to test adjustments made to learning strategies through actions and reflection on those actions. Fifth was the process of doing, reflecting, and redoing. The participants felt that if they could use this technology with the built-in functionality and follow the same process more than once, they could learn this content and apply it to perform well in any situation. Or in other words, become a better learner. Table 7 lists a summary of claim 3 and how this claim relates to research question 3.

Table 7

Summary Table of Claim 3 and How It Relates to Research Question 3

<table>
<thead>
<tr>
<th>Students’ learning</th>
<th>Relations to research question 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in score</td>
<td>• The scores of some participants changed based on memorization of the tasks</td>
</tr>
<tr>
<td></td>
<td>• The scores of others changed because they chose not to perform certain tasks that they did not believe applied to the situation</td>
</tr>
<tr>
<td>Change in metacognitive awareness</td>
<td>• Participants used reflection at levels that matched their need as a support mechanism</td>
</tr>
<tr>
<td></td>
<td>• The students’ ability to place themselves in the problem space contributed to the amount of contextual information they needed to be successful (i.e., starting at the beginning or at the point of failure)</td>
</tr>
<tr>
<td>Change in reflection</td>
<td>Followed a process:</td>
</tr>
<tr>
<td></td>
<td>• Participants chose a learning strategy to learn about and memorize the task items provided on the checklist</td>
</tr>
<tr>
<td></td>
<td>• Participants learned about self-awareness and the use of reflection after they had gained experience with the simulation</td>
</tr>
<tr>
<td></td>
<td>• After the debriefing session, the participants had something to focus on during the redo scenario</td>
</tr>
<tr>
<td></td>
<td>• Participants redid actions and tested adjustments to their learning strategies through monitoring and evaluation</td>
</tr>
<tr>
<td></td>
<td>o This step in the process is where the two groups differed</td>
</tr>
<tr>
<td></td>
<td>• The participants felt that if they could use this technology with the built-in functionality and follow the same process more than once, they could learn this content and apply it to perform well in any situation</td>
</tr>
</tbody>
</table>

Note. Claim 3: Reflective redo invites participants to think about their thoughts and learn about their metacognition and reflective skills. Research question 3: What evidence exists that the reflective redo activity alone creates change in learning in relation to metacognition and reflection?
CHAPTER V
DISCUSSION, FUTURE RESEARCH, AND CONCLUSION

My objective for this study had both broad and specific aspects. The broad objective was to better understand how this technology supports metacognition and reflection. The specific objective was to understand how reflective redo affects student learning in relation to metacognition and reflection. This research involved students using a 3D simulation designed to train firefighting Incident Commanders in the protocols to follow as part of a team of first responders. This simulation supports a specific functionality that allows all actions to be recorded and played back for review, much like a DVR. At any point during the playback of a saved scenario, a new scenario can be created that allows students to start from the point of failure and focus on and fix previous mistakes. My literature review revealed that there are other technologies similar to that used in my study. Those technologies also record user actions and allow a playback of those actions for review. However, the technology used in this study allows the user to start at a point of failure, which was identified by the facilitator (the researcher), and redo past actions in an effort to learn the content and perform better. My interest lies in this difference in technology, and the focus of this research is on discovering the influence of reflective redo on participant thinking and learning outcomes.

This firefighting training simulation was designed to support the efforts of teachers while also helping students gain new knowledge and providing an environment in which they can put that knowledge into practice. During the design of this simulation,
the idea was never considered that learning with this technology would replace the role of a teacher. Therefore, in the claims I have previously made and whose implications I will now discuss, it is to be understood that the participants’ experience includes the use of the technology as well as guidance from a facilitator.

I now discuss the claims that (a) this technology, when accompanied by a facilitator, can be used to help participants improve the awareness of their metacognition, (b) use of this technology and a debriefing facilitator helps students focus their reflection and organize their thoughts, and (c) reflective redo invites participants to think about their thoughts and learn about their own metacognition and reflective skills.

**Claims**

*Claim 1 states: This technology, when accompanied by a facilitator, may help participants improve their awareness of their metacognition.*

In the previous chapter, I gave examples of some participants who were aware of existing learning strategies, but did not think about their chosen learning strategy during the learning activity. For example, some of the participants used visualization as a learning strategy, but were not aware of how to use that strategy or think about it during the scenarios. This means that these participants were unaware of their own thinking or their ability to monitor their thinking. Schraw (1998) supported this finding by noting that students need to be made aware of what metacognition is and how to use metacognition to improve learning. Once students complete a learning exercise with this technology, a facilitator or teacher can identify the skills the students used and help make
them more aware of how those skills can be used when learning the intended content.
Baker and Brown’s (1984) research showed that metacognition can be taught. For
example, students can explain instructional material to themselves (Vincent et al., 2002),
monitor (Flavell, 1979; Haller et al., 1988), and ask questions (Haller et al., 1988).

