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A Comparison of Offline and Online Measures of Metacognition

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Abstract

Both offline and online measures have advantages and disadvantages as ways of measuring metacognitive skills. The present study compared data using an offline measure of metacognition, The Metacognition Five (MC5), to an online think-aloud and reflect when prompted measure. The online measure used *The Oregon Trail*, a computer game used in social studies curriculum. The participants were 8th grade students who were asked to play *The Oregon Trail* once as a “novice” and then again as an “expert” (after having played six additional times on their own). The results suggest there is no difference in correlations between the offline measure and the online measure when assessed for novice versus expert players. Furthermore, especially for expert players, the online measure more strongly correlates with success playing *The Oregon Trail* than the offline measure. Additionally, online measures were a stronger predictor of course performance than the offline measure. Lastly, there was no significant difference between novice and expert players for mean levels of metacognition. Experts traveled significantly farther than novices but had fewer survivors than the novices.

Introduction

Self-Regulated Learning

Self-regulated learning refers to our ability to understand and control our learning environments, based on Bandura's social cognitive theory of self-regulation (Schraw, Crippen & Hartley, 2006). Bandura's theory centers around the idea of reciprocal determinism which states that learning is the result of personal, environmental, and behavioral factors and how each of these three factors affects the other two factors (Schraw et al., 2006).

According to Schraw et al. (2006) self-regulation can be broken down further into three main categories: cognition, metacognition, and motivation. Cognition includes skills necessary to encode, memorize, and recall information. Metacognition includes skills that enable learners to understand and monitor their cognitive processes. Motivation includes beliefs and attitudes that affect the use and development of cognitive and metacognitive skills. All three of these mechanisms play an important role in a students' self-regulated learning process.

Self-regulation is an important topic to study because people cannot influence their own motivation and actions very well if they do not pay adequate attention to their own performances, the conditions under which they occur, and the immediate and distal effects they produce (Bandura, 1991). Self-regulation is especially important for students in order for them to understand their learning processes so they can improve them.

Self-regulated learning consists of the use of learning activities and strategies. Self-regulated learners are able to flexibly shift between different learning activities, depending on their goals and task constraints. They are able to execute learning activities that lead to knowledge, comprehension, integration and problem solving (De Jong & Simons, 1990). Other researchers (Cleary & Zimmerman, 2001; Zimmerman, 1986) view self-regulated students as metacognitively, motivationally, and behaviorally active participants in their own learning process who self-generate thoughts, feelings, and actions to attain their learning goals.

Metacognition in Self-Regulation

Metacognition is a fundamental element in learning and a main component of self-regulated learning. In general, metacognition refers to knowledge and regulation of cognition (Schraw et al., 2006). Knowledge of cognition consists of knowledge about oneself as a learner, as well the conditions that constrain learning. Regulation of cognition includes a wide variety of abilities such as goal setting, planning, implementing strategies, monitoring, and evaluating one's learning (Schraw et al., 2006). In everyday terms, metacognition is often referred to as "thinking about thinking."

Ambrose, Bridges, DiPietro, Lovett, and Norman (2010) created a five-step model of metacognition that breaks down the process of metacognitive thinking. This model incorporates five components of metacognition: (1) assessing the task, (2) identifying strengths and weaknesses, (3) planning, (4) applying various strategies and monitoring ones' performance, and (5) reflecting and adjusting when necessary. This particular model treats these components as interdependent parts of metacognition and assumes that all are linked back to motivation.

The first step in the model is assess the task. When students are given an assignment it is important that they fully understand the task goals in order to figure out a way to successfully complete it. The second step of the model is evaluating strengths and weaknesses. When given an assignment students think about what parts of the assignment they know they are good at and which parts of the assignment they anticipate struggles. They can then acknowledge these differences when they are completing the assignment. The next step is planning. This is arguably the most important step of the metacognition model. Students need to be able to break down assignments into increments and plan accordingly for completion. A good example of this is creating multiple drafts of a paper. Students may plan to have certain parts of the paper done at different times in order to ensure the final paper is done by the due date. The next step is applying various strategies and monitoring performance. Students now apply strategies in order to follow through on their plan to complete the assignment and monitor their performance along the way. Finally, the last step of the model is reflecting and adjusting. Students reflect on whether the approach they are using to complete the assignment is efficient so they may adjust the process if necessary for future assignments.

Students that are skilled in metacognitive strategies are able to think about their own thinking; they can track their progress and ultimately reflect on their learning. However, based on a comprehensive examination into the need for teaching strategic learning skills, Joseph (2010) stated that many struggling students fail to understand the learning process and lack introspective skills, resulting in unproductive approaches to their schoolwork. Metacognition and all its facets are important for all students to understand in order for them to become better learners and achieve academic and personal development.

Motivation in Self-Regulation

Ambrose et al. (2010) suggest that students' motivational beliefs and views about learning play a critical role in the metacognition model and all five components of the model are linked to motivation, while students need to be engaged in the learning process. Based on this belief, motivational factors of learning are imperative to fully comprehend the phenomenon of metacognition and implement ways to teach students about its advantages.

Motivation refers to individuals' belief in their ability to complete mastery oriented goals and their self-efficacy that enhance engagement and persistence (Schraw, 2007). Mastery goal orientation means that students believe that they have some control over factors related to learning. This may mean that motivated students do not give up easily when a learning task challenges them. Self-efficacy also relates to motivation as belief in one's ability to succeed and accomplish a task can play a major role in how individuals approach tasks and how motivated they are to accomplish them. The ways in which students see assignments as valuable or interesting is also directly related to their motivation. This includes their engagement and attitude towards class material.

A study conducted by Zepeda, Richey, Ronevich, and Nokes-Malach's (2015) investigated whether a six-hour metacognitive intervention designed to teach the declarative and procedural components of planning, monitoring, and evaluation could increase students' metacognition, motivation, learning, and preparation for future learning in middle school science. They tested forty-nine 8th grade students from two physics classes at an urban, public middle school. The study highlighted the importance of metacognitive skills, by demonstrating that direct instruction and practice of multiple metacognitive skills can improve metacognitive monitoring, learning, transfer, and motivational outcomes for students. They found that metacognitive training can improve both cognitive and motivational aspects of learning. This correlation between metacognition and motivation provides evidence to support the idea that enhancing one component of self-regulated learning can lead to benefits in another. More specifically, they found that students who went through the six-hour metacognitive intervention reported greater task value in what they were assigned, higher endorsements of mastery-approach goals, and also a stronger endorsement of incremental theories of intelligence and beliefs of self-efficacy.

Pintrich and De Groot (1990) found that students who had high self-efficacy were more likely to report use of cognitive strategies, to be more self-regulated in terms of useful metacognitive strategies, and more often persist at difficult or uninteresting academic tasks. Students' belief in their capabilities supports a strong relationship between motivation and metacognition. Moreover, the intrinsic value of academic tasks was strongly related to use of cognitive strategies and self-regulation. Ultimately, students who were motivated to learn the material and believed that their school work was interesting and important were more cognitively engaged in trying to learn it. In addition, these students were more likely to be self-regulating and to report that they persisted on their academic work. This also demonstrates that motivation and metacognition are interdependent.

