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A Comparison of Online and Offline Measures of Metacognition: Featuring The Silk Road Game

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Featuring *The Silk Road* Computer Game

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Abstract

The central research question underlying this project is how well offline and online measures of metacognition agree with each other, and how well these measures of metacognition predict specific task performance and general academic performance in courses. Metacognition includes skills that enable learners to understand and monitor their cognitive processes related to learning. Offline methods of assessing metacognition are collected either before or after task performance, whereas online methods assess metacognition during task performance. The present study compared an offline measure of metacognition, The Metacognition Five (MC5), to an online measure that used a "reflect when prompted" methodology. The online measure was based on *The Silk Road*, a computer game developed by Trinity College students. The participants were 14 Trinity College students who were asked to play *The Silk Road* once as a "novice" and then again as an "expert" (after having played three additional times on their own). The results showed no significant correlations between the offline measure and the online measure, whether assessed for novice or for expert players. Furthermore, there was no evidence to support hypotheses that the offline measure would predict course grades better than the online measure or that the online measure would predict game performance better than the offline measure. Lastly, there were no significant differences between novice and expert players for game performance outcomes.

Self-Regulated Learning

Albert Bandura's social cognitive theory of self-regulation (1991) suggests that human behavior is influenced by two sets of factors: external outcomes and self-regulatory processes. External outcomes refer to an individual's environment, which can impact learning even though no environment ensures learning (Zimmerman, 1986). In regards to self-regulatory processes, Bandura focuses on an individual's capacity to self-reflect and react as a response to their feelings and motivations. Thus effective learning is based on the interaction between an individual's learning environment and internal affective factors. Therefore, self-regulation theory focuses on how students activate, alter, and sustain their learning practices in specific contexts (Zimmerman, 1986).

Self-regulated learning is an individual's ability to comprehend and manage their own learning (Schraw, 2007). Self-regulated learning includes elements such as an individual's ability to plan, set goals, employ problem-solving strategies, and monitor their progress (Schraw, 2007). By implementing such components, self regulated learners are strategic and flexible when engaged in a learning task.

Schraw's (2007) model of self-regulation includes three components: cognition, motivation, and metacognition. Cognition includes the skills that are necessary to encode, memorize, and recall information. Cognition can be further divided into knowledge of cognition and regulation of cognition. Knowledge of cognition is when an individual is aware of themselves as a learner. Knowledge, which includes facts and concepts, can be divided into three subcategories: declarative knowledge, procedural knowledge, and conditional knowledge (Veenman, Van Hout-Wolters, & Afflerbach, 2006). A person's ability to regulate their cognition depends on what strategies the individual employs when learning (e.g., goal setting,

planning, and evaluating the task). Ultimately, cognition is the process by which an individual takes in information and transforms it based on their thoughts and experiences, which is essential in self-regulated learning (Schraw, 2007).

Motivation relies on an individual's own beliefs and attitudes about mastering a goal. Motivation relates to an individual's self-efficacy and persistence, which can impact the individual's cognitive and metacognitive skills in relation to learning (Schraw, 2007). When students orientate themselves into mastering a goal, they believe they have some control over the factors involved in the learning process. What this means is that motivated students do not give up easily when a task is challenging. Self-efficacy helps in this respect as well because it is the belief in an individual's ability to succeed in a task, which can impact how the individual approaches the task by how motivated they are to accomplish it (Schraw, 2007). In a study conducted by Pintrich and De Groot (1990), students who had high self-efficacy reported more cognitive and metacognitive strategies, and were more persistent in difficult or uninteresting academic tasks. The intrinsic value a student places on an academic task is related to the motivation the student will put forth to learn the material. This can determine how cognitively engaged and self-regulated the student will be when engaged in the learning task. Motivation is key because it is a factor that impacts how students approach assignments, where the assignment is seen as valuable, interesting, or neither. Therefore, motivation affects an individual's engagement and attitude towards a task such as homework. Motivational beliefs play a critical role in the self-regulated learning process.

Metacognition

As stated, the final component of Schraw's (2007) self-regulation model is metacognition. Metacognition includes the skills that enable learners to understand and monitor

their cognitive processes while learning. Ambrose, Bridges, Lovett, DiPietro, and Norman (2010) defined metacognition as an individual's ability to reflect upon and direct their own thinking processes in relation to learning. Ambrose and colleagues (2010) focus on metacognition in college students and proposed a five-step model that highlights the main components of metacognitive thinking. The metacognition model includes: (1) assessing the task, (2) identifying one's strengths and weaknesses, (3) planning, (4) applying various strategies and monitoring one's performance, and (5) reflecting and adjusting when necessary. The Ambrose et al. (2010) model of metacognition assumes that all components are interdependent parts of metacognition and that they are all linked to an individual's motivation.

The first step of Ambrose et al.'s (2010) metacognitive model is for an individual to assess the task. When students receive an assignment, they must fully understand the directions and the task's goals in order to figure out how to successfully complete it. The second step of the model is for an individual to evaluate their personal strengths and weaknesses. When a student is given an assignment, they must determine what areas of the assignment they know they are good at as well as the parts of the assignment where they anticipate struggle. For example, if a student must give a presentation, the student may have organization skills, but may struggle on communicating and delivering a presentation to a group. Therefore, the student should be able to recognize their abilities before completing the assignment. The third step in Ambrose et al.'s (2010) model is planning. Planning is a crucial step for metacognition because students must be able to break down the assignment into seperate, incremental steps up in order to plan accordingly for completion of the assignment. An example of the planning step is when a student must write a paper. The student may plan to complete a paragraph or section of the paper each day to ensure that the final paper is complete by the due date. The fourth step is for an individual

to apply various strategies and to monitor their performance when working on a task. Students can apply strategies as they make their way through their plan to complete the assignment, and can monitor their progress along the way. For example, a student who has the final paper may employ an outlining and research strategy before writing each paragraph in full. As the student progresses through the paper, they would monitor their performance to see if they are on track. The final step of the metacognitive model is to reflect and adjust. A student should reflect on whether they approach they used to complete the assignment is efficient so that they can adjust the process if necessary.

Students who are well versed in their metacognitive abilities should be able to think about their own thinking (Ambrose et al., 2010). Numerous studies have shown where a metacognitive learner can benefit, which includes areas such as communication of information, oral and reading comprehension, writing, attention, memory, and problem-solving (Flavell, 1979). Metacognitive skills are therefore necessary for students to develop in different areas of learning. However, Joseph (2010) stated that many students who are struggling fail to understand their learning processes and lack introspective skills, which results in them having unproductive approaches to completing schoolwork. Therefore, understanding metacognition is beneficial for all students because it will afford them the opportunity to develop personally and academically so that they will become better learners.

Assessments of Metacognition

The study of metacognition has grown as researchers strive to understand the differences in assessment methods that aim to measure an individual's metacognitive processes. There are two main types of assessments for metacognition: offline and online. Offline measures collect metacognitive strategy data either before or after task performance, whereas online measures

assess an individual's metacognition during task performance. Each assessment method has strengths as well as weaknesses; therefore, both should be compared to determine how they measure metacognition differently.