If metacognition is taught to students or, in other words, if students are made
aware of metacognition by talking with a facilitator or teacher, then this technology can
be used to test those skills, as with monitoring progress during the redo scenario. As
stated, a participant who chose visualization as a learning strategy was not aware of how
to use that learning strategy during the scenario, meaning that the participant did not
know how to monitor progress based on how the new content was first learned.

Pintrich (1999) stated that “students’ metacognitive knowledge and use of
metacognitive strategies can have an important influence upon their achievement” (p.
460). Once metacognitive strategies are learned, the technology provides an environment
in which these skills can be practiced. The participant who used visualization could use
this technology to test visualization as a learning strategy by performing multiple
scenarios. Specifically, the participant could test the chosen learning strategy when
performing a redo scenario because starting at the point of failure forces users to think
about their previously made actions while monitoring the progress they made up to that
point of failure. If the user is aware of monitoring (or any other strategy) as a
metacognitive strategy, then this strategy can be practiced and improved upon as well.
However, students need to be motivated or have a reason to perform metacognitive
strategy (Pintrich, 1999; Pintrich & De Groot, 1990). This technology can provide both
the motivation and the reason for students to practice metacognition.

*Claim 2 states: Use of this technology with the support of a debriefing facilitator may help students focus their reflection and organize their thoughts.*

**Focused Reflection**

Before using the simulation, participants reflected on actions they had once performed (Schon, 1983), or even actions they had seen in movies or on TV. J. S. Brown et al. (1989) reported that knowledge and context are inextricably connected, and without a meaningful context, knowledge or learning will not change. The research of J. S. Brown et al. confirms why most of the participants thought about anything related to the new content. They were trying to mentally create their own context that made sense to them to help them understand the meaning of the new content (Brown et al., 1989).

This technology, like other technology, provided the context for the participants to apply their new knowledge (Hannafin & Land, 1997). During the first scenario, most participants had a difficult time understanding the meaning of the tasks and how to give commands. Once they gained experience with the simulation, that is, once they understood the context in which the tasks were applied, they understood the tasks’ meaning.

As stated previously, before using the simulation, most of the participants in this study reflected on anything from their past that was related to the new content in an attempt to create a context which they could apply to the new content to help give it meaning. In other words, the participants applied the new content knowledge to past experiences to create a context that would help their learning of the current content
Collins and colleagues (1991) defined situated learning as “the notion of learning knowledge and skills in contexts that reflect the way the knowledge will be useful in real life” (p. 122). In this study, the participants were reflecting on past knowledge about related situations that would help them apply the new content. When learning is separated from a context, students see knowledge as the final product rather than as a tool to solve problems (Herrington & Oliver, 2000), meaning the participants memorized the provided new content, but did not know the best way to apply that content in the current situation. Once the participants gained experience with the technology, or the context in which the new content could be applied, they understood the meaning of the task items, which helped focus their reflection by relating past knowledge and experiences to the current situation. Applying new knowledge within a context is necessary for learning. Knowledge must be applied and tested, and connections must be made for meaning and understanding when learning by doing (Collins et al., 1991).

The playback system provides another element of the context of the simulation in which users review their actions and can make a connection between what a task is and how and when it should be performed. A debriefing session gives a facilitator the opportunity to discuss the actions reviewed with the playback system as well as to discuss what students are thinking about when performing the actions. A facilitator can identify the actions that need fixing and thus help participants focus their reflection on their actions. Focusing reflection is part of a pattern of understanding and helps students learn new content in a more meaningful process (Land & Hannafin, 1997). New actions are initiated as a result of previous experiences or performed actions (Land & Hannafin,
1996), meaning that during the redo scenario, the participants’ learning was a process of reflection-in-action in which actions were used to focus thinking and reflection was directed by the previously performed actions (Schon, 1983).

**Organized Thoughts**

The participants’ thoughts became more organized after they had gained experience with the technology and had spoken with the facilitator during the debriefing session because their new knowledge changed from abstract to concrete. This change occurred because once the new content was applied in the context of the technology and with help from the facilitator, it had meaning. This change allowed the participants to think about the task items in ways that helped them create their mental order of importance. Many of the participants thought about the task items in terms of “now I can do this, and then this, and then this.”

Many of the participants reported that after reviewing their actions with the playback system, they realized that they performed some of the tasks incorrectly. So after they were informed of the mistake they needed to fix, they started to think about how the fixed mistake related to what they had previously thought and done and what they would now have to think and do for the redo scenario. By reflecting on actions performed incorrectly during Scenario 1, they knew what not to do and could match that knowledge against their personal mentally created order of importance. By reflecting on the actions seen during the debriefing session, they knew how to fix their mistakes and could then continue along in their order of importance. In other words, their thoughts were organized in a way that related to what they did, how they reflected on what they did, and what they
were going to do and think during the redo. “I need to do this and then this and then this
and then this.”

