Reflective Redo from the Point of Failure in Virtual Environments

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ABSTRACT

Training simulations provide opportunity for users to repeat actions until mastering a task or learning objective. Once a mistake has been identified, however, difficulties may arise in replicating the exact sequence of previous actions, particularly in a complex, open-ended environment. We present an investigation of student learning, reflection, and metacognition when using a 3D simulation with built-in functionality that allows students to redo their actions by focusing on the point of failure instead of starting from the beginning. Interviews and observations were used to gather qualitative data, finding that starting at the point of failure within a complex, multiplayer simulation holds advantages and presents obstacles for student learning.

Two key findings were identified during this study. The first key finding relating to the influence of reflection while redoing on learning was that participants used reflection with varying degrees of complexity as a scaffolding mechanism. The second key finding was that the students' abilities to orient 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.

Key Words: Education, Training, Simulation, Metacognition, Reflection

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Reflective Redo from the Point of Failure in Virtual Environments: Effects on Metacognition and Reflection

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INTRODUCTION

There have been many attempts to improve how students learn with training simulations designed to facilitate metacognition and reflection (Lin, 2001; Shang et al., 2006; Vincent, Aleven, & Koedinger, 2002; Wang & Reeves, 2007). One implemented method that can help in the facilitation of metacognition and reflection when learning with simulations has been termed an After Action Review (AAR). An AAR is a team-building exercise in which learners come together after performing a training exercise to reflect upon and identify both mistakes and good decisions, discuss possible alternatives, and talk about how to implement solutions (Baird, 1999; Scott, 1984). 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 ten minutes and during the AAR a mistake was identified at the eight-minute mark. 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 eight 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 the thought processes are 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 was 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 are influenced when starting at the point of failure within a first-responders open-ended complex multi-player training simulation. We 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, we 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 to help us better understand how this experience affects their thought processes.

A specific functionality 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 us to focus on participants' reflections during the redo of the previously saved scenario from their point of failure and on how their metacognitive and reflective abilities were affected.

Based on the analysis of the participants' interactions with this simulation, we present a qualitative exploration of how their reflective and metacognitive activities were influenced when using the simulation and how this technology supports those activities.
Participants memorized tasks that needed to be performed and at the same time learned the purpose of each task. A debriefing session between scenarios was implemented to help participants identify their mistakes and give them an opportunity to ask questions. Participating in this debriefing session and using this technology which supports scenario regeneration from the point of failure helped participants use and learn about metacognitive and reflective activities. However, metacognitive and reflective activities were not discussed nor taught during the debriefing session. Participants reviewed their actions and discussed the tasks they either missed or performed incorrectly. Using data from all participants, we discuss in specific terms how *reflective redo* influenced student thinking.

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 technology that allows users to start at the point of failure, in this case, 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

When redoing some kind of activity during a training 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.

Thinking about our thoughts or cognition is termed *metacognition*. Metacognition has been defined as "the deliberate conscious control of one's own cognitive actions" (Brown, 1980) or, in other words, how learners think about their thoughts. Other researchers have identified and defined common components of metacognitive knowledge such as procedural and conditional knowledge and the components of metacognitive regulation such as planning, monitoring, and evaluation (Schraw, 1998; Young & Fry, 2008). 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 reflective 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 training and educational tools such as simulations that support metacognition and reflection (Azevedo, 2005; Hill et al., 2006; van Lent et al., 2004; Lin & Lehman, 1999; Seale & Cann, 2000; 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. Starting from the beginning means students are practicing both correctly and incorrectly performed actions during the redo of 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 of the scenario, particularly in simulations. Therefore, there is a need to know what the effects are on reflection and metacognition when starting from the point of failure.

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 & K. C. Coats, 2009) records all simulated team members' actions, voices, and how long the recorded scenario lasted (Shelton, Stowell, 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 to lead a discussion during the debriefing session to trigger reflection on past actions. An additional functionality built into the simulation is the *regen* tool. A saved scenario can be regenerated (regen) at any point along the saved timeline. This scenario saving and regeneration allows for multiple outcomes based on any single scenario. As shown in Figure 1, a key decision was made at point C. The facilitator can start recording a new scenario at point C creating a new scenario from that point in time, leading to a new outcome. Now T_2 or scenario 2 contains the exact saved actions in T_1 (scenario 1) from A – C (Shelton, Scoresby, & Parlin, 2010). This regen functionality allows the learner to start at the point of failure instead of the beginning of the simulation to fix that mistake.