Cognition in Self-Regulation

The final component of self-regulation is cognition. Schraw et al. (2006) defined cognition as the process of taking in material and transforming it into knowledge. It encompasses the process of gaining knowledge and then understanding it through thought and experience. Cognition relies on three types of learning abilities: the use of simple strategies, problem-solving, and critical thinking (Schraw et al., 2006).

While metacognition involves the use of strategies in order to monitor and regulate one's cognition, cognition involves information processing and organization, particualrly the use of different cognitive strategies. Schraw (2007) divided the cognition component of metacognition into knowledge of cognition and regulation of cognition. Knowledge of cognition is divided into three subcategories: declarative knowledge, procedural knowledge, and conditional knowledge. Regulation of cognition includes skills such as goal setting, planning, implementing strategies, monitoring, and the evaluation of learning.

According to Borkowski (1992) any important cognitive act has motivational consequences and these consequences either stimulate or disengage future self-regulatory actions. This highlights the interdependency of the components of self-regulation, as cognition affects motivation, which then influences the use of future self-regulation. Essentially, cognition is interdependent on motivation and metacognition, and all three are integral elements of successful self-regulation.

Metacognition in Adolescence

Adolescence is a particularly important time for the development of metacognitive skills. Having the ability to monitor and manage one's thought process is important in all areas of an adolescent's life so increasing metacognitive skills becomes needed for school, work, and in our personal life.

Neurological changes play a significant role in the cognitive development of adolescents. Zepeda et al. (2015) stated that changes in the frontal cortex and increased myelination throughout the brain help adolescents to engage in more complex reasoning and utilize more executive control over cognitive processes and the behavioral expression of these processes. Additionally, as adolescents gradually grow older, they expand their social networks, which also impacts cognitive development. Adolescents begin to interact with more adult figures, as well as, their peers, which is another factor that increases their cognitive development. The increased intellectual stimulation from multiple sources increases positive socio-cognitive conflict and creates deeper cognitive understanding and development for adolescents (Moshman, 1998).

Focusing on developmental changes in adolescents in both cognitive and metacognitive skills, Schneider (2008) found support for the belief that children's ability to judge their own memory performance after study of test materials seems to increase over the elementary school years. However, even young children are able to monitor their performance quite accurately when judgments are not given immediately after study, but are somewhat delayed. Thus, developmental differences were not so much observed in the metacognitive knowledge itself but in its efficient application to self-regulation strategies. Finally, Pressley (1995) found that processing speed and performance on tasks relating to self-regulation showed enhanced development throughout adolescence, further demonstrating a developmental milestone for metacognitive improvements during adolescence.

Assessments of Metacognition

As self-regulated learning and metacognition have become topics of research, there has become increased interest in the different assessment methods that measure how self-regulated learners engage in the process of learning. Currently there are a wide variety of assessments that include both offline and online measures. Offline measures use retrospective reports that ask about previous use of metacognitive strategies, while online measures assess metacognition while individuals are engaged in a learning task. In online measures, participants may explain decisions during task performance, be instructed to answer questions about their decisions during task performance, or be observed during task performance. Each assessment method has pros and cons, so an important way to further metacognition research is comparing different assessment methods.

Offline assessments. A common offline assessment used to gather data regarding self-regulated learning and metacognition involves the use of self-report questionnaires. These questionnaires feature Likert-type scales to assess the frequency of reported strategy use (Boekaerts & Corno, 2005). One major reason this assessment is used is because it can be easily administered to large groups (Veenman, 2011). Second, it is an appealing measurement because it does not interrupt the actual process of learning. Self-report questionnaires ask participants to report strategy use and actions retrospectively. It may also be a better predictor of global performance outcomes, such as course grades, because it is itself a global self-report measure.

There are several offline measures of metacognition developed that have relatively high internal reliability. This suggests that participants are consistently reporting the same strategies at similar rates. These self-report assessments include the Metacognitive Awareness Inventory (MAI), the Jr. MAI, the Motivated Strategies of Learning Questionnaire (MSLQ), and the Metacognition Five (MC5).

A widely used measurement of metacognition is the 52-item Metacognitive Awareness Inventory (MAI) developed by Schraw and Dennison (1994). This questionnaire was created for adults and focuses on two specific components of metacognition: knowledge and regulation of cognition. Later, Sperling, Howard, Miller, and Murphy (2002) developed a Junior MAI version geared towards children in 3rd to 9th grade. This version measures the same categories of metacognition with questions more easily accessible to children. Both these offline measures have relatively high internal reliability and are viable options to assess metacognition in both adults and children.

The Motivated Strategies of Learning Questionnaire developed by Pintrich, Smith, Garcia, and McKeachie (1991) is another commonly used offline assessment of self-regulated learning. The MSLQ incorporates questions about students' learning strategies, both cognitive and metacognitive, along with motivation questions. With the motivation scales there are measures of self-efficacy for learning performance and test anxiety as a measure of average affective state. Furthermore, Wigfield and Eccles (2000) developed an additional motivational assessment used to assess students' achievement values. These achievement values measure students' perceived usefulness, importance, and interest in a specific subject. Wigfield and Eccles (2000) found that this motivational variable is predictive of performance in specific subjects. When a student finds a subject useful, they are more likely to perform well in that particular subject area. This is evidence that offline measures of metacognition in the form of self-report questionnaires are useful predictors of academic performance and success.

Another offline measure of metacognition used in the current study is the Metacognition Five (MC5). Howe, Naratil, Reuman, and Anselmi (unpublished, 2013) originally developed this new questionnaire to measure student's metacognitive levels based on the Ambrose et al. (2010) model of metacognition. The MC5 is a retrospective, questionnaire that assesses the five metacognitive steps outlined by Ambrose et al. (2010). The MC5 includes 35 self-report items, which use a five-point Likert scale, with equal number of questions for all five steps of the model.

Although there are multiple offline assessments of metacognition, there are still several disadvantages associated with these self-report questionnaires. Veenman (2011) suggested that learners may not be fully aware of ongoing processes, which may affect the verbalization of these processes in self-reports. An example of this is Zepeda et al.'s (2015) study, which found that even after a six-hour metacognitive intervention producing clear gains of metacognitive skills acquired by middle schoolers, the students did not report their use of planning, monitoring, and evaluating on their self-report questionnaires, despite being given explicit instruction on the nature, development, and application of these skills. This could be because students may not have been aware of their use of metacognitive skills in the moment as they were actively using the skills, or the recollection of their use may not have been accurate. Because students engage in problem solving so often, this may mean that their use of metacognitive strategies become automatic. This might hinder their ability to recognize their use of specific metacognitive skills, on survey questions, because it comes so naturally to them after repeated use. Also, depending on how much time there is between task performance and the retrospective questionnaire, the time lag can potentially influence how much students remember about their metacognitive skill use. Veenman (2011) also reported that learner-perceived self-reports of strategies may not correspond to actual learner behavior. This suggests a validity problem because while answering questions, learners have to consult their memory in order to reconstruct earlier processes and performance. This can lead to memory failure, distortions, or reconstructions contributing to inaccurate responses. Moreover, Veenman (2011) claimed that learners may be inclined to give social-desirable answers with self-report questionnaires, labeling their behavior according to what they think the researcher is asking.