Claim 3 states: Reflective redo invites participants to think about their thoughts and learn about their own use of metacognition and reflection. To review, student thinking during a redo of a scenario, after the initial scenario reflection, may be called reflective redo when the simulation technology can support starting from the point of failure. The facilitator identified the mistake or point of failure and it is from this point in time the participants would start in the redo of scenario 1. Even though reflective redo is the process of thinking during the redo of a scenario after the initial scenario reflection, reflective redo would not be possible if a mistake was not identified.

After completing Scenario 1 and participating in the debriefing session with the facilitator, participants were forced to think about what the tasks meant and how those tasks should be used during the redo scenario. In some cases, participants believed that some of the tasks previously performed during Scenario 1 did not really apply to the current emergency situation. For example, as previously reported, one participant’s task item score dropped by one from Scenario 1 to the redo scenario because he believed that one of the task items he gave as a command during Scenario 1 did not really apply and therefore did not need to be used during the redo scenario.

After choosing a learning strategy, many of the participants used metacognitive strategies, such as monitoring or evaluation, to adjust their learning strategy if necessary to ultimately improve their learning of this new content. However, without applying what was learned via their learning strategy, the participants could not implement
metacognition. Using the technology gave the participants the environment in which to apply the learned content. Using the technology to perform actions, reflect upon those actions, and then redo those actions gave participants the opportunity to think about their thoughts and apply metacognitive strategies.

This technology also gave students confidence in their learning and actions. For example, after they saw the actions they had performed via the playback system, they knew that they had (a) learned the new content, and (b) implemented the task item in a correct manner. Redoing Scenario 1 also gave the students confidence after they realized they had learned or performed the task items correctly. In some cases, the participants used this confidence to test their learning strategy by trying tasks differently during the subsequent scenarios in an effort to learn how the tasks should be implemented. Gaining confidence and, as discussed in Claim 2, gaining experience and a context in which to apply new knowledge created an environment where the participants could practice metacognitive strategies such as monitoring and evaluating their task-related and learning progress. The participants could learn about the way they learned or learn about how they thought about their thoughts when they applied skills such as monitoring and evaluation.

When starting at the point of failure and using reflective redo, the participants were forced to think about what actions they had performed, what action they needed to perform that would fix their mistake, and how that action was going to influence future actions. For many of the participants, this pattern of thinking was focused on their mentally created order of importance, allowing them to monitor their current progress, i.e., assess how many task items they had already performed. A few of the participants
felt uncomfortable when starting at the point of failure and implementing reflective redo. These participants were identified as having a different ability to use reflection as a support mechanism. They could not use reflection and metacognition in the same way the other participants did because they could not place themselves at the point of failure and know what they had already performed up to that point. Even though their use of reflection and metacognition were different from those of the other participants, reflective redo forced them to think about or reflect upon their progress just the same as when starting at the point of failure.

Those participants who could reflect upon past actions and had no difficulty or discomfort starting at the point of failure may have had a more natural ability to use and implement metacognition and reflection than those who did have difficulty reflecting or had feelings of discomfort. The study as designed does not reveal the cause of this difference. If time on tasks was increased or the number of task items to be performed was decreased, then maybe there would not be two groups in regard to reflective redo. Perhaps if the participants had more than one experience with reflective redo, they could improve their awareness and use of reflection and metacognition and not have feelings of discomfort. What the study does reveal is that reflective redo forced the participants to use reflection and metacognition even though some may have been more aware of their personal abilities than others.

**Significance of the Study**

Why can’t students improve their metacognition, reflection, and learning by
simply practicing or redoing the same scenario from the beginning? Students can improve their metacognition and reflective skills and learning by practicing. Research has shown that technology can be used to help this improvement (Lin, 2001; Schraw, 1998; Shang et al., 2006). However, as identified in this study, when students start at the point of failure, they are forced to implement reflective skills. They may reflect upon actions previously performed and also reflect upon their thought process when learning the new content and applying that new knowledge.

Research has shown that technology-supported reflection can increase knowledge, but little research discusses or explains the influence of reflective redo when starting at the point of failure. This study can help researchers and educators better understand how redoing within a computer-simulated environment affects the role of metacognition and reflection in learning. More specifically, this study can help researchers understand how students think about their thinking and how they reflect upon their actions. Previous research has shown that reflection and metacognitive awareness have improved learning when facilitated by a subject-matter expert (SME; Brown et al., 1989; Ke, 2008; Schraw, 1998). Better understanding of reflective redo goes beyond the SME and may lead to a new trend in educational software design and development by showing how or why reflection and metacognition can be taught when using this replay and redo functionality with a simulation. The significance of this research lies in showing the benefits of creating new knowledge in educational research and practice.
Limitations of the Study

One of the limitations of this study is its generalizability. Because this research was conducted on Utah State University (USU) students, the findings apply only to the students who participated in this study, meaning those who learn with this type of simulation and involve an SME. However, the information from this research can help both individuals and groups with their own learning styles. The findings can also indicate new ways to better understand reflection and metacognition and how both can be designed into games and simulations for learning.