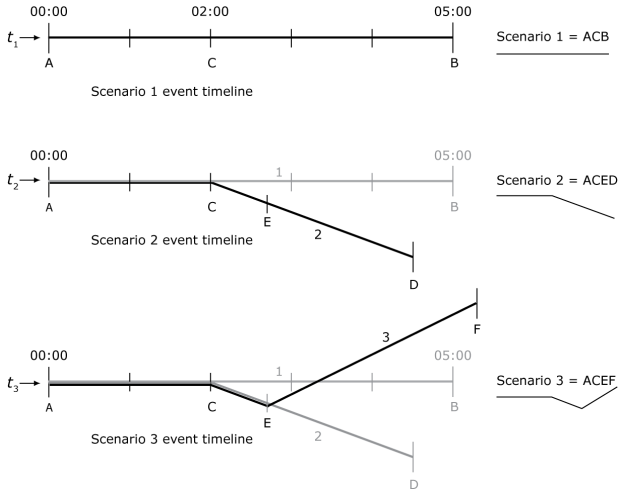

Figure 1. A visual representation of the regen tool. New scenarios were regenerated at points C and E (Shelton, Scoresby, & Parlin, 2010).

Because little is known about the effects of redoing a training activity from the point of failure rather than from the beginning, as in most AAR simulations, there is a need to understand the reflection and metacognition that takes 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.

The purpose of this research as seen in Figure 2 was to better understand the use of technology-supported metacognition and reflection by investigating how HEAT supports metacognition and reflection. To investigate how this simulation supports metacognition (planning, monitoring, evaluation) and reflection, 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?

METHODS

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 within a specifically designed computer-simulated environment. The research design used elements related to an observational study (Creswell, 2008) which was implemented in research using both elements of grounded theory and designed-based research (DBR) (Barab & Squire, 2004; Collins, Joseph, & Bielaczyc, 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. The role of the SME in this study was to facilitate the debriefing session by identifying 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.

Objective	Theoretical areas of investigation	Research questions	Data sources	Analysis	Operationalized
To better understand how technology supports aspects of metacognition and reflection.	Metacognition	Q1	Participant observations Video observation Notes Interview/ email	Categorical comparison using benchmarks of • Metacognitive knowledge and regulation	Thinking about their thinking pertaining to do, reflect, redo
	Reflection	Q2		Comparison using benchmarks of • Reflection-on-action • Reflection-in-action	Thinking about their actions pertaining to do, reflect, redo

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

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 became 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 become aware of their own thoughts and whether metacognitive knowledge and regulation helped them succeed when using 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 awareness of their thoughts. Observational data and interview questions measured how the use of reflection both in-action and on-action was influenced by reflective redo.. The study as designed provided the best chance of discovering how metacognition and reflection were influenced. Insights from this research help to show 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 was useful in exploring research problems in new areas (Isaac & Michael, 1995) and can be used in laying the groundwork for future research.

Participants (Sample)

Participants for this research were between 18 and 24 year old college undergraduates. The participants were self-selected college students who were attending introductory psychology classes within the department of psychology. The students fulfilled a class requirement by participating in the study. We 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. The names of the participants used in this paper have been coded and changed to protect their identity.

Instruments

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. 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.

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

Saved 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

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.

Observations
During each scenario and the debriefing session, researchers 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.

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' opinions 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). The following are some sample interview questions:

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?

Procedures
During the simulated scenario and as part of this intervention, three users participated in the environment at one time: one study participant and two confederates. The study participant was designated as the Incident Commander (IC), and it was from this study participant that data were gathered. The confederates' roles were 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 confederates 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.

Each scenario lasted anywhere from five to ten minutes. A few participants required more time to complete their scenarios. The procedures of the study intervention followed these steps:

1. Study participants were instructed on the protocol items on the checklist.
2. Study participants started Scenario 1.
3. A researcher 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, from the point of failure.
4. Study participants started Scenario 2 and new data were collected.
5. A researcher interviewed the study participants using open-ended, semi-structured interview questions.

FINDINGS

We make two assertions throughout the description of each section (metacognition and reflection) pertaining to that particular section and how the assertion relates to the research question. The first assertion 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 assertion is that using this technology with support from a debriefing facilitator may help students focus their reflection and organize their thoughts.

Metacognitive Knowledge

Procedural knowledge or knowing how to use 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. For example, 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 of the list. 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).

Conditional knowledge, or knowing 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, the interviewer 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 has been defined as the participants' awareness of their progress in completing checklist task items, and evaluation has been 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 was interesting that some participants, such as Jack, used aspects of metacognition like 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. Autumn was an example of a participant who used the planning strategy of chunking related task items, but 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. Other researchers have supported this lack of metacognitive awareness (Schraw, 1998; Schraw & 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.