Offline assessments. Common offline measures used in metacognition research are self-report questionnaires. Self-report questionnaires are intended to capture an individual's use of reported cognitive and metacognitive strategies across different situations (Boekaerts & Corno, 2005). The situations could be domain-specific or task-specific, such as mathematics or strategies used by a student engaged in learning the unit circle. Researchers use self-report inventories to assess metacognitive skills and relate them to achievement measures, such as course grades. Likert scales are a hallmark of questionnaires because they can assess the frequency of a behavior reported by the individual (Boekaerts & Corno, 2005). Researchers who use questionnaires have the advantage of being able to easily administer their survey to large groups, thus gathering more data in less time (Veenman, Bavelaar, Wolf, & Van Haaren, 2014). Another advantage of utilizing questionnaires for metacognitive research is that it does not interrupt the learning task because it asks individuals to report on their strategy use retrospectively (Treglia, 2018).

Overall, offline assessments of metacognition have high internal consistency reliability, which indicates that individuals are reporting the same strategies at similar rates (Treglia, 2018). There are several self-report measures that each have high internal consistency reliability, including the Metacognition Awareness Inventory (MAI; Schraw & Denninison, 1994), the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia, & McKeachie, 1991), and the Metacognition Five (MC5; Naratil, Howe, Reuman, & Anselmi, 2013).

The Metacognition Awareness Inventory (MAI) was designed by Schraw and Denninison (1994) and is intended to assess an adult's general self-regulated learning skills across the disciplines. The questionnaire consists of 52 items that are classified by either cognitive knowledge type or by specific metacognitive processes. Another commonly used offline measure is the Motivated Strategies for Learning Questionnaire which was developed by Pintrich, Smith, Garcia, and McKeachie (1991). The MSLQ contains questions pertaining to college student's cognitive and metacognitive learning strategies, paired with their academic motivations. There are scales for self-efficacy and evaluation anxiety to measure an individual's affective state that are incorporated into the motivational questions. Additionally, Wigfield and Eccles (2000) developed an extension to the motivational measures to assess students' achievement values. These achievement values were composed of several components, including the student's perceived importance of doing well on the subject, the usefulness of the subject, and intrinsic value or interest in the subject. Wigfield and Eccles (2000) found that when participants perceive a subject as useful then they will perform better in the subject than if they thought it was just important to do well in the subject. Therefore, it is important to measure participant's motivations in self-report questionnaires using predictors of academic influences and intrinsic values. Another offline measure of metacognition that is used in the current study is the Metacognition Five (MC5). The MC5 was originally developed by Howe, Naratil, Reuman, and Anselmi (unpublished, 2013) and was based on Ambrose et al.'s (2010) model of metacognition. Ambrose et al. (2010) outline five metacognitive steps, and the MC5 is intended to measure student's metacognitive levels based on each step. The MC5 is a retrospective questionnaire consisting of 35 items on a Likert scale.

There have been several disadvantages associated with offline measures of metacognition. One drawback of offline measures is that participants may not be entirely aware of ongoing processes, which may affect the verbalization of these processes in self-reports (Veenman, 2011). This is because cognitive and metacognitive strategies operate at different levels that the learner may not be conscious of. Therefore, while students are engaged in a problem-solving task, they may not be conscious of using their metacognitive skills. However, their recollection is not accurate due to their potential inability to recognize or think retrospectively on which strategies they employed. A second drawback of offline measures proposed by Veenman (2011) is that learners' self-reports of strategies may not correspond to the behaviors they engaged in during the task. This suggests a validity problem for questionnaires because learners must consult their memory in order to reconstruct earlier processes and performance in a task. This recall can lead to memory misattribution and reconstruction or bias, which would make for inaccurate responses (Veenman et al., 2014).

Online assessments. Online methods measure metacognitive strategy use during task performance (Veenman et al., 2014). Online measures typically include think aloud protocols, reflect when prompted protocols, and log file analysis in hypermedia environments. Think aloud protocols require the learner to verbalize their ongoing thoughts, feelings, and self-regulated strategies concurrently to solving the online task. Reflect when prompted protocols ask the participant to answer questions the researcher prompts them about a specific decision the learner made during the online task. Finally, log file analysis automatically records and codes the learner's metacognitive activities on computer software according to a preset coding scheme (Veenman et al., 2014); for example, how long the task takes the learner to complete or what buttons the learner clicked on during the online task.

A key strength of utilizing online methods is that they do not rely on retrospective self-reports. Instead, online measurements use actual learner behavior that is based on externally defined criteria, which is then later validated using 'blind' judges to ensure reliability in the coding system (Veenman et al., 2014). However, there are a few drawbacks of using online methods, which include their time consuming and labor-intensive nature as they need to be individually administered (Veenman et al., 2014). In a comprehensive review that analyzes the advantages and pitfalls of new methods for assessing strategy use, Veenman (2011) found that the think aloud protocol may be intrusive to the online task. However, Ericsson and Simon (1993) found no evidence that participants who were giving concurrent verbal expressions of their thoughts about a task were altering their task performance compared to participants who completed the same task in silence. Therefore, there is conflicting evidence about whether verbalization during a task inhibits task performance.

Prior studies conducted by Gonzalez (2016), Regalado (2017), and Treglia (2018) that have utilized online assessments of metacognition. Gonzalez (2016) and Regalado (2017) used the reflect when prompted method, and recorded the types of decisions made along the *Oregon Trail* computer game using behavioral tallies. Both the behavioral tallies and the coded statements from the reflect when prompted procedure were positively correlated with academic performance and with scores on the MC5 measures. Treglia (2018) found that the online measure was a stronger predictor of course performance, rather than success playing the *Oregon Trail* computer game, compared to the offline measure. Treglia's study results did not confirm her hypotheses related to assessment methods and their corresponding success criteria, and instead provided surprising results. However, the quantitative results from the study were not statistically significant due to small sample sizes. Although quantitative results from these previous studies

were weak, the online assessment measures of metacognition can be further developed in metrics, verbalization protocols, and coding schemas for future research, such as the current study.

Think aloud versus reflect when prompted. In Simon and Ericsson's model of verbalization (1993), there are several levels of verbal data. One type of verbalization is the aforementioned think aloud protocol. During a think aloud session, participants would be continuously reporting their thoughts, feelings, and self-regulation strategies while completing a task (Boekaerts & Corno, 2005). Participants are instructed to say every thought that comes to mind during task performance, without interpretation or judgement (Bannert & Mengelkamp, 2007). While this verbalization has the advantage of recording ongoing thoughts and feelings as the task is occurring, it has the disadvantage of not allowing participants to articulate their inner thoughts successfully. In turn, this is where another type of verbalization comes into play: the reflect when prompted protocol. The reflect when prompted method involves mediating processes such as introspection and reflection while verbalizing thoughts about the task (Bannert & Mengelkamp, 2007). The reflect when prompted method has participants reflect at certain times while they are engaged in the task in order to gauge more direct responses (Bannert & Mengelkamp, 2007).