A sampling bias is another possible limitation in that only psychology students participated in this study. Had computer science students been participants in this study then the collected data and findings may have been different. Also, had more students been used for this study there is the possibility that more patterns and themes would have been identified during the data analysis phase.

Another limitation or the possibility of adding bias into the study was my presence as the researcher and observer. First, I may have introduced biases because I was collecting, coding, and analyzing the data used to answer the research questions. Second, because I trained the participants on how to use the simulation and defined the steps on the checklist, the participants in this study may have assumed that I was advocating the simulation and wanted to have significant findings. This preconceived idea may have affected the participants’ answers to their interview questions. For example, some of them may have exaggerated their opinions, and others may have felt ashamed to admit that they did not like it or that they did not see any value in it. Although
an anonymous survey could control for participant exaggeration, the survey could not be anonymous in this case because the data collected from the survey were connected to and analyzed with the other data. Moreover, because only those who were willing to participate in this research were included, a final limitation is the number of people who did not participate in this research.

Because I was the facilitator, researcher, and data analyzer, the possibility exist that researcher bias was introduced into the findings. I made efforts to analyze the data objectively so that I could find out what the influence of reflective redo was on student reflection, metacognition, and learning. Providing multiple coders to code and analyze the data could have controlled for the possibility of researcher bias. I chose not to have multiple coders because of the unique position I was in as the data collector and analyzer. I wanted to look for certain types of body language and verbal cues that would have been difficult to glean from notes and transcripts created by others.

The length of the intervention was very short and because of the short amount of time the students used the simulation and participated in reflective redo, a procedural bias may have been introduced in that more may have been revealed through the data that could have been gathered from the use of a longer intervention. Lengthening the time the user spends with the simulation and therefore has more time to performing reflective redo could be performed in future research.

The reason why I did not use a control group (which isolates the differences between two groups) is because I was not studying the efficacy of reflective redo compared to starting from the beginning of the simulation. I was trying to understand
what reflective redo is and how it influences students’ experiences with reflection and metacognition within a specifically designed learning environment.

**Future Research**

Metacognition and reflection and how they influence learning have been researched for at least 30 years (Brown, 1980; Schon, 1983). Research on metacognition and reflection 30 years ago consisted of studying how people thought while reading text or performing live actions like teaching in the classroom. However, technology today has brought learning to a new level by providing new means and learning opportunities, which means metacognition and reflection and their influence on learning can be researched within the context of math games (Ke, 2008) or military training simulations (Hill et al., 2006). But questions still exist regarding what it is about these technologies that influence participant metacognition and reflection. Does use of technology improve one’s metacognition and reflection?

This study helped to determine that the HEAT technology supports metacognition and reflection and allows participants to practice these skills. For example, participants monitored their progress or evaluated their learning strategy. Further research could help identify how other areas of metacognition are affected, such as planning and declarative, procedural, and conditional knowledge. Becoming aware of these metacognitive aspects is one thing, but understanding how technology affects them may help improve the way students learn, and more specifically, help improve the way they learn with technology.

In this study, the MAI identified that some students were more aware of their
metacognition than others. However, within each participant’s MAI score, they were more aware of some areas than others. Future research could also include identifying how participants use areas they are more aware of and how those areas help learning. Research would also be valuable in not only identifying the areas of metacognition with lower levels of awareness but in determining how to improve those areas and whether once they are improved, student learning improves when using technology.

There is a possibility that other factors such as personality and memory capacity may have resulted in the current findings. Personality differences could explain why some participants answered the interview questions more verbosely than others. The difference in memory capacity may also be the reason behind the differences in task item scores. But together, these two examples I feel, did not influence the current findings because the study design allowed me to gain insight into each individual’s experience with the simulation and reflective redo. Through the data analysis, I found similar themes and patterns among the participants, despite their differences. The study was designed to find how the use of the technology mixed with reflective redo influenced the whole learning experience and not how individual differences are influenced. It is true that some participants performed more task items than others, but in general there was an increase in scores between the different scenarios. The purpose of the study was to find how this experience affected their learning about their use of reflection and metacognition and how they used those skills to learn new content. However, future research could be performed to look at individual differences to identify how those specific factors (personality and memory capacity) may have an impact on one’s learning experience.
with the simulation and reflective redo. Future research could also be designed to use a control group in an effort to identify the efficacy of reflective redo within a learning environment.