Another offline means to gather data regarding self-regulated learning and metacognition is through observations of overt behavior of learners. Observations capture ongoing, rather than recalled actions. The observation method results in a rich data base of verbal and non-verbal behavior in relation to tasks and social interaction patterns using pre-determined coding systems and scoring procedures (Boekaerts & Corno, 2005). Researchers watch participants for specific actions that are later coded for pre-determined metacognitive behaviors. This method provides both quantitative results, such as, counting the actions that can be categorized, and also qualitative results, that describe the actions of the participants. For example, Turner (1995) examined the effects of instructional contexts on children’s motivation for literacy. They observed eighty-four first grade children in two types of instructional classrooms during daily instruction while completing literary tasks to see the strategies used in learning to read. The observation method proved to be the best option for gathering data in this study because observation could document what children actually did rather than what they said they did. That is, observation tied behaviors directly to tasks; with observation children's body language and self-verbalizations could be used as guidelines in interpreting their behaviors.

Online assessments. Online methods concern measurements taken concurrent to task performance (Veenman, 2011). Examples of online methods used for the assessment of strategy use include the think-aloud method, reflect when prompted method, observation of online activities, eye movement registration which tracks eye movements during task performance, and log file registrations using computer software to automatically record learner activities on the computer.

In a think aloud session, participants continuously report thoughts, feelings, and self-regulation strategies while solving a problem or completing an assignment (Boekaerts & Corno, 2005). With this method, participants are generally instructed to say every thought out loud that comes into their mind during task performance without any interpretation, explanation, or judgement (Bannert & Mengelkamp, 2007). This produces verbalization data. The procedure has the advantage that ongoing thoughts and feelings are recorded as they occur, rather than recalled after doing the task (Boekaerts & Corno, 2005). Some disadvantages are that participants may not be able to accurately articulate their inner thoughts successfully, students may need a great deal of practice before they can manage the dual task, and the extra task of reporting one's cognitions and feelings might interfere with the target task, thus creating some mental overload and bias (Boekaerts & Corno, 2005; Veenman, 2011).

Because online methods occur simultaneously with task performance the drawbacks of using retrospective thinking no longer exists. One of the biggest strengths of using online methods is that actual learner behavior is coded according to an externally defined criteria.

Veenman (2011) argued that this rules out error variance due to subjective learner perceptions which can occur with offline measurements.

Although observations and log file registrations both keep track of metacognitive behaviors, these methods fail to capture the thoughts and motives underlying those behaviors. Moreover, online methods are time-consuming and labor intensive as they need to be individually administered and the raw material needs to be assessed according to a coding scheme (Veenman, 2011). Veenman has suggested that thinking aloud may be intrusive to the task at hand; in a comprehensive review of more than forty studies, however, Ericsson and Simon (1993) found no evidence that merely giving concurrent verbal expression to one's thoughts altered accuracy of task performance compared to that of subjects who completed the same tasks silently under otherwise similar conditions. Thus, Ericsson and Simon (1993) concluded there is not sufficient evidence that verbalization during task performance with the think-aloud method changes the course or structure of the thought processes. Therefore, there is some evidence this is a viable way to record self-regulated learning strategies and metacognition without interference of the participant’s actions. Online methods, recording metacognitive use during a specific task performance, may also prove to be a better predictor of success in that particular task. While offline assessments compile general information on metacognitive use and may be a better predictor of global performance outcomes, online measures are more specific to a particular task and may better predict success on that task.

A pilot study conducted by Gonzalez (2016) utilized online assessments of metacognition. Gonzalez (2016) used the think-aloud method and recorded metacognitive behaviors of students while playing *The Oregon Trail* computer game. The tallies of behaviors for each of the quantitative “Oregon Trail” online measurement of metacognition, were aggregated and correlated with both measures of metacognition as well as academic performance. Although quantitative results from this pilot study were weak, they suggested promise for future studies that online measures of metacognition can be developed further using a metacognitive task such as *The Oregon Trail*.

Think-aloud versus reflect when prompted. As previously described, the think aloud method has participants report their strategy use while directly involved in task performance. This method can also be compared to a similar procedure known as reflect when prompted. Instead of having participants continuously say everything they are doing during a task, the reflect when prompted method asks participants about reflections at certain times while they perform a task for more directed responses (Bannert & Mengelkamp, 2007).

Regalado (2017) expanded on the pilot study of Gonzalez (2016) by tallying metacognitive behaviors of students while playing *The Oregon Trail* computer game and also using the think-aloud and reflect when prompted online assessment methods. Students were instructed to continually explain their decision making process while playing the game and were also asked probing questions during game-play that were later coded for metacognitive levels. Results showed that online measures of metacognition, while playing *The Oregon Trail,* had positive correlations with the offline survey measure, as well as grades. This may provide evidence for the use of this type of metacognitive assessment.

Bannert and Mengelkamp (2007) analyzed the effects of online verbalization methods of metacognitive skills assessment on learning performance during hypermedia learning. They presented two main types of verbalization from their participants. The first was a think aloud method in which the experimental group was instructed to read and think aloud during learning. The second was a reflect when prompted method in which participants were prompted at each navigational step to reflect on the reasons why they chose specific information. Their task was to learn the concepts and principles of operant conditioning presented in a hypermedium within 30 minutes. They chose to use hypermedia environment because it required further strategic decisions by learners, as the student had to choose permanently not only between various text nodes, but also between distinct information presentation formats.

Bannert and Mengelkamp discussed three types of verbal data originally developed by Ericsson and Simon (1993). The first level is talk aloud where the participants say the verbally encoded content out loud without any specific effort or intermediate processes. The second level is think aloud where mediation processes take place because the content is not originally encoded in a verbal form. The third level is verbalization procedures that involve mediating processes before verbalization. Reflect when prompted is an example of level 3 assessment. Mediation processes are necessary at this level since participants have to explain their thoughts, ideas, or motives.

Bannert and Mengelkamp (2007) concluded that the variation of the verbalizations method of metacognitive skills assessment had no significant effect on recall, knowledge, or on transfer task performance. Therefore, it can be presumed that the think aloud and reflect when prompted methods do not alter metacognition and are viable ways to measure self-regulation and metacognition. According to the results of the study, the think aloud method based on level 1 and level 2 verbalizations did not seem to significantly affect metacognitive processes during hypermedia learning. Bannert and Mengelkamp concluded that thinking aloud does not affect learning performances relative to the control condition. They interpreted this as indirect evidence that thinking aloud does not interfere with metacognition and, therefore, recommended this type of verbalization as a metacognitive online assessment method.