Bannert and Mengelkamp (2007) analyzed the effects of the think aloud and reflect when promoted verbalization methods on learning performance during a hypermedia learning environment. The participants' task was to learn the concepts of operant conditioning in a 30 minute span. The participants in the think aloud group were instructed to read and think aloud during learning, while the participants in the reflect when prompted group were prompted at each navigational step to reflect on reasons why they chose specific information to learn more about.

According to the results of the study, the think aloud method does not affect learning performance compared to the control condition, whereas the reflect when prompted condition achieved only marginally better transfer performance. Bannert and Mengelkamp (2007) interpreted these results as indirect evidence that the think aloud method would not interfere with metacognition; therefore, they recommend this type of verbalization as a metacognitive online assessment method.

A study conducted by Lin and Lehman (1999) utilized periodic prompts to scaffold students in reflecting on their own learning processes during a computer simulation of a biology laboratory activity. Scaffolds were defined as various types of instructional aids that are used to support student learning (Lin & Lehman, 1999). Lin and Lehman (1999) incorporated three types of prompts: (1) reasons justification, where students were prompted to give reasons for their actions, (2) rule based, where students were prompted to explain rules and procedures, and (3) emotion based, where students are prompted to reflect on their feelings. The results found that the reason justification method was the most effective out of all the groups in directing students' attention to understand when, why, and how to employ strategies, and how to transfer their understanding to other problems (Lin & Lehman, 1999). Therefore, using either the think aloud or reflect when prompted protocols have been shown to be practical means of assessing metacognition during online tasks.

The correlation between offline and online measures. There have only been a few studies that have investigated the relationship between offline and online measures of metacognition. Veenman et al. (2014) tested fifty-two young teenage students on a computerized learning task, called the "Otter-task." The Otter-task required participants to experiment with five independent variables in order to discover how their combined effects impact the growth of

the otter population. Participants' activities during this task were stored in log files on the computer and automatically scored on indicators of metacognitive skills. Afterwards, participants completed learning performance posttests about what metacognitive skills they utilized during the Otter-task. Results showed that the participants' offline self-reports did not correlate with their actual metacognitive strategy use during the task. Therefore, participants did not accurately recall what strategies they had previously used during the task.

Winne and Jamieson-Noel (2002) further supported the claim that offline self-reports do not correlate with actual online behaviors. Sixty-nine college students were tested using an online software tool called PrepMate that traced the participants' strategies while studying a text about a cause-and-effect system. Once the participants finished studying the text, they completed a self-report questionnaire about their perceptions of and practices during their study of the text. The results showed that students overestimated their use of study tactics. This inaccuracy about study tactics raises issues for researchers when interpreting student self-reports because they did not match up with the actual online metacognitive behaviors practiced during the online task. Therefore, Winne and Jamieson-Noel suggested that the online log files were a more accurate way to measure metacognition because it avoids distortions that intrude upon students' self-report perceptions during think-aloud procedures or retrospective questionnaire reports.

Previous research conducted by Treglia (2018) at Trinity College investigated the relationship of offline and online measures of metacognition. The study used twenty 8th grade students who completed *The Oregon Trail* computer game while being prompted to reflect on their decisions. The participants were also asked to complete a self-report questionnaire on the metacognitive strategies they used in their social studies course. Treglia found the online measure had a stronger correlation of success playing *The Oregon Trail* than the offline measure.

Additionally, Treglia found that the online measures were a stronger predictor of course performance than the offline measure.

While there is literature comparing online assessments of metacognitive to offline measures, the research does not incorporate enough information on the different outcomes that verbalization protocols can have on metacognition levels. For this reason, it would be beneficial to the literature to conduct more research on comparing online and offline measures of metacognition.

Practice

An individual's experience with a certain task has an impact on their metacognitive levels. This is because the individual is performing a task they are familiar with, and is thus utilizing different metacognitive skills than if they were engaged in a task they had never done before. For example, if a participant were to complete a task with no prior experience, they may be unable to specify task demands and knowledge regarding strategies or abilities before problem-solving. Participants with no experience would therefore put more cognitive effort into "assessing the task." Thus, experience plays a primary role in the metacognitive strategies participants use to complete the task. On the other hand, participants with prior experience may put the majority of their effort into the "reflect and adjust as needed" step of the Ambrose et al. (2010) model of metacognition.

These expectations coincide with Akama's (2007) study that examined the influence of task experience on metacognitive experiences. Metacognitive experience was defined as an individual's subjective experience when problem-solving, for example, an individual's feelings and judgments while engaged in a task. As Akama (2007) stated, metacognitive experience looks different at different stages of problem-solving. Before problem-solving, metacognitive

experience is based on previous knowledge and experiences. During problem-solving, metacognitive experience includes the process of how the problem is solved, which can be fluid or interrupted. Finally, there is after problem-solving, where metacognitive experience is revised based on the processes used and the outcome of the problem-solving task. Akama (2007) concluded that task experience influences the task performance outcome and strategies used during the task.

Veenman and Elshout (1999) investigated the relationship between participants with task experience and how experience impacts metacognitive skill levels. In their study, the level of expertise was divided into two groups. The experts with task experience were students who had successfully completed six years of physics education, whereas students who attended physics courses for three years or less were considered to be novices with limited task experience. The participants were given a series of questions on the computer regarding thermodynamics. While answering the aforementioned questions, the participants were instructed to think aloud. The results show that the level of metacognitive skills spoken about in the participants' responses were significantly higher for expert subjects than the novices. Veenman and Elshout's (1999) research further supports the claim that task experience increases metacognitive skill levels.

Current Study

The purpose of the current study was to follow-up on the research previously conducted on metacognition in adolescents. As part of ongoing research at Trinity College, the present study was an extension of the studies by Gonzalez (2016), Regaldo (2017), and Treglia (2018). Previous studies examined the differences and efficacy of a reflect when prompted online measure in assessing metacognition in comparison to offline measures. The previous research also began to investigate how metacognitive experience impacts players when engaged with the

online task, *The Oregon Trail* computer game. The former research studies aimed to evaluate metacognition levels using online and offline measures for 8th grade students at a magnet school, whereas the current study focused on a new online measure for college students.

The current study uses a newly developed computer game called *The Silk Road*, which was created by Aldrich, Kane, and Ky (2019) and coincides with the 7th grade curriculum at the same magnet school as the previous studies. However, the participant population for the current study is college age students in order to ensure the game functions as intended and is understandable before a younger participant population utilizes *The Silk Road* game in the upcoming years. *The Silk Road* computer game has made significant improvements in regard to metrics for capturing success criteria. While the player is engaged in game play, log files will be running in the background to record specific data, such as: overall time of game play, the time the player faces an obstacle and what that obstacle is, when decisions based on the obstacles occur and what decisions the players made were, the health of each character at the end of the game, when each character died if they did, and the leftover possessions the player has in their caravan at the end of the game. The log file information can be printed out after game play to be transcribed for data analysis.