As previously stated, this study identified two groups among the participants. Those in one group could reflect upon their past actions and place themselves at the point of failure with little problem. Those in the second group found it difficult or uncomfortable to be placed at the point of failure and to try to use reflection to know where they were in the problem space. Further research could help identify why those in the second group were uncomfortable being placed at the point of failure. I know that they liked to have the whole process in their heads and they felt that by starting from the beginning they could recreate that process. But why did these participants have this desire and the rest of the participants did not?

To continue this line of thought, further research may help understand whether changes to the way the participants use this technology, for example, having more practice with the simulation or fewer task items, would change the fact that some participants find it difficult to start at the point of failure. And if one’s comfort level can be changed when one starts at the point of failure, how does that influence one’s learning? These questions may also be answered differently if future research consisted of studying reflective redo with a simulation that consisted of new content.

Future research could also include expanding the context by making reflective redo less reliant of the role of the facilitator. Because reflective redo relies on the identification of the mistake or point of failure to exit, and that identification is currently
performed by a facilitator, future research could be performed to find how something like an intelligent tutoring system may replace the role of the facilitator. Once a scenario was completed, a tutoring system could be designed to identify where the mistakes occurred and then provide information process that user followed.

**Conclusion**

Student thinking during a redo of a scenario, after the initial scenario reflection, may be called reflective redo when the simulation technology can support starting from the point of failure. There is little known about reflective redo in which students reflect upon previously performed actions while redoing actions from the point of failure of a saved scenario. The HEAT simulation contains functionality that allows students to view their actions through a playback system and redo their saved actions from the point of failure. Because this technology is so new, there is little understanding of the effects this functionality has on learning. My research begins to explain how this technology not only supports metacognitive and reflective activities but how reflective redo influences student learning of new content within the context of this technology and with the guidance of a facilitator. This research involved students interacting with the software technology by acting as leaders and giving commands to two others. By exploring the way these participants thought about their thoughts and reflected on their actions during the redo of a saved scenario, I found that participants learned about and understood what the new content meant and how it was used. I also found that participants can learn about or become more aware of their metacognition and with the help of a facilitator or teacher,
students can improve these skills and improve the way they learn. My research revealed two key findings when identifying learning in relation to metacognition. First, reflective redo’s influence on learning was that participants’ reflection at levels that matched their need as a support mechanism. Second, the students’ ability to place themselves in the problem space contributed to the amount of contextual information they needed to be successful, in this case, either starting from the beginning or from the point of failure. By investigating reflective redo within the context of a technology-supported, facilitator-led metacognitive and reflective activity, this research provides a foundation for further investigation into learning new content.
REFERENCES


**Kozulin, A. (1986). Vygotsky in context. Thought and language. What is this?**


APPENDICES
Appendix A

Intervention Timeline
Intervention Timeline

9:30 am
- Introduction of Impendent Commander participant and researcher
- Participant fills out MAI survey
10:00 am
- Introduction between IC and other participants and researcher
10:05 am
- Introduce HEAT and controls
- Introduce Incident Command Checklist to the participants
- Explain items on checklist and what they entail
10:25 am
- Researcher starts scenario 1 and makes personal observations
- All four participants will participate in house fire scenario 1
10:35 am
- Researcher leads debrief scenario 1 which includes:
  - Use playback functionality
  - Discuss commands given that apply to checklist
  - Discuss missed checklist items
  - Give time to participant to think about and reflect upon past actions
10:55 am
- Researcher starts scenario 2
- All four participants will participate in house fire 2
11:05 am
- Researcher interviews participant who played the Incident Commander role
12:00 pm
End interview (can continue if needed)

The following describes the steps a participant experienced during this research.
Appendix B

Simulation Training Checklist
Simulation Training Checklist

<table>
<thead>
<tr>
<th>Initial Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Building Description</td>
</tr>
<tr>
<td>• Smoke/Fire Conditions</td>
</tr>
<tr>
<td>• Initial Actions or Assignments</td>
</tr>
<tr>
<td>• Call Command</td>
</tr>
<tr>
<td>• Name Incident</td>
</tr>
<tr>
<td>• Command Location</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Offensive</td>
</tr>
<tr>
<td>• Defensive</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operational Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Investigation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Water Supply</td>
</tr>
<tr>
<td>• RIT (2in/2out)</td>
</tr>
<tr>
<td>• Utilities</td>
</tr>
<tr>
<td>• Ventilation</td>
</tr>
<tr>
<td>• Accountability – PAR</td>
</tr>
<tr>
<td>• Search</td>
</tr>
<tr>
<td>• Fire Above or Below</td>
</tr>
<tr>
<td>• Time Benchmark</td>
</tr>
<tr>
<td>o Re-declare Strategy</td>
</tr>
<tr>
<td>• Scene Security</td>
</tr>
</tbody>
</table>
Appendix C

Scenario Description
Scenario Description

A shown in Figure C-1, scenario 1 is a house fire located in the kitchen on the stove. The firefighters all arrive on scene in front of the house as seen in Figure C-2. It is their duty to put out the fire while following the commands of the incident commander. Scenario 2, shown in Figure C-3, is a fire located in a bedroom, but in the same house as in scenario 1.