Monitoring

Most participants had a difficult time monitoring their personal progress during Scenario 1 because they did not have a context in which to apply the tasks they had learned. Participants reported that learning was difficult 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 the interviewer 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.

While analyzing how the students were monitoring their thoughts, we identified two groups and their opinions of reflective redo. 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, one group of 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.

Evaluation

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 was 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 was what the learner wanted or expected, then the learner may evaluate the learning strategy positively because it worked well. If the end result was less than what was wanted, then something about the learning strategy needs to change.

Table 1. ***Summary table of assertion 1 and how it relates to research question 1***

Students' Thoughts Pertaining to Metacognition	**Relations to Research Question 1**
Metacognitive Knowledge	
Procedural Knowledge	• Represented by three main strategies: repetition, visualization, and chunking • Those who used only repetition as a learning strategy thought mainly about the tasks they had forgotten to do during Scenario 1 • A mental review of the task items was how some participants verified their learning strategies • 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	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
Metacognitive Regulation	
Planning	• All planned but some not aware of learning strategy or even knew what to do with their learning strategy • Some participants' planning strategy was to create order of importance, these tended to have emergency training or experienced an emergency • Order of importance can be used as a monitoring tool
Monitoring	• Initially could not or had a difficult time because had no experience or context to apply task items • 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 • Improved ability from scenario to scenario • Some could not monitor and start at point of failure
Evaluating	• Participants thought about how many task items they performed in each scenario • Evaluated the effectiveness of their chosen learning strategies by thinking about how well they can done • Redo gave a chance to evaluate their progress and the learning strategy

Note. Assertion 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

Assertion 2: Use of this technology with support of a debriefing facilitator may help students focus their reflection and organize their thoughts. We used reflection-in-action and reflection-on-action as

benchmarks for the analysis of the participants (Schon, 1983). The participants' reflection was analyzed 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.

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, we 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.

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 was 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, Krampe, & Tesch-Rˆmer, 1993). Ericsson et al. 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 et al. also stated that if students received constant feedback and continued to practice, then they could enhance their learning.

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. 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. The interviewer 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.

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. The majority of the participants fell into this group. 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.

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. 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.

Table 2. Summary table of assertion 2 and how it relates to research question 2

Students' Reflection	Relations to Research Question 2
Reflection-on-action	
Before Scenario 1	• Participants reflected on any past knowledge or experience (Group 1 & 2) • Participants matched current actions with what they had seen in movies (Group 1 & 2)
During Redo Scenario	• Participants reflected on the actions they had performed during Scenario 1 (Group 1 & 2) • Participants reflected on the actions they had seen with the playback tool (Group 1 & 2) • Reflecting on these actions helped the participants identify and focus or think about fixing their mistakes (Group 1)
Reflection-in-action	
Means to Monitoring	• Participants reflected on past actions and felt that during the redo they knew what to do (Group 1) • Participants reflected on the checklist to test their progress in completing the task items (Group 1) • Participants reflected on the actions performed in Scenario 1 and matched those action to the order of importance they had created for themselves (Group1)
During the Debriefing Session	• Participants focused their efforts and thought about how to fix the mistakes made during Scenario 1 (Group 1 & 2) • Reflection helped the participants know what not to do and could match that knowledge against their personal mentally created order of importance (Group 1)

Note. Assertion 2: Use of this technology with support of a debriefing facilitator may help students focus their reflection and organize their thoughts. Group 1: Could start at the point of failure without discomfort. Group 2: Could not start of the point of failure and feel comfortable.

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 reflection and metacognition. This 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, the researchers found that participants learned about and understood what the new content meant and how it was used. The researchers 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. Further exploration of how learning was impacted through metacognition and reflection is investigated as additional aspects of this research, not reported here. However, this research reveals two key findings when identifying learning in relation to metacognition. First, reflective redo allowed for participants' reflections that addressed the need for 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.

Future Research

This study explored the use of scenario regeneration technology that allows learners to start from the point of failure in its support of metacognition and reflection and its allowance to practice these skills. It is important to first gain a basic understanding of what reflective redo is and how it affects student thinking during training simulations. This understanding could be used in further research to help identify the efficacy of the reflective redo by comparing learning new content when starting from the point of failure versus starting from the beginning. How does reflective redo affect performance and efficiency? Is it comparably a better strategy? How could reflective-redo strategies be better leveraged? Understanding what was done incorrectly, what cues the learner might have missed, and learning to perform the proper procedures should all be considered when understanding how trainees approach how to "fix" a mistake.

Of the two groups identified in this study, further research could help identify why those in the second group were uncomfortable being placed at the point of failure. It was clear 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?

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