The current study investigated the degree of convergence when using a reflect when prompted method for the online measure, *The Silk Road*, in comparison to an offline self-report measures, the MC5. Based on Treglia's (2018) findings, I predicted that the mean level of metacognition will be higher in participants with game play experience than the novice players. I also predicted that the online measure of metacognition will correlate positively with success playing *The Silk Road*, while course grades will correlate better with the offline questionnaire.

Hypotheses

H_1: The offline measure (MC5) will correlate positively, but modestly (r = 0.3 - 0.4), with the online measure (*The Silk Road*).

H_{2A}: The MC5 will predict course grades better than *The Silk Road* measure will.

H_{2B}: *The Silk Road* measure will predict game performance better than the MC5 will.

H_3: Online assessments, based on *The Silk Road* game, will predict game-play outcomes more strongly when the assessments are derived from players after they have developed expertise.

Based on previous research findings, the offline and online measure of metacognition should have a certain degree of convergence. Additionally, the MC5 offline measure is a general and retrospective report based on the learners' metacognitive strategies that were used during their Introduction to Psychology courses, which should therefore correlate with the outcome of their course grades. Therefore, success in *The Silk Road* is more specific and uses the online measure that is tailored to the game itself and should produce a strong correlation. Furthermore, a player should have better success in *The Silk Road* as an expert because they will have more task experience than the novice players.

Method

The Silk Road Task

The online protocol used the unpublished computer game, *The Silk Road*. This computer game was developed to assess metacognition in students who are learning about the journey traders and their caravans made during the 1st century along the network of trade routes that connected Europe to China. Participants play as a caravan leader who must overcome obstacles to bring their caravan members, as well as their trading goods, safely from Rome, Italy to Luoyang, China. Based on the objectives of the game, *The Silk Road* task would require high levels of metacognition.

Recruitment of Participants

Following the guidelines from Trinity College's Institutional Review Board, a recruitment flyer was given to students in two Introduction to Psychology courses after prior approval from the course professor was given. These recruitment flyers included an overview of the study, compensation details, and information on how to contact the researcher to participate in the study (see Appendix A).

Participants

All 14 participants (43% male, 57% female, M_{age} = 20 years and 2 months, SD_{age} = 1 year and 4 months) were students who were recruited from Trinity College and volunteered to participate in this study. All 14 participants were from one of two sections of the same course, taught by the same faculty member. The participants' class years included 2020 (22%), 2021 (14%), 2022 (14%), and 2023 (50%). The participants racially identified as being Asian (14%) or White/Caucasian, Not of Hispanic Origin (86%). The participants identified English (64%) or Other (36%) as their first language. When asked about their video game experience, the following question was asked: How often do you play video games? Participants rated this item on the scale with options: "Never" (28%), "Rarely" (57%), or "A few times a week" (14%).

Measures and Procedures

Offline measure of metacognition: Metacognition 5 (MC5). Naratil, Howe, Reuman, and Anselmi (2013) developed the MC5 for use in previous versions of this study (Gonzalez, 2016; Regalado, 2017; Treglia, 2018). The MC5 is a self-report survey that measures participants' perceived frequency in their use of different metacognitive skills in an academic course. It is based on Ambrose et al.'s (2010) model of metacognition which breaks down the process of metacognition into five different steps: assess the task, identify strengths and

weaknesses, plan, apply strategies and monitor performance, and reflect and adjust. The MC5 consists of a total of 35 questions with each metacognitive step being assessed by seven questions (see Appendix B). The MC5 questions were included in a self-report questionnaire with a total of 35 items that was handed out to the participants during their first testing session. The participants responded to each question using a 5-point Likert scale, ranging from "Never" to "Always." Cronbach's alphas for the scales were as follows: MC5 overall, .78; assess the task, .30; identify strengths and weaknesses, .27; plan, .68; apply strategies and monitor performance, .59; and reflect and adjust, .69.

Online measure of metacognition. The 14 participants were given a time slot to come into the Metacognition Laboratory for their two separate testing sessions. For the first round of testing each participant was considered a "novice" who had never played *The Silk Road* computer game before. After additional experience playing the game, the participants were considered an "expert." The average time between the two sessions was 3 days. Data was collected during February 2020 and March 2020 for both the novice and expert sessions. Each testing session was audio recorded and computer-screen recorded to be transcribed later and coded by researchers based on coding criteria, which will be discussed later on.

There was a set procedure during the novice online testing round. Each participant was first given a consent form (see Appendix C), then each player was given an instruction handout, which included background information, instructions, and a scoring section to read before the testing session began (see Appendix D). The participants were instructed to go over the player instructions document before starting to play the game. After the participants looked over the document, they indicated to the researcher that they were ready to start. The researcher then read a predetermined script to the participant that explained the purpose of the study, the fact that they

were being recorded, and how to communicate clearly as they were tested (see Appendix E). After the researchers' introduction, each participant played *The Silk Road* for a total of 25 minutes or until all of their caravan members died, and the game automatically ended. The reflect when prompted method (Bannert & Mengelkamp, 2007) was used as the participants given questions at certain points in the game where they were asked to explain the reasoning behind their actions (see Appendix F). Following the game-play each participant was asked a series of follow up questions to reflect on their decisions while they played. These questions included why they thought they were successful or not, and what they could have done differently to change the outcome of the game (see Appendix G).

After novice testing was completed, each participant was asked to play *The Silk Road* a total of three more times on their own before retesting as an expert. Each participant was asked to come into the laboratory during an agreed time to complete their additional practice games on a computer that had *The Silk Road* preloaded. The participants were each given a practice sheet to record their extra practice rounds (see Appendix H). Participants were given a date approximately one week after novice testing to be re- tested as an expert.

For the expert testing session participants set up a date and met in the Metacognition Laboratory again. The researcher followed the same procedure as the novice testing session: the participants were given the same player instruction handout to read before the testing session began, participants were tested for 25 minutes, participants were prompted to reflect on decisions, and participants were also asked the same follow-up questions after the expert testing round was completed to reflect on their game-play.

Online coding procedures. In order to code the participant responses from the reflect when prompted method a standardized coding system was developed. Every time a player

reached an obstacle the researcher would follow this four-step process: (1) record the obstacle; (2) decide whether the player made a decision or not, i.e. yes or no; (3) if yes, then determine the type of decision they made as a result of the obstacle; and (4) determine the level of metacognition used to make that decision.

If a participant encountered an obstacle, it was categorized as one of the 16 possible options: (1) bad weather; (2) injury; (3) trade; (4) camel died; (5) robbed; (6) bear attack; (7) run out of food; (8) sick; (9) caravan part broke; (10) caravan fire; (11) find items [caravan, camels, food, treasure]; (12) caravan member death; (13) river or water crossing; (14) divide in path; (15) arrived at a landmark; and (16) other.