*Figure C-1. A screenshot of the fire in the kitchen of scenario 1.*
Figure C-2. A screenshot of the house used in both scenarios.

Figure C-3. A screenshot of the bedroom fire in scenario 2.
**Scenario Storyboard**

Scenario 1: Kitchen fire

- After logging into the simulation, all three firefighters arrive on scene in front of the house.

- The student participant (Incident Commander, IC) will immediately take control of the situation.

- The IC will give directions to the other participants while attempting to give as many commands as possible on the checklist.
  - Some commands may include:
    - Firefighter 1 to inspect the exterior of the house
    - Firefighter 2 to search the house for victims

- Once the scenario is completed (IC’s decisions), the student and facilitator will participate in a debriefing session, which as shown in Figure C-4 includes discussion, review of commands given during scenario 1, and ask questions for further clarification if needed. Figures C-5 and C-6 show the loading of and playback of scenario 1 for review during the debriefing session.
Figure C-4. Brad watching the playback of his actions performed during scenario 1.

Figure C-5. A screenshot of loading scenario 1 so Brad could watch his actions performed during scenario 1.
Figure C-6. The playback of scenario 1 that Brad watched during the debrief session.

- After the debrief session, the IC and other participants will redo scenario 1 and try to fix any errors made and improve the number of task items performed. Figure C-7 shows the regeneration of scenario 1 so Brad can fix the mistake that took place at 2:24:68.
Figure C-7. Creating a new scenario at the point of failure for Brad so he could redo scenario 1 and fix the mistakes he made starting at 2:24:68.

- After redoing scenario 1, the study participants will then participate in scenario 2. Scenario 2 is the same as scenario 1 but the fire is located in an upstairs bedroom. There is no playback and review of scenario 2.
Appendix D

Metacognitive Awareness Inventory
<table>
<thead>
<tr>
<th></th>
<th>Metacognitive Awareness Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>I ask myself periodically if I am meeting my goals.</td>
</tr>
<tr>
<td>2.</td>
<td>I consider several alternatives to a problem before I answer.</td>
</tr>
<tr>
<td>3.</td>
<td>I try to use strategies that have worked in the past.</td>
</tr>
<tr>
<td>4.</td>
<td>I pace myself while learning in order to have enough time.</td>
</tr>
<tr>
<td>5.</td>
<td>I understand my intellectual strengths and weaknesses.</td>
</tr>
<tr>
<td>6.</td>
<td>I think about what I really need to learn before I begin a task.</td>
</tr>
<tr>
<td>7.</td>
<td>I know how well I did once I finish a test.</td>
</tr>
<tr>
<td>8.</td>
<td>I set specific goals before I begin a task.</td>
</tr>
<tr>
<td>9.</td>
<td>I slow down when I encounter important information.</td>
</tr>
<tr>
<td>10.</td>
<td>I know what kind of information is most important to learn.</td>
</tr>
<tr>
<td>11.</td>
<td>I ask myself if I have considered all options when solving a problem.</td>
</tr>
<tr>
<td>12.</td>
<td>I am good at organizing information.</td>
</tr>
<tr>
<td>13.</td>
<td>I consciously focus my attention on important information.</td>
</tr>
<tr>
<td>14.</td>
<td>I have a specific purpose for each strategy I use.</td>
</tr>
<tr>
<td>15.</td>
<td>I learn best when I know something about the topic.</td>
</tr>
<tr>
<td>16.</td>
<td>I know what the teacher expects me to learn.</td>
</tr>
<tr>
<td>17.</td>
<td>I am good at remembering information.</td>
</tr>
<tr>
<td>18.</td>
<td>I use different learning strategies depending on the situation.</td>
</tr>
<tr>
<td>19.</td>
<td>I ask myself if there was an easier way to do things after I finish a task.</td>
</tr>
<tr>
<td>20.</td>
<td>I have control over how well I learn.</td>
</tr>
<tr>
<td>21.</td>
<td>I periodically review to help me understand important relationships.</td>
</tr>
<tr>
<td>22.</td>
<td>I ask myself questions about the material before I begin.</td>
</tr>
<tr>
<td>23.</td>
<td>I think of several ways to solve a problem and choose the best one.</td>
</tr>
<tr>
<td>25.</td>
<td>I ask others for help when I don’t understand something.</td>
</tr>
<tr>
<td>26.</td>
<td>I can motivate myself to learn when I need to</td>
</tr>
<tr>
<td>27.</td>
<td>I am aware of what strategies I use when I study.</td>
</tr>
<tr>
<td>28.</td>
<td>I find myself analyzing the usefulness of strategies while I study.</td>
</tr>
<tr>
<td>29.</td>
<td>I use my intellectual strengths to compensate for my weaknesses.</td>
</tr>
<tr>
<td>30.</td>
<td>I focus on the meaning and significance of new information.</td>
</tr>
<tr>
<td>31.</td>
<td>I create my own examples to make information more meaningful.</td>
</tr>
<tr>
<td>32.</td>
<td>I am a good judge of how well I understand something.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>33. I find myself using helpful learning strategies automatically.</td>
<td></td>
</tr>
<tr>
<td>34. I find myself pausing regularly to check my comprehension.</td>
<td></td>
</tr>
<tr>
<td>35. I know when each strategy I use will be most effective.</td>
<td></td>
</tr>
<tr>
<td>36. I ask myself how well I accomplish my goals once I’m finished.</td>
<td></td>
</tr>
<tr>
<td>37. I draw pictures or diagrams to help me understand while learning.</td>
<td></td>
</tr>
<tr>
<td>38. I ask myself if I have considered all options after I solve a problem.</td>
<td></td>
</tr>
<tr>
<td>39. I try to translate new information into my own words.</td>
<td></td>
</tr>
<tr>
<td>40. I change strategies when I fail to understand.</td>
<td></td>
</tr>
<tr>
<td>41. I use the organizational structure of the text to help me learn.</td>
<td></td>
</tr>
<tr>
<td>42. I read instructions carefully before I begin a task.</td>
<td></td>
</tr>
<tr>
<td>43. I ask myself if what I’m reading is related to what I already know.</td>
<td></td>
</tr>
<tr>
<td>44. I reevaluate my assumptions when I get confused.</td>
<td></td>
</tr>
<tr>
<td>45. I organize my time to best accomplish my goals.</td>
<td></td>
</tr>
<tr>
<td>46. I learn more when I am interested in the topic.</td>
<td></td>
</tr>
<tr>
<td>47. I try to break studying down into smaller steps.</td>
<td></td>
</tr>
<tr>
<td>48. I focus on overall meaning rather than specifics.</td>
<td></td>
</tr>
<tr>
<td>49. I ask myself questions about how well I am doing while I am learning something new.</td>
<td></td>
</tr>
<tr>
<td>50. I ask myself if I learned as much as I could have once I finish a task.</td>
<td></td>
</tr>
<tr>
<td>51. I stop and go back over new information that is not clear.</td>
<td></td>
</tr>
<tr>
<td>52. I stop and reread when I get confused.</td>
<td></td>
</tr>
</tbody>
</table>
Appendix E