In another study by Lin and Lehman (1999), periodic prompts were provided to students to scaffold them 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 learning where students proceed when guidance is provided (Palincsar & Brown, 1984). Three types of prompts were employed: reason justification (students were prompted to give reasons for their actions), rule based (students were prompted to explain rules or procedures), and emotion focused (students were prompted to reflect on their feelings). The reflect when prompted method proved to be the most effective way to measure students' variable control problem solving and transfer in order to get the most complete responses when guided.

De Jong (1987) also assessed metacognitive skills of students using level 2 and level 3 verbalization methods. The level 2 verbalization method involved participants being instructed to think aloud constantly during a task, whereas the level 3 verbalization method involved participants being prompted to think aloud only at marked points during task performance. Data produced by both online methods predicted learning outcomes much more accurately than scales of the offline questionnaire. Therefore, online methods of assessing metacognition through think aloud and reflect when prompted both have shown to be practical means to assess metacognition.

The correlation between offline and online measures. Few studies have focused on comparing the correlation between offline and online measures of metacognition. Sarac and Karakelle (2012) investigated the interrelationships between two offline and two online measures. The first offline measure used was a teacher rating scale adapted from Sperling et al. (2002) to collect teachers' opinions about their students' metacognition. The teachers rated each of their students on a scale ranging from "very low metacognition" to "very high metacognition." The second offline measure used was the self-report inventory, the Junior MAI. The first online measure used was a think-aloud protocol where students were instructed to think aloud while studying a text on the design, working principles, and types of balloons taken from Demirel (1995). The second online measure used was accuracy ratings of text comprehension. Accuracy measured the degree to which children's confidence judgments matched their actual test performance. The results showed that the offline metacognitive measures were not significantly correlated with the two online measures. These results suggest that offline and online measures form distinctive assessment structures and these assessment structures are internally coherent. These findings support the view that metacognitive processes form a complex structure that needs to be assessed using various methods for the greatest accuracy.

Veenman, Bavelaar, De Wolf, and Van Haaren (2014) tested fifty-two 13 year-old students on a computerized inductive-learning task. The Otter-task required participants to experiment with five independent variables in order to discover their (combined) effects on the growth of the otter population. Learner activities during this task were stored in log files and automatically scored on indicators of metacognitive skills. Afterwards, participants completed learning performance posttests. Results showed that students' offline self-reports do not correlate with their actual metacognitive strategy use during the task. This means that learners did not actually do what they said they did or may not accurately recall what they had previously done.

Winne and Jamieson-Noel (2002) further supported the claim that offline self-reports do not align with actual online behaviors. Sixty-nine college students ages 17 to 43 were tested using a software tool called PrepMate that traced their study tactics while studying a text about a cause-and-effect system. Immediately after studying the text, students completed a self-report questionnaire about their perceptions of and practices during their studying of the text. Among other things, the students were asked how often they used study tactics that the software recorded while they were studying. The results showed that students were slightly positively biased (overconfident) about their achievement and moderately positively biased (overestimated) about their use of study tactics. This calibration bias and 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. Winne and Jamieson-Noel believed that their research showed the trace features of studying as it took place, and suggested this method as a more accurate way to measure metacognition, as it avoids possible distortions that may intrude when students self-report perceptions during think-aloud procedures or retrospective reports.

While there is literature on both think-aloud online assessment of metacognition, reflect when prompted method, and a mixture of both (Sarac & Karakelle, 2012; Veenman et al., 2014; Winne & Jamieson-Noel, 2002), many different aspects of online measures of metacognition have not been directly tested in relationship to offline measures. It would be beneficial to have more research examining this comparison to determine the best ways to measure metacognition.

Practice

Novice versus expert learners. One aspect of metacognition assessment that has not been extensively studied is whether experience with the certain task being tested has an impact on the metacognitive levels being reported. It is reasonable to assume if you are performing a task you are familiar with, you might use different metacognitive skills than when you are engaged in a task that you have never done before. For example, if you are playing a game for the first time you might put more effort into the “assessing the task” step of the metacognition model, as opposed to a game you have played many times before. In the latter case, the majority of your effort may be directed towards the “reflecting and adjusting” step of the metacognition model because you have more previous knowledge to refer back to. One question to ask is whether previous task experience actually changes the aspects of metacognition used?

Hillerbrand (1989), stated that in general, someone considered an “expert” is able to manipulate incoming information into recognizable patterns and then match the information to internal problem representations. This capacity reduces the burden on cognitive processing by eliminating extraneous information and increasing cognitive capacity. Based on this knowledge, it can be assumed that once someone is experienced with a task and their cognitive processing changes, that their metacognition level would change along with it.

To examine the influence of task experience on metacognitive experiences, Akama (2007) tested seventy participants on tasks they either had prior experience with, or no previous experience with. Metacognitive experience refered to subjective experience of people during problem-solving which included various types of feelings, estimates, judgments, and ideas. For example, to feel the difficulty of a problem, to estimate the effort required to solve it, and to estimate the correctness of problem-solving were all considered metacognitive experiences. The sources of metacognitive experiences differ at different stages of problem-solving. Before problem-solving, metacognitive experiences were based on previous knowledge of and experiences in similar problems. During problem-solving, the process of problem-solving was the basis of metacognitive experiences. After problem-solving, metacognitive experiences were formed based on processes and the outcome of problem-solving.

In order to test the influence of task experience on metacognitive experiences, the Metacognitive Experiences Questionnaire was given to participants to measure their metacognitive experiences before, during, and after a problem-solving task. For the experienced task, since individuals had prior knowledge of the task, they were expected to know how to solve it before beginning. This would involve using certain metacognitive strategies, such as, planning, and reflecting and adjusting. On the other hand, participants completing the task with no prior experience and no knowledge about the task, could not specify task demands and knowledge regarding strategies or abilities before problem-solving. This means they primarily used different metacognitive strategies to figure out the task, such as, assess the task and identifying strength and weaknesses to solve the task they had no previous knowledge about. Akama (2007) concluded that task experiences clearly influenced the relationship between metacognitive experiences and task performance.

Veenman and Elshout (1999) investigated the relationship between participants with task experience and participants with limited task experience in accordance with metacognitive levels. Their study focused on the transformation of general metacognitive skills of novices into domain-specific regulatory procedures of experts. Level of expertise was assessed using a questionnaire inquiring a student's previous education in physics. Students who successfully completed six years of physics education at secondary school were regarded as advanced students with task experience, whereas students who attended physics courses at secondary school for three years or less were considered to be novices with limited task experience. A Computer Assisted Instruction (CAI) program was used to give participants a series of twenty questions regarding thermodynamics. While using the CAI, program participants were asked to think aloud. Their responses were later analyzed for metacognitive skillfulness. Results showed that the level of metacognitive skillfulness was significantly higher for advanced subjects relative to novices. This 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 with middle school children. As part of ongoing research at Trinity College, the present study was an extension of the studies by Gonzalez (2016) and Regalado (2017). The current study examined the efficiency of a think-aloud/reflect when prompted online measures in assessing metacognition in comparison to offline measures. Its purpose was to evaluate the correlation between an online measurement of metacognition (think-aloud/reflect when prompted) and academic performance in social studies and success, while playing *The Oregon Trail* computer game (1990 MS-DOS version), to an offline measurement of metacognition (the self-report questionnaire MC5).