Then it was determined if the participant made a decision after encountering that identified obstacle as either (1) no; or (2) yes.

If the participant did not make a decision after encountering an obstacle, then the coding for that response stopped there. If the participant did make a decision, then the type of decision they made was categorized into one of 25 possible decisions: (1) buy supplies at a landmark; (2) see a doctor at a landmark; (3) change food rations; (4) change pace; (5) check supplies; (6) look at map; (7) check health status; (8) hunt; (9) stop to rest; (10) repair caravan; (11) sea crossing - take a boat across; (12) sea crossing - caulk caravan; (13) sea crossing - ford across; (14) get more information [this applies at sea and river crossings]; (15) river crossing - take a boat across; (16) river crossing - caulk caravan; (17) river crossing - ford river; (18) river crossing - wait to see if conditions improve; (19) divide in path - Samarkand; (20) divide in path - Balch; (21) divide in path - Aksu; (22) divide in path - Hoton; (23) refer back to instructions and scoring criteria; (24) ask the researcher a question; and (25) refer back to previous experience.

Finally, those decisions and explanations as to why participants chose those particular decisions were coded for metacognitive level. This was done using a scale of zero to three: (0) metacognition absent; (1) metacognition present, but limited; (2) metacognition present; and (3) metacognition present, and elaborate (see Appendix I for coding criteria and examples).

The researchers used the coding system to calculate the mean number of coded obstacles, coded decisions, and mean level of metacognition for each participant. The number of coded obstacles, coded decisions, and number of coded responses for metacognitive level was different for each participant. This is because the number of obstacles that each participant encountered varied and whether their responses could be coded all the way through the four step process for metacognitive levels (see Table 1).

Success Criteria. In order to determine success while playing *The Silk Road,* four indicators of success were identified. The first success criterion was the distance traveled along the road. The amount of distance traveled was recorded based on how far participants made it on the road within the 25-minute testing session or until all their caravan members died (see Table 1). There was a total of 14 stops along the road: (1) Rome, Italy; (2) Constantinople; (3) Antioch; (4) Dura-Europas; (5) Qumis; (6) Merv; (7) Samarkand and Balch, (8) Kashgar; (9) Aksu and Hoton; (10) Dunhuang; (11) Anxi County ; (12) Wuwei; (13) Chang'an; and (14) Luoyang (see Appendix J).

The second success criterion was whether the participant survived along *The Silk Road* by the end of the 25-minute testing session (see Table 1). Participants have a 25 minutes testing session and the outcome on whether they survived through the end is rated as a no (1) and yes (2) answer.

The third success criterion was number of surviving caravan members at the end of the 25-minute testing session or until all caravan members died (see Table 1). Participants start with a total of five caravan members so the outcome could range from 0-5.

The fourth success criterion was the health of the caravan members at the end of the 25-minute testing session or until all caravan members died (see Table 1). Participants started with five caravan members, each with their own health bar. Participants could monitor each member's personal health bar throughout the testing session. The outcome for each member can be from dead, critical, poor, sufficient, healthy, and very healthy.

The fifth success criterion was the number of possessions left in the caravan after the 25-minute period or until all caravan members have died. The items a player can have include food, camels, ammunition, clothes, and spare caravan parts (see Table 1).

Final course grade. As a measure of students' academic performance and success, researchers used a test grade from the course each student was recruited from. The test grade was used because it comes from the Introduction to Psychology course that each of the students were recruited from. Therefore, there was a stable comparison for academic performance. The test grades that were utilized was the first exam of the course. The grades were calculated based on a 0-100 scale.

Results

Hypothesis 1: Correlation between offline and online measure of metacognition.

There was no evidence to support the hypothesis that the offline measure correlated positively or modestly with the online measure (see Table 2). The correlations between the offline and online measures of metacognition do not significantly differ at the novice and expert assessments. These nonsignificant correlations may be attributed to the offline and online

measures capturing different aspects of metacognition. Each type of measure may be useful for different prediction purposes.

Hypothesis 2A: Offline measure will predict course grades better than the online measure.

Compared to the online measure of metacognition, the offline measure of metacognition was not a stronger predictor of course grades (see Table 2). Collecting several exam scores or using a final course grade may be a more reliable criterion measure.

Hypothesis 2B: Online measure will predict game performance better than offline measure.

Neither the MC5 offline measure nor the *The Silk Road* online measure of metacognition predicted success for individuals playing *The Silk Road* game (see Table 3). There were five outcome measures for playing *The Silk Road* game, including (1) distance traveled, (2) whether the participant survived the 25 minute session, (3) the number of survivors, (4) the mean health of the caravan members, and (5) the total remaining possessions. There are built in correspondences among these five outcome measures. For example, an individual may have a higher level of metacognition, allowing them to travel further along the road, but the further they travel the more likely their caravan members' health will deteriorate, thus the number of survivors is fewer. Therefore, the correspondences among these success criteria must be further analyzed and understood in order to understand how success should be determined for persons playing *The Silk Road* game.

Hypothesis 3: Online assessments, based on *The Silk Road* game, will predict game-play outcomes more strongly when the assessments are derived from players after they have developed expertise.

The correlations between metacognition measures collected after the students had developed some expertise did not differ from the correlations that were measured at the novice stage and game play outcomes (see Table 3). The participants may have needed more time in between practice sessions or more practice sessions than what was allotted in order to show that expert assessments would have higher predictive power.

Discussion

Based on previous research findings of metacognition assessment (Boekaerts & Corno, 2005; Veenman, et al., 2014), both offline and online assessments are valid ways to measure an individual's metacognition. Therefore, we expected a relationship between the offline MC5 measure and the online *Silk Road* measure, in addition to correlations with criterion measures of success in an academic course and game performance criteria. The correlations between the offline and online measures of metacognition did not show a positive or modest relationship. The nonsignificant correlations between the offline and online measures may indicate that the two measures are still acceptable means to measure metacognition, but they capture different steps of Ambrose et al.'s (2010) model of metacognition. Therefore, the offline and online measures may be useful for different predictive purposes, such as measuring an individual's general academic success or success in a specific task.

The offline self-report MC5 measure assessed students' beliefs about how frequently specific metacognitive behaviors occurred in the context of an Introductory Psychology course, while the online "reflect when prompted" measure assessed students' metacognitive behaviors in a specific task while playing *The Silk Road* computer game. Overall, the offline measure of metacognition did not predict course grades better than the online measure, nor did the online measure predict success at playing *The Silk Road* game better than the offline MC5 measure.

This could be because for this specific study the offline measure was correlated to the first exam grade where the students may not be adjusted to the test taking requirements or study habits necessary to perform best on their Introduction to Psychology exams. Therefore, grades from future exams should be collected and compared to the MC5 measure. As for the online measure's nonsignificant findings, this could be attributed to correspondences among the success criteria. An individual's level of metacognition may be high, however, factors such as traveling further along the trail which leads to caravan members' health declining and a higher probability of deaths then impacts correlations with the success criteria. Therefore, correlations among success criteria should be further researched in order to understand how success should be measured for participants playing *The Silk Road* computer game.