Interview Questions after Intervention
Interview Questions after Intervention

Reflection-in-action and Reflection-on-action

Reflection-in-action:

1. During the simulation, how do you use reflection?
2. In your opinion, how does reflecting during the simulation affect you?
3. Can you apply reflection-in-action to other activities?
   a. If yes, how does this type of reflection help your learning?
4. How do you use reflection when studying/learning?
5. If you are reflecting during the simulation, what are you reflecting on?

Reflection-on-action:

6. How do you think you did?
7. Is there anything that you think would have helped you improve your performance?
8. What is your opinion about these tools (redoing and playback)?
   a. Do you feel they helped your ability to learn? If yes, how?
   b. What about these tools could be better?
9. How do you think this type of learning will affect your personal learning style?

Planning:

10. Did you make any predictions about how you were going to include all of the items on the checklist?
11. Did you think about the content matter before you got started?
12. Did you think about parts or all of the items of the checklist?

Monitoring

13. Did you think about what you already knew about the topics?
14. Did you think about the mental procedures you were performing to remember the checklist items during the simulation?
15. Did you think about the how much you understood the topics and how those topics are used?

Evaluating/regulation

16. How do you feel you did?
17. How do you feel you could have done better? What could you have done to perform better?
18. During the simulation were you thinking about what you wanted to gain/goals?
19. Was there a time when you felt uncomfortable about your level of knowledge of the topics?

Declarative Knowledge
20. When learning the firefighting content, how do you recognize what information is important?
21. How well do you organize information when you are learning?
22. When it comes to learning this new information, can you explain what your ability to remember new information?
23. When learning this content can you control how well you learn?
24. What kind of a judge are you of how well you understand this content?

**Procedural knowledge**

25. When learning about firefighting tactics, how have you used learning strategies that have worked in the past?
26. Can you describe to me what kind of strategies you used and for what purpose?
27. When learning this content can you tell me if and how you used learning strategies automatically?

**Conditional Knowledge**

28. What kind of learning strategies did you use for this content and how did you use them?
29. How do you feel about learning something that you know little or nothing about?
30. Can you describe how you motivate yourself to learn something new when you need to?