This study included qualitative analysis from transcription of the participants' responses corresponding to the steps from Ambrose et al.'s (2010) metacognition model, as well as, quantitative analysis from the choices participants made while playing *The Oregon Trail*.

Based on Akama (2007) and Veenman and Elshout's (1999) findings, I predicted the mean level of metacognition will be higher for experienced players than for novice players. Additionally, based on Akama's (2007) findings and Hillerbrand's (1989) statements about experts, I hypothesized that when comparing online measures with offline measures, there will be a stronger correlation for experienced players than for novice players. This hypothesis is further supported by Veenman and Elshou (1999), who found that metacognitive skillfulness for a particular task increased with the acquisition of expertise showing skillfulness between novice and advanced subjects.

Hypotheses

H1. When comparing online measures with offline measures, there would be a stronger correlation for expert players than for novice players.

H2. Expert players' online measure of metacognition would more strongly correlate with success playing *The Oregon Trail* than the offline measure.

H3. Offline measures would be a stronger predictor of course performance, compared to online measures of metacognition.

H4. Expert players would have a higher mean metacognition than novice players and, therefore, be more successful playing *The Oregon Trail*.

Based on previous research stating metacognition increases with task experience it is proposed that the expert assessment will more closely correlate with offline measures of metacognition since it is a more widely accepted means to measure metacognition. Additionally, it is thought because the MC5 offline measure is a more general and cumulative measure of metacognition that it will correlate with a more general outcome of social studies grades, whereas success in *The Oregon Trail* is more specific, therefore it is more likely to have a stronger correlation with the specific online measure using the game. Furthermore, it is also assumed that expert players online measure of metacognition would be higher than novice players due to increased task experience, therefore, they would have more success playing the game.

Method

***The Oregon Trail* Task**

The online protocol used the 1990 MS-DOS version of *The Oregon Trail* computer game. This computer game was originally created for students to learn about the journey of pioneers during the era of Westward expansion in the United States during the 19th century. Students play as a wagon leader who must overcome obstacles to bring their wagon party safely from Missouri to Oregon. Based on the objectives of the game, it was determined that *The Oregon Trail* was a task that required high levels of metacognition.

Recruitment of Participants

Following the guidelines from Trinity College's Institutional Review Board, consent forms were sent home with the students in order to recruit participants. These consent forms included an overview of our research goals and procedure, as well as a place for guardians to indicate whether or not they would allow their child to participate in the study (see Appendix A).

Participants

The total sample was twenty students from Hartford Magnet Trinity College Academy (HMTCA), a middle school located in Hartford, Connecticut. All 20 participants were 8th graders. Among these participants, 35% identified as male and 65% identified as female.

HMTCA is an interdistrict magnet school in the Hartford metropolitan region. Because magnet schools consist of students across different school districts, these students came from a variety of hometowns. 30% of participants were from Hartford while the remaining 70% were from nine other towns in the region. This group of students was also found to be racially and ethnically diverse, with 35% identifying as White, 25% identifying as Black, 25% identifying as Hispanic, and 15% identifying as Asian.

Measures and Procedures

Offline measure of metacognition: Metacognition 5 (MC5). Naratil, Howe, Reuman, and Anselmi (unpublished, 2013) developed the MC5 for use in previous versions of this study. The MC5 is a self-report survey that measures students' perceived frequency in their use of different metacognitive skills. 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. Students were given the MC5 survey over the course of four days within their respective advisory classes. All four surveys were distributed and collected in December 2017. The MC5 consists of a total of 35 questions with each metacognitive step being assessed by 7 questions (see Appendix B). 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, .894; assess the task, .718; identify strengths and weaknesses, .592; plan, .606; apply strategies and monitor performance, .737; and reflect and adjust, .683.

Online measure of metacognition. The twenty selected 8th graders were each taken out of their US World History class individually for testing sessions in the teachers’ lounge. Each student was tested two separate times. For the first round of testing each student was considered a “novice” who had never played *The Oregon Trail* computer game before, while the second time each student was considered an “expert” after additional experience playing the game. Data was collected from January 2018 to March 2018 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.

Online testing procedures for the novice testing round provided each student with background information, instructions, and a scoring sheet to read before the testing session began (see Appendix C). They were instructed to go over these documents before starting to play the game. After the students looked over the documents they indicated to the researcher that they were ready to start. The researcher then read a pre-determined 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 D). After that, each participant played *The Oregon Trail* for a total of 25 minutes or until all of their wagon members died, and the game automatically ended. A mixture of both the think-aloud and reflect when prompted methods were used as the students were instructed to continually explain why they made decisions as they played. Additionally, they were asked prompting questions at certain points in the game where they explained the reasoning behind their actions (see Appendix E). Following the game-play each student 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 F).

After novice testing was completed, each student was asked to play *The Oregon Trail* a total of six more times on their own before re-testing as an expert. Each student was given a practice sheet to record their extra practice rounds and asked to bring it back for re-testing (see Appendix G). Students were given a date approximately one week after novice testing to be re-tested as an expert.

For the expert testing session students were individually taken out of class again, following the same procedure as the novice testing session, i.e. given the same background, instructions, and scoring sheet to read before the testing session began, they were tested for 25 minutes, and instructed to follow the think-aloud and reflect when prompted protocol. They 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 think-aloud and reflect when prompted methods a standardized coding system was developed. Every time a player reached an obstacle a 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 16 possible options: (1) bad weather; (2) injury; (3) lost; (4) oxen died; (5) oxen injury; (6) river crossing; (7) robbed; (8) run out of food; (9) sick; (10) wagon broke; (11) wagon fire; (12) death; (13) look around; (14) arrived at fort/landmark/gravesite; (15) divide in path; 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 stops there. If the participant does make a decision, then the type of decision they made was categorized into one of 25 possible decisions: (1) ask the researcher a question; (2) attempt to trade; (3) buy supplies at a landmark; (4) change food rations; (5) change pace; (6) check supplies; (7) get more information; (8) go hunting ; (9) look around; (10) did not look around; (11) look at map; (12) refer back to previous experience; (13) refer back to printed instructions/scoring criteria; (14) repaired wagon; (15) river crossing – ford river; (16) river crossing – caulk wagon; (17) river crossing – take ferry; (18) river crossing – wait to see if conditions improve; (19) river crossing – hire an Indian to help; (20) stop to rest; (21) talk to people; (22) divide in path – The Dalles; (23) divide in path – Fort Walla Walla; (24) divide in path – Columbia River; and (25) divide in path – Barlow Toll Road.

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; (3) metacognition present, and elaborate (see Appendix H for coding criteria and examples).

Using this coding system, researchers calculated the mean number of coded events and mean level of metacognition for each participant. The number of coded events and number of coded responses for metacognitive level varied depending on how many obstacles were encountered for each participant and how many could be coded all the way through the four step process for metacognitive levels. Mean number of coded events for novice was 18.40 (SD = 8.63) while mean number of coded events for expert was 27.25 (SD = 12.55). Mean level of metacognition for novice was 2.30 (SD = 0.41) while mean level of metacognition for expert was 2.40 (SD = 0.29).

Success criteria. In order to determine success while playing *The Oregon Trail*, two indicators of success were identified. The first success criterion was distance traveled. It was recorded how far participants made it on the trail within the 25-minute testing session or until all their wagon members died. There was a total of 14 stops along the trail: (1) Independence, Missouri; (2) Fort Kearney; (3) Chimney Rock; (4) Laramie; (5) Independence Rock; (6) South Pass; (7) Fort Bridger; (8) Soda Springs; (9) Fort Hall; (10) Fort Boise; (11) Blue Mountains; (12) Fort Walla Walla; (13) The Dalles; and (14) Oregon City.

Novice players made it an average of 4.5 stops (SD = 2.62), which is between Laramie and Independence Rock, while expert players made it an average of 9.45 stops (SD = 4.78), which is between Fort Hall and Fort Boise along the trail (see Appendix I for full map including each stop on the trail).

The second success criterion was number of surviving wagon members at the end of the 25-minute testing session or until all wagon members died. Participants start with a total of five wagon members so the outcome could range from 0-5. Novice players had an average of 2.70 surviving wagon members (SD = 2.23), while expert players only had an average of 1.05 surviving wagon members (SD = 1.39).

Second quarter grades. As a measure of students' academic performance and success, researchers used second quarter grades from the 8th grade US World History class. Second quarter grades were used because they most closely coincided with *The Oregon Trail* related curriculum on Westward expansion in the United States and the testing dates of the study. The second quarter report cards were given to students in January 2018. The grades were calculated based on a 0-100 scale and also categorized into letter grades ranging from F to A+.

Results

Correlations between Offline and Online Measures of Metacognition

The correlation between the offline measure of metacognition and online novice testing was $r = .33$, $p = .16$. The correlation between the offline measure of metacognition and online expert testing was $r = .13$, $p = .59$. The correlations between the offline and online measures of metacognition do not significantly differ at the novice and expert assessments. The nonsignificant correlations between offline and online measures may indicate that the measures examine different aspects of metacognition; therefore, each measure may be useful for different prediction purposes.

Correlations between Offline and Online Measures of Metacognition and Performance Measures

Table 1 displays correlations between the offline and online measures of metacognition as well as the performance measures of distance traveled while playing *The Oregon Trail*, wagon members survived while playing *The Oregon Trail*, and 8th grade second quarter US World

History grades. The correlations involving online measures and measures of success playing *The Oregon Trail* are nominally stronger than the correlations with the offline measure, but the differences between the correlations are not statistically significant. Contrary to original predictions, online measures were a stronger predictor of course performance than the offline measure. Larger sample size and increased statistical power may provide more reliable results.

Change in Online Metacognition and Game Performance from Novice to Expert Assessment

Table 2 displays descriptive statistics for online metacognition levels, distance traveled, and wagon members survived from novice and expert assessments. There was no significant change in online metacognition from novice to expert assessment, paired sample t(19df) = -1.45, $p = .16$. Novice and expert assessments of metacognition correlated .70, $p = .001$. Players traveled significantly further at the expert assessment than novice assessment, paired sample t(19df) = 4.57, $p < .001$. Distance traveled at the novice assessment correlated .25, $p = .28$, with distance traveled at the expert assessment. Players had fewer wagon members survive at the expert assessment than novice assessment, paired sample t(19df) = -3.12, $p = .006$. The number of wagon members who survived at the novice assessment correlated .21, $p = .38$ with the number of wagon members survived at expert assessment. Distance traveled and number of wagon members who survived correlated .38, $p = .10$, at the novice assessment and .67, $p \leq .001$, at the expert assessment.

Discussion

Previous research in the area of metacognition assessment suggests both offline and online assessments are acceptable ways to measure metacognition. Given this, we expected a relationship between the offline and online measures, specifically a stronger correlation for expert players than for novice players when compared to the offline measure. The correlations between the offline and online measures of metacognition do show a slight positive relationship, but do not significantly differ at the novice and expert assessments. The nonsignificant correlations between offline and online measures may indicate that the two measures are still valid means to measure metacognition but they just examine different aspects of Ambrose et al.'s (2010) model of metacognition. Therefore, each measure may be useful for different prediction purposes, such as academic success or success in a specific task or assignment. Even if both forms of assessment measure different aspects of metacognition and are used for different prediction purposes, both can be acceptable methods to measure metacognitive skills.

The online think-aloud and reflect when prompted measure assessed students' metacognitive behavior in a specific task while playing *The Oregon Trail*, while the MC5 offline survey measure assessed students' beliefs about how frequently these behaviors occurred in the context of a social studies course. Overall, the offline measure of metacognition did not predict success playing *The Oregon Trail* at either assessment occasion, nor did the offline measure of metacognition predict course grades. By contrast, results showed slightly stronger positive correlations for online novice assessment for the two defined criteria for success playing *The Oregon Trail*, as well as a statistically significant positive correlation between online novice assessment and quarter two grades. The online expert assessment of metacognition was a positive predictor of success playing *The Oregon Trail*, as well as, quarter two grades. These findings confirm expectations that expert players' online measure of metacognition will more strongly correlate with success playing *The Oregon Trail* than the offline measure but contradicted the original expectations that the offline MC5 measure would be a better predictor of course performance, compared to online measures of metacognition. This could be because for this specific study the online measure more accurately recorded students' metacognition. The student participants took the offline survey together in a classroom setting where they could have been distracted by their peers and not taken the survey seriously, whereas the online measure was conducted individually so it could have produced more accurate responses pertaining to metacognitive levels.

Lastly, looking at just the online measure from novice to expert assessments, we predicted expert players would have higher mean metacognition than novice players. The results showed no significant difference in mean metacognition for novice versus expert game players. The mean metacognition of both novice and expert players was relatively high with an average score of 2.30 and 2.40, respectively. Although there was a pre-determined general coding outline for scoring student responses to determine metacognition level, the scores being assigned were still ultimately up to the discretion of one researcher. The researcher scoring may have given more high scores for responses than another researcher would have. Additionally, results showed that experts traveled significantly farther than novices, but had fewer survivors overall. Initially, this may seem like the farther participants made it, the fewer wagon members survived, but in reality, because distance traveled was positively correlated with number of surviving wagon members, the expert players that made it the farthest had the most wagon members survive. Looking at just the means misrepresents the results because there was a substantial proportion of expert participants who did not make it very far along the trail before all their wagon members died, ultimately pulling down the average from all the expert participants that made it far along the trail with many surviving wagon members.

While many predicted relationships were found not to be significant, it is important to note that it is surprising to find any significant correlations with a sample size of only 20 participants. At this point, my results show many promising trends but it remains difficult to draw many definite conclusions. A larger sample may increase statistical power and provide more reliable results.

Limitations

As with any study there are always limitations to be discussed. One limitation includes the time spent between novice testing and expert testing sessions. Although all expert re-test dates were scheduled approximately one week after novice testing, the actual time intervals varied. The time that elapsed between novice and expert testing sessions ranged from 7 to 32 days due to circumstances beyond the control of the experimenter, such as snow days, student absences, and scheduled schoolwide events.

Another limitation of this study was the number of practice rounds completed by the students. All participants were asked to complete an additional six practice rounds on their own before re-testing as an expert, playing twice as each occupation, but some students did not do the full six or did more than six. This could have had an impact on metacognitive levels from novice to expert as some students had more or less experience with the task than others.

By design, the criterion for “expert” was six practice rounds. That was determined based on what the researchers thought would be an appropriate amount of extra practice to make an impact on metacognitive levels and give students more experience playing the game. Alternative operational definitions of “expert” might include successfully completing The Oregon Trail several times. The amount of practice time students were willing to put in on their own was also considered in order to try and achieve the most complete participation.

Furthermore, because the participants were being tested at school in the teachers’ lounge there were occasional disruptions in the middle of testing, such as teachers walking in the room, students walking by and knocking on the door to get the attention of their friends being tested, and even a lock down drill. These distractions may have had an impact on how students reported strategy use during online testing.

Lastly, the amount of previous experience with *The Oregon Trail* and computer games in general varied. Some students had indicated they already had minimal previous experience playing *The Oregon Trail* in another class before or had even played the card game version of the game which uses similar game format. Obviously if some students had previous knowledge of the game prior to novice testing that could impact the results and ultimately the difference in mean metacognitive levels of novice versus expert players. Also, the amount of experience students had playing computer-simulated games may also have impacted the present results. Students who play computer games frequently may be able to play *The Oregon Trail* better the first time than someone with no previous computer game experience. This variable was also not taken into account in the current study.

Recommendations for Future Research

The current study only used students from the 8th grade, therefore limiting generalizability beyond this age group. It is possible if the study was conducted with populations of students at other grade levels, the results would change. In the future it would be interesting to test multiple grade levels for offline and online levels of metacognition.

Additionally, the current study only used the computer game *The Oregon Trail* for the online measure to be compared to the offline measure. It would also be interesting to extend the general design of the study to using other computer games.

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Tables

Table 1. Correlations Between Offline and Online Measures of Metacognition and Performance Measures.

Metacognition Measure	Performance Criteria				
	Distance Traveled		Wagon Members Survived		Q2 Grades in SS
	Novice	Expert	Novice	Expert	
Offline (MC5)	.11	.25	.00	-.16	-.03
Online- Novice	.30	--	.36	--	.53*
Online- Expert	--	.50*	--	.42†	.64**

Note. Q2 Grades in SS = Quarter 2 Grades in Social Studies. N = 20. † $p < .10$ *$p \leq .05$ **$p \leq .01$

Table 2. Change in Online Metacognition and Game Performance from Novice to Expert Assessment.

	Online Metacognition		Distance Traveled		Wagon Members Survived	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Novice	2.30	0.41	4.50	2.63	2.70	2.23
Expert	2.40	0.29	9.45	4.78	1.05	1.39

Note. N = 20.

Appendices

Appendix A

HARTFORD MAGNET TRINITY COLLEGE ACADEMY
at The Learning Corridor
Sally A. Biggs, Principal

Dear Parent/Guardian,

As part of the Learning Corridor partnership and our relationship with Trinity College we have been invited to participate in an ongoing research project. Students will be asked about their learning strategies and academic motivation. The study, *Self-Regulated Learning in Middle School*, is designed to measure whether differences in age and gender affect students' motivational beliefs and ways in which students self-regulate their learning in social studies and math.

During the 2nd marking period students will be surveyed about their learning strategies and academic motivation in social studies and math. We anticipate to complete the project in 4-5 sessions (typically 20 minutes each) spread out over the duration of one marking period. Trinity Professors Dina Anselmi and David Reuman will be overseeing the project. The surveys will be conducted by Trinity students under our direct supervision.

In addition to the general experimental design, your child may be asked to join a subset of students who will answer questions related to their thought processes during an educational computer game. The responses will be audio recorded and each recording will be assigned a confidential ID number. Once the responses are transcribed the recordings will be destroyed.

If you have any questions or concerns regarding this exciting opportunity, please feel free to contact one of us and/or Mrs. Biggs (860-695-7201). We look forward to sharing our research results in the spring. Please sign this consent form indicating you have read this letter and agree to have your child participate in this study.

Sincerely, Mr. Ewing, Miss Heller, and Mr. Roarty

Title of Project: *Self-Regulated Learning in Middle School*

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I acknowledge that I have received and read a letter explaining the *Self-Regulated Learning in Middle School* study. I understand that there are no known risks to participants in the study, that my child is 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 investigators.

☐ I grant permission for my son / daughter to participate.

☐ I do not grant permission for my child to participate.

I acknowledge that I have received and read a letter explaining that a specific subset student will be selected within the main *Self-Regulated Learning in Middle School* study and their responses will be audio recorded. I understand that there are no known risks to participants in the study, that my 8^{th} grade child is 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 investigators.

☐ I grant permission for my 8^{th} grade son / daughter to participate in this extension of the main study.

☐ I do not grant permission for my child to participate in this extension of the main study.

Print Your Son's / Daughter's Name	Print Your Name
Your Son's / Daughter's Signature	Your Signature

Appendix B

MC5 questionnaire (day 1, form A):

IMPORTANT QUESTIONS ABOUT **YOUR LEARNING!**

DAY 1
Form 8A
FALL 2017

YOUR NAME ______________________________

BLOCK ______________

1. What is your birth date? (month/date/year)

____

2. What is your sex:

☐ FEMALE ☐ MALE

3. Which of the following groups best describes you?
(You may check more than one group, if appropriate.)

☐ ASIAN OR PACIFIC ISLANDER

☐ HISPANIC, REGARDLESS OF RACE

☐ BLACK / AFRICAN-AMERICAN, NOT OF HISPANIC ORIGIN

☐ WHITE / CAUCASIAN, NOT OF HISPANIC ORIGIN

☐ AMERICAN INDIAN OR ALASKAN NATIVE

4. In what city or town do you live?

____

INSTRUCTIONS: We are interested in what you, as a learner, do when you work on and prepare for assignments or tests as a part of your social studies class.

Please read the following sentences and choose the answer that relates to you and the way you are when doing work for class. Please answer as honestly as possible.

5. When I am given an assignment in my social studies class that asks me to remember a lot of information, I can tell what works best for me to remember everything.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

6. After completing a test or assignment in my social studies class, I think about what went well.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

7. When I have a test coming up in my social studies class, I do most of my studying at the last minute.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

8. I read directions more than once before I start working on a social studies assignment.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

9. I use skills – like taking notes, asking myself questions, and slowing down – when I read for my social studies class.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

10. I know what my strengths are on the work I do in my social studies class.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

11. After I get an assignment back in my social studies class, I try to figure out how I could improve my work for next time.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

12. When I start a social studies assignment 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.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

13. I do not understand the purpose of assignments in my social studies class.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

14. I review my writing for my social studies class before I hand it into the teacher.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

15. I make an effort to examine my weaknesses on the work I do in my social studies class.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

16. I change my ways of completing a social studies assignment when I realize that they are not working.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

17. When I work on a writing assignment in social studies, I immediately start writing without making an outline or a graphic organizer.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

18. I read directions carefully to make sure I understand all the different parts of a social studies assignment.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

19. I ask my social studies teacher for help.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

20. I can tell just how much time it will take me to complete assignments in my social studies class.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

21. When I get a bad grade in my social studies class, I do not study any differently for the next assignment.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

22. When my social studies homework requires specific materials, I remember to bring them home from school.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

23. I understand directions for assignments in my social studies class.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

24. When I read for my social studies class I first focus on headings, bold words, and summaries and then read the material more carefully.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

25. My grades on assignments in my social studies class are different from what I expect them to be.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

26. After completing a test or assignment in my social studies class, I think about what did not work well.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

27. When I have a social studies assignment that will be due more than a week in the future, I start working on it as soon as possible.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

28. I rush through directions to get started on a social studies test as soon as possible.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

29. I compare my most recent grades in my social studies class to my earlier grades to see if I'm improving.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

30. I know what my weaknesses are on the work I do in my social studies class.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

31. When my teacher returns a social studies test, I try to figure out what I didn't understand.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

32. When I have a writing assignment due in social studies, I do most of my work at the last minute.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

33. After I read a social studies assignment, I make sure I know what the main goal of the assignment is.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

34. I use skills – like using flash cards, study guides, and working with a partner – when I prepare for a social studies test.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

35. I make an effort to examine my strengths on the work I do in my social studies class.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

36. When I get teacher comments or corrections on a writing assignment in my social studies class, I don't pay attention to them.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

37. I make a "to do" list before I start working on a social studies assignment.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

38. When I have nearly finished a social studies assignment, I read the directions one last time to make sure I have completed all parts of the assignment.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

39. I turn in tests for my social studies class without checking my answers.

1	2	3	4	5
NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS

40. Compared with other students in my social studies class I expect to do well.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

41. I'm certain I can understand the ideas taught in my social studies class.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

42. I expect to do very well in my social studies class.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

43. Compared to others in my social studies class, I think I'm a good student.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

44. I am sure I can do an excellent job on the problems and tasks assigned for my social studies class.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

45. I think I will receive a good grade in my social studies class.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

46. My study skills are excellent compared with others in my social studies class.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

47. Compared with other students in my social studies class, I think I know a great deal about the subject.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

48. I know I will be able to learn the material for my social studies class.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

49. In general, how useful is what you learn in social studies?

1	2	3	4	5	6	7
NOT AT ALL USEFUL						VERY USEFUL

50. How useful do you think the social studies you are learning will be for what you want to do in the future?

1	2	3	4	5	6	7
NOT AT ALL USEFUL						VERY USEFUL

51. For me, being good at social studies is

1	2	3	4	5	6	7
NOT AT ALL IMPORTANT						VERY IMPORTANT

52. In general, I find working on social studies assignments

1	2	3	4	5	6	7
VERY BORING						VERY INTERESTING

53. Would you take more social studies if you didn't have to?
(Check one answer.)

_______ 1) I very definitely would take more social studies.

_______ 2) I probably would take more social studies.

_______ 3) Maybe I would take more social studies.

_______ 4) I'm not sure.

_______ 5) Maybe, but not that likely.

_______ 6) I probably would not take any more social studies.

_______ 7) I very definitely would not take any more social studies.

54. When I take a social studies test, I think about how poorly I am doing compared with other students.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

55. When I take a social studies test, I think about items on other parts of the test I can't answer.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

56. When I take a social studies test, I think of the consequences of failing.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

57. I have an uneasy, upset feeling when I take a social studies test.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

58. I feel my heart beating fast when I take a social studies test.

1	2	3	4	5	6	7
NOT AT ALL TRUE OF ME						VERY TRUE OF ME

Appendix C

The Oregon Trail

In this game you will take on the role of the pioneers as they venture to Oregon. You will travel along the trail while encountering countless obstacles. Your goal is to get to Oregon with all of your family members alive and healthy while also maintaining left over possessions from your journey.

Instructions

First, you will choose an occupation:
-You can be a banker from Boston starting with $1600 to buy supplies
-You can be a carpenter from Ohio with $800
-You can be a farmer from Illinois with $400

Next, you will choose a month to leave.

Finally, you will use Matt's General Store to buy supplies for your journey.

At any point during the game you can select "size up the situation" where you can:
1. Continue on the trail
2. Check your supplies
3. Look at the map
4. Change your pace- choose from a steady pace, a strenuous pace, or a grueling pace
5. Change food rations- choose from filling, meager, or bare bones
6. Stop to rest- chose how many days you want to rest for
7. Attempt to trade- you will be given options that you can accept or decline
8. Talk to people- they may provide advice on how to move forward successfully
9. Hunt for food- using the bullets you buy you can hunt for food
10. Sometimes buy more supplies depending on where you are stopped

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

Points

Points are based on:

(1) Profession- points stay the same for a banker, double for a carpenter and triple for a farmer at the end of the game
(2) The number of surviving family members
(3) The health of surviving family members (family members in better health receive more points)
(4) Remaining possessions, including cash

Appendix D

Instructions for the student/participant:

"We want to understand how you make decisions when playing THE OREGON TRAIL 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 <u>do not</u> 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 E

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? ________________________ (PLANING/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 month did you choose to leave? _______________ (PLANNING/REFLECT & ADJUST?)

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

   b.) What are some disadvantages of leaving that month? (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 student about why they bought the items they bought (ammunition, clothing, spare parts, food, oxen; example, may buy a lot of oxen 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 student saved some money – *"Why did you decide to save some of your money?"*** (PLANNING/APPLY STRATEGIES)

6) *During a **River Crossing*** – make sure to ask the student **why** they chose the action that they decided on. (ford, caulk, ask a Native American for help, take the ferry, wait) (APPLY STRATEGIES & MONITOR PERFORMANCE/ REFLECT & ADJUST)

7) When **A WAGON MEMBER GETS SICK OR INJURED-** make sure to ask the student 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 student 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 student 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 SUPPLIES-** ask them why (PLANNING/REFLECT & ADJUST)