Lastly, the results showed no significant difference in the criterion validity of metacognition measures for novice versus expert game players, which could be explained by the lack of time in between practice sessions or the small number of practice sessions allotted to players to gain a better understanding of how to play *The Silk Road* game and perform well in terms of the success criteria.

While the predicted relationships were found not to be significant, it is important to note that the sample size was only 14 participants, and thus it would be surprising to find any significant correlations. A larger sample may increase statistical power and provide more reliable results.

Limitations

The nonsignificant results found in this study may partly be due to identifiable limitations. One limitation can be attributed to the population utilized in this study. This was the first time *The Silk Road* game online measure has been used in comparison to the MC5 offline

measure. Thus, there might have been ceiling effects because the data showed limited variability in either of the measures, which may be due to the population coming from a highly selective small liberal arts college. Therefore, the students at this school already potentially have high levels of metacognition that helped them do well in academics and get into higher education. Also, the students may now be developing their metacognition more upon being enrolled in college. Due to the population, participants are likely to be nearly uniformly high in metacognition, which would have allowed for the limited variability in the measures.

Another limitation comes from the sample size. This study collected data from only 14 participants in a three-week period. The expectation was to get at least 20 participants, but data collection had to be cut short due to the COVID-19 pandemic. Therefore, it remains quite difficult to evaluate the efficacy of the new online measure due to the small sample size, however, more research should be done to determine its validity.

Lastly, the online *Silk Road* game measure unexpectedly froze on three participants. The game froze during two separate practice sessions and once during an expert testing session. For the practice session rounds, the participants were told not to redo the task because they had both made it more than halfway along the trail, and to do another practice may have influenced their expertise as compared to the other participants who also had three additional practice rounds. As for the student whose expert session was cut short, the data collected was taken from their last stopping point. Therefore, this singular participant's expert testing data is not at its full potential if it were not for the game being frozen. Ultimately, the game having frozen on these three participants may have had an impact on how experienced the players were and what the final tallies were for the five success criteria.

Future Research

As stated previously, the current study only used participants from a small liberal arts college. The current research was to act as a pilot study for *The Silk Road* game because it can be extended out for seventh graders as their curriculum pertains to Asian history. With this population, there is more variability in how much metacognition the students are expected to show. The data that was collected for the current study should be kept as one age group, but future studies can perform the exact procedures on seventh graders to investigate how well they play *The Silk Road* game compared to college students.

Another area for future research would be for the participants to have additional practice opportunities to gain expertise at playing *The Silk Road* game. It would be interesting to discover whether metacognition changes after more extended practice. It is possible to see if participants are not only able to get further along the Silk Road, but without their members dying, because they have built up their metacognition to keep their health high and ration their possessions better.

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Tables

Table 1. Comparison of Silk Road Measures at Novice and Expert Testing Sessions.

	Novice		Expert			
Silk Road Measures	M	SD	M	SD	Paired-*t*	Sig.
Number of decisions made	48.43	21.12	82.64	40.72	-2.81	0.015
Number of explanations coded	28.43	5.62	30.43	9.68	-0.79	0.44
Mean metacognition	2.00	0.31	2.18	0.24	-1.81	0.09
Success Criteria						
Distance travelled	5.50	3.48	10.21	4.95	-3.84	0.002
Survive 25 minutes?	1.86	0.36	1.86	0.36	0.00	1.00
Number of surviving members	3.14	1.79	1.71	1.27	3.33	0.005
Mean health	3.07	1.21	2.64	1.15	1.25	0.23
Number of possessions	1250	1195	908	604	1.39	0.19

Note. N = 14.

Table 2. Correlations Among Metacognition Measures and Course Grade.

Measure	1	2	3	4
1. Off-line MC	--			
2. On-line MC - Novice	-0.17	--		
3. On-line MC - Expert	0.09	0.06	--	
4. Psychology Grade	-0.301	-0.4	-0.24	--
M	3.92	2.00	2.18	88.6
SD	0.29	0.31	0.24	4.5

Note. N = 14.
Off-line MC = Off-line Metacognition (MC5) Scale;
On-line MC - Novice = On-line Metacognition (The Silk Road) - Assessment as Novice;
On-line MC - Expert = On-line Metacognition (The Silk Road) - Assessment as Expert.

Table 3. Correlations Among Metacognition Measures and Measures of Success Playing *The Silk Road* Game

	Metacognition Measures		
Measures of Success Playing *The Silk Road* Game	Off-line	On-line (Novice)	On-line (Expert)
Novice Game-Play			
Distance travelled	0.31	0.23	--
Survives 25 minutes?	-0.22	-0.03	--
Number of survivors	-.54*	-0.04	--
Mean health	-0.41	0.02	--
Possessions	-0.28	-.53†	--
Expert Game-Play			
Distance travelled	0.19	--	-0.2
Survives 25 minutes?	0.03	--	0.09
Number of survivors	-0.38	--	-0.19
Mean health	-0.07	--	-0.07
Possessions	0.13	--	0.02

Note. N = 14. † $p \leq .10$ *$p \leq .05$

Appendix A

Recruitment Notice for Students

Learning Strategies Study

Welcome to the Learning Strategies research study! My name is Madison Kane and I've designed a research study to understand students' learning strategies and academic motivation. I'm seeking participants over the age of 18 for two testing sessions, each an hour long. You will complete a questionnaire as well as play a computer game. Participants will receive $10 of Amazon or Peter B's Cafe gift card compensation for each session. Your participation would be greatly appreciated. Please write your name and email below if you are interested in participating and hand it back to me. I will contact you to set up our first testing session. If you have any questions, please contact me at madison.kane@trincoll.edu.

_____
Print Name

_____
Email

Appendix B

Offline Measure Questionnaire

Learning Strategies

MC5_1-MC5_35. Please answer the questions below: Please base your answers on the Trinity course that you identified earlier in the questionnaire.

Each question had the following options: (1) Never, (2) Rarely, (3) Sometimes, (4) Often, or (5) Always.

1. When I am given an assignment in my Trinity course that asks me to remember a lot of information, I can tell what works best for me to remember everything.
2. After completing a test or assignment in my Trinity course, I think about what went well.
3. When I have a test coming up in my Trinity course, I do most of my studying at the last minute.
4. I read directions more than once before I start working on my Trinity course assignments.
5. I use skills – like taking notes, asking myself questions, and slowing down – when I read for my Trinity course.
6. I know what my strengths are on the work I do in my Trinity course.
7. After I get an assignment back in my Trinity course, I try to figure out how I could improve my work for next time.
8. When I start an assignment for my Trinity course, I check that I have all the things I will need – for example, a textbook, a computer, my notes, or the assignment itself – to complete the assignment.
9. I do not understand the purpose of assignments in my Trinity course.
10. I review my writing for my Trinity course before I hand it into the professor.
11. I make an effort to examine my weaknesses on the work I do in my Trinity course.
12. I change my ways of completing my Trinity course assignments when I realize that they are not working.
13. When I work on a writing assignment in my Trinity course, I immediately start writing without making an outline or a graphic organizer.
14. I read directions carefully to make sure I understand all the different parts of my Trinity course assignment.
15. I ask my Trinity course professor for help.
16. I can tell just how much time it will take me to complete assignments in my Trinity course.
17. When I get a bad grade in my Trinity course, I do not study any differently for the next assignment.
18. When my Trinity course homework requires specific materials, I remember to bring them to class.
19. I understand directions for assignments in my Trinity course.
20. When I read for my Trinity course I first focus on headings, bold words, and summaries and then read the material more carefully.

21. My grades on assignments in my Trinity course are different from what I expect them to be.
22. After completing a test or assignment in my Trinity course, I think about what did not work well.
23. When I have an assignment for my Trinity course that will be due more than a week in the future, I start working on it as soon as possible.
24. I rush through directions to get started on my Trinity course test as soon as possible.
25. I compare my most recent grades in my Trinity course to my earlier grades to see if I'm improving.
26. I know what my weaknesses are on the work I do in my Trinity course.
27. When my professor returns a test in my Trinity course, I try to figure out what I didn't understand.
28. When I have a writing assignment due in my Trinity course, I do most of my work at the last minute.
29. After I read an assignment for my Trinity course, I make sure I know what the main goal of the assignment is.
30. I use skills – like using flash cards, study guides, and working with a partner – when I prepare for a test in my Trinity course.
31. I make an effort to examine my strengths on the work I do in my Trinity course.
32. When I get comments or corrections from my professor on a writing assignment in my Trinity course, I don't pay attention to them.
33. I make a "to do" list before I start working on an assignment for my Trinity course.
34. When I have nearly finished an assignment for my Trinity course, I read the directions one last time to make sure I have completed all parts of the assignment.
35. I turn in tests for my Trinity course without checking my answers.

Appendix C

Consent Form

Dear Participant,

You are invited to take part in a project, titled *Learning Strategies*, conducted as a part of an Honors Psychology Thesis at Trinity College. The research is being conducted by Madison Kane under the supervision of Professor David Reuman. This research has been approved by the Trinity College Institutional Review Board (IRB). The purpose of this study is to understand students' learning strategies and academic motivation. If you choose to participate in the study, you will answer a questionnaire related to a particular Trinity course you are taking, as well as complete two sessions of an educational computer game. Your participation will require approximately 1.5 hours of your time with the researcher as well as some additional time independently playing the computer game. At the end of the semester, your Trinity College instructor will notify Madison Kane of your grade from the relevant Trinity course. Understanding college students' learning strategies can eventually help college faculty improve teaching strategies.

Participants will receive a $10 gift card at the conclusion of an initial questionnaire and game playing session. You will be asked to play an educational computer game on your own several times after this initial session. You will receive an additional $10 gift card at the conclusion of a final game playing session.

There are no foreseen risks in participating in this study. The information collected in the study will be used for educational purposes only. Results from this research may be published or presented at professional meetings, but identities of individual participants will never be revealed. Your information will be combined with information from other people taking part in the study. Questionnaire responses and audio recordings of the educational computer game will all be assigned a confidential ID number. Once the audio recordings are transcribed and coded, this data will be deleted.

Your participation is completely voluntary. If you decide to participate in the study, you may withdraw your consent and stop participating at any time, without penalty or loss of benefits to which you are otherwise entitled. You must be at least 18 years of age in order to participate. If you have any questions or concerns, please feel free to contact: Madison Kane at

madison.kane@trincoll.edu or David Reuman at david.reuman@trincoll.edu or an IRB representative at irb@trincoll.edu.

I acknowledge that I have received and read the consent form explaining the *Learning Strategies* study. I understand that there are no known risks to participants in the study, that I am free to withdraw from participation at any time, and that any questions that I may have about the study will be answered fully by the principal investigator.

By signing below, I consent to participate in the *Learning Strategies* study.

_____
Print Your Name

_____
Your Signature

_____
Date of Consent

Appendix D

Instructions for Players

The Silk Road

In this game you will take on the role of Roman traders and explorers as they venture to China along the historic Silk Road. You will travel along the trail while encountering countless obstacles. Your goal is to get to China with all of your caravan members alive and healthy while also maintaining your left over possessions from your journey.

Instructions

First, you will choose an occupation: (All occupations start with $800.)

1. Trader: expertise in negotiating deals for lower prices
2. Hunter: helps with hunting and obtaining food
3. Carpenter: can repair broken caravan pieces and help with fording bodies of water

Next, you will choose a season to leave: Fall, Winter, Spring, or Summer.

Finally, you will buy supplies from Titus' Colosseum Shop for your journey.

1. Caravan Supplies: Camels, Axles, Tongues, and Wheels
2. Food and Ammunition
3. Clothes

At any point in the game, you can "size up the situation" where you can:

1. Probe for more information
2. Hunt for food: how much ammunition you are willing to use to hunt for food
3. Change your food rations: choose from filling, meager, or bare bones
4. Change your pace: choose from a steady pace, a strenuous pace, or a grueling pace
5. Check your general status: see health of caravan members and check supplies
6. Look at the map
7. Stop to rest: choose how many days you want to rest for

At landmarks, you will be able to do the same options as well as

8. Attempt to trade: you will be given options that you can accept or decline
    a. Only purchased or found items can be traded.
9. See a doctor: choose to heal all of your caravan members for money

Remember: the further along you travel the more expensive supplies are to buy.

Final Tally of Points

Points are based on:

1. How far along the route the caravan gets
2. The number of survivors
3. The health of caravan members
4. Possessions, including cash

Appendix E

Introduction and Prompt Instructions

Instructions for the student/participant:

"We want to understand how you make decisions when playing THE SILK ROAD game. As you are playing the game please tell us what you are thinking and why you make the decisions you do. We will sometimes also stop you to ask questions to explain why you made a certain choice.

*Please speak **loudly and clearly** so that we can hear your answers completely.*

There are no right or wrong answers so treat this like you are playing any other game.

Please try to explain your answers as completely as possible.

If you have any questions while you're playing the game, please feel free to ask."

Instructions for researcher: For each action the student makes throughout the game, make sure to ask **WHY** he/she did something.

You do not have to write down all of the participant's responses as they will be recorded. **HOWEVER**, please try to take notes for questions that have blank spaces/boxes for you to write in.

Reminders:

For each obstacle that pops up ask *"what does this mean for your journey?"*

If the student is going too fast or not talking out loud then say *"make sure to explain your choices to me as you go"* or *"please remember to tell me your thinking while you're playing."*

If the student asks the researcher a question about the obstacle, then say *"you have different options for how to address that obstacle."*

Appendix F

Researcher Road Questions

1. Do you understand how to play the game? (ASSESS THE TASK)

2. What do you think the end goal of the game is? (ASSESS THE TASK)

3. What occupation did you pick? _____ (PLANNING/EVALUATING STRENGTHS & WEAKNESSES)

    a. What are some advantages for you of choosing this occupation? (EVAL STRENGTHS)

    b. What are some disadvantages for you of choosing this occupation? (EVAL WEAKNESSES)

4. What season did you choose to leave? _____ (PLANNING/REFLECT & ADJUST?)

    a. What are the advantages of leaving the season that you chose? (EVAL STRENGTHS)

    b. What are some disadvantages of leaving that season? (EVAL WEAKNESSES)

5. What did you decide to buy? (PLANNING/APPLYING STRATEGIES)

    a. Why did you decide to spend as much money as you did on the particular things you bought? (PLANNING/APPLYING STRATEGIES/EVALUATING STRENGTHS & WEAKNESSES)

    Note to researcher: feel free to probe the participant about why they bought the items they bought (ammunition, clothing, spare parts, food, camels; example, may buy a lot of camels and ammunition because those are hard to come by, but they can always hunt for food when needed) (PLANNING/APPLYING STRATEGIES/EVALUATING STRENGTHS & WEAKNESSES)

    Follow up: **If the participant saved some money –** ***"Why did you decide to save some of your money?"*** (PLANNING/APPLY STRATEGIES)

6. During a **RIVER OR WATER CROSSING** – make sure to ask the participant **why** they chose the action that they decided on. (ford, caulk, take the ferry, wait) (APPLY STRATEGIES & MONITOR PERFORMANCE/ REFLECT & ADJUST)

7. When **A CARAVAN MEMBER GETS SICK OR INJURED**- make sure to ask the participant why they chose the action that they decided on. (APPLY STRATEGIES & MONITOR PERFORMANCE/ REFLECT & ADJUST)

8. When they **RUN OUT OF FOOD**- make sure to ask the participant why they chose the action that they decided on. (hunt, change meal portions, etc.) (APPLY STRATEGIES & MONITOR PERFORMANCE/ REFLECT & ADJUST)

9. When they decide to **ACCEPT OR DENY A TRADE**- make sure to ask the participant why they chose the action that they decided on. (EVALUATE STRENGTHS & WEAKNESSES/APPLY STRATEGIES & MONITOR PERFORMANCE/ REFLECT & ADJUST)

10. When they **LOOK AT THE MAP**- ask them why (PLANNING/ASSESS THE TASK)

11. When they **CHANGE PACE**- ask them why (APPLY STRATEGIES & MONITOR PERFORMANCE/REFLECT & ADJUST)

12. When they **CHANGE FOOD RATIONS**- ask them why (APPLY STRATEGIES & MONITOR PERFORMANCE/REFLECT & ADJUST)

13. When they decide to **REST**- ask them why (why that number of days?) (PLANNING/APPLY STRATEGIES & MONITOR PERFORMANCE/REFLECT & ADJUST)

14. When they decide to **HUNT**- ask them why (APPLY STRATEGIES & MONITOR PERFORMANCE/REFLECT & ADJUST)

15. When they **CHECK GENERAL STATUS** ask them why (PLANNING/REFLECT & ADJUST)

16. When they decide to **BUY SUPPLIES OR SEE A DOCTOR AT A LANDMARK**- ask them why (PLANNING/REFLECT & ADJUST)

Appendix G

Post Game Questions

1. Does the student survive at the end of the 25 minutes? (please circle one)

   YES NO

2. If **only some of your members or none of your members survived**, what do you think you could have done differently to change this outcome? (EVALUATE WEAKNESSES/REFLECT & ADJUST)

   If **all of your members survived**, why do you think you were so successful? (EVALUATE STRENGTHS/REFLECT & ADJUST)

3. Overall, would you have made any changes at the beginning of the game if you could? (REFLECT & ADJUST)

Appendix H

Extra Practice Sheet

The Silk Road Extra Practice

Instructions: Play *The Silk Road* computer game on your own a total of three more times (one time as each occupation). These must all be played at some point before re-testing. Please record what happened while playing each round below and give this paper back to the experimenter.

Round 1
Occupation: Trader
How long did you play for (minutes):_____
Did you make it to China: Yes No
How many people survived: 0 1 2 3 4 5
What was the final health of each caravan members:
1. _____ 2. _____ 3. _____ 4. _____ 5. _____
What were the final resources you had:
Food: _____ Camels: _____ Ammunition: _____ Clothes: _____
Caravan Parts- Tongues: _____ Wheels: _____ Axels: _____

Round 2
Occupation: Carpenter
How long did you play for (minutes):_____
Did you make it to China: Yes No
How many people survived: 0 1 2 3 4 5
What was the final health of each caravan members:
1. _____ 2. _____ 3. _____ 4. _____ 5. _____
What were the final resources you had:
Food: _____ Camels: _____ Ammunition: _____ Clothes: _____
Caravan Parts- Tongues: _____ Wheels: _____ Axels: _____

Round 3
Occupation: Hunter
How long did you play for (minutes): _____
Did you make it to China: Yes No
How many people survived: 0 1 2 3 4 5
What was the final health of each caravan members:
1. _____ 2. _____ 3. _____ 4. _____ 5. _____
What were the final resources you had:
Food: _____ Camels: _____ Ammunition: _____ Clothes: _____
Caravan Parts- Tongues: _____ Wheels: _____ Axels: _____

Appendix I

Metacognition Level

General Coding Outline

(0) Student did not answer with any evidence linked back to metacognitive strategies based on Ambrose et al. (2010) metacognition model; gave no response; gave an inappropriate response.
(1) Student gave partial explanation or superficial analysis, just sufficient enough to demonstrate some part of the metacognitive process.
(2) Student gave relevant/reasonable complete response.
(3) Student gave complete response with sufficient elaboration of metacognitive strategies.

Example responses of 0:

- "Because maybe, I don't know."
- "I don't know why I don't want to look around, I just wasn't in the mood."

Example responses of 1:

- **"**I don't even know what the tongue is, so I'm just going to assume three."
- "I caulked the caravan so I could get over the river easier than having trouble getting across."
- "I chose the northern route because I want to get there really fast."

Example responses of 2:

- "I chose to look around to see what is out there and to see if there will be people nearby."
- "I'm going to change food rations so they don't eat as much. I'm going to change it to meager because that's a good amount."
- "Uhm, I'm going to talk to people to know if the river is like calm or if there's anything around here to like go see...or things like that."

Example responses of 3:

- "Yes, I think they might need a rest since they've had many problems so I'm going to stop and rest because one of them has measles and one of them has small pox so...two days because hopefully that's it, I don't want to wait too long."
- "I already remembered the river at this point. So usually you only want to go across by fording it when it's two and a half feet or less. And you want to caulk it when it is four feet or higher or three feet; and you want to go take a ferry when it's like 20 feet. So I will caulk the caravan this time."

Appendix J

The Silk Road Game Map