**Demographic Information**

31. Male or Female?
32. How much gaming experience do you have?
33. What types of games do you play?
Appendix F

REG Planning
**REG-planning:**

<table>
<thead>
<tr>
<th>Collin-predictions:</th>
<th>Collin-content:</th>
<th>Collin part or whole:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organized thoughts by using an acronym. This way he could stay in that order and know where he is.</td>
<td>I just went over the content over and over in my head</td>
<td>Started at whole then went part to part</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alfredo: Put things in order of importance</th>
<th>Alfredo: planning learning by thinking about how he was going to do things</th>
<th>Alfredo: thought about the content in parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfredo: Planned by thinking about past experience and how to build on that</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ammsae: Put thing in order of importance</th>
<th>Ammsae: planned by breaking into parts</th>
<th>Ammsae:</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;I kind of chose things that I felt were more important. Like if you were put in a real situation it would be more important to do &quot;these&quot; things before the others. But in all reality you need them all to make it work. I think it's easier to remember if you do a little shuffling, little shuffling.&quot;</td>
<td></td>
<td>Couldn't plan for next move because didn't have anything to build. Once I pointed out wrong she could plan for next steps</td>
</tr>
</tbody>
</table>
VITA

JON M. SCORESBY

Education

- Ph.D. Student, Instructional Technology, Utah State University, 2005 - present
- M. Ed., Instructional Technology, University of Georgia, 2004
- B.S., Business Management, Information Systems Emphasis, Brigham Young University, 2002

Professional Memberships

- American Educational Research Association

Prior Employment

<table>
<thead>
<tr>
<th>Dates</th>
<th>Place of Employment</th>
<th>Role(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2005 -</td>
<td>Creative Learning Environment, I.D.I.A.S. USU</td>
<td>Research Assistant/Project Coordinator</td>
</tr>
<tr>
<td>Present</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005 - 2007</td>
<td>M.Ed Instructional Technology Outreach/Edtech Program, USU</td>
<td>Program Manager</td>
</tr>
<tr>
<td>Aug 2003-</td>
<td>Office of Instructional Support and Design</td>
<td>Project Manager, Graduate Assistant</td>
</tr>
<tr>
<td>Dec 2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 2002 –</td>
<td>Center for Instructional Design, BYU</td>
<td>Macromedia Flash Programmer</td>
</tr>
<tr>
<td>June 2003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999-2002</td>
<td>Knowledge Gain Publications</td>
<td>Interactive CD, Web Designer</td>
</tr>
<tr>
<td></td>
<td>Orem, Utah</td>
<td></td>
</tr>
</tbody>
</table>

Prior Teaching

University Level

<table>
<thead>
<tr>
<th>Semester</th>
<th>Institution</th>
<th>Course</th>
<th>Level</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2009</td>
<td>Utah State University</td>
<td>INST 3500</td>
<td>Undergrad</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Teaching Technology to Secondary Education Teachers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Awards/Honors

- Awarded Steppingstones Technology Innovation Grant (Oct. 1, 2010)
- Graduate Research Assistant of the Year 2007
- Ageia PhysX Rocks, 2nd Place, Independent company promotion for innovative and useful applications awarded to HEAT project: $750 unrestricted award, 2007
- Graduate Research Assistantship, Creative Learning Environments, Summer 2005 – Present

PART A: RESEARCH

Publications

Refereed Journals


PEER REVIEWED UNDER REVIEW:


Book Chapters

BOOK CHAPTER CONTRIBUTIONS:


Refereed Proceedings

PUBLISHED:


Scholarly Presentations


Multimedia Materials

Software Design & Development

*H.E.A.T*: 3D Virtual Game and Simulation Engine. Technology involving the creation and maintenance of a networked virtual environment for a variety of future teaching and training applications, currently aimed at training first responders and other emergency personnel for strategy and tactics. The engine includes instructional-specific features for after action review and debrief, and a potentially infinite number of scenario regenerations branching from an existing, saved scenario (2008). Hazard, Emergency, Accident and Training module available at: [http://imrc.usu.edu/](http://imrc.usu.edu/)
SLAP 3D: the Science Learning Active Playspace (2008). The purpose of SLAP 3D is to promote learning of science in fun, game-like environments by providing a free and open application available through an Internet browser. Its games combine creativity, ingenuity, problem solving and competition in a setting where players can achieve world-wide recognition for their innovative thinking. In addition to the slap3D.com website, the SLAP Create application allows any person to create games for the SLAP 3D system without any programming experience. SLAP Create is installed as part of the SLAP 3D software.

http://www.slap3d.com
Educational Game Design & Development


Digital Video
H.E.A.T. v2.0 (2008). Promotional DVD emphasizing educational aspects of specific instructional features of the HEAT game engine, especially scenario playback for after action review and scenario regeneration features.


H.E.A.T. v1.0 (2007). Promotional DVD highlighting the original design and development of the HEAT application and virtual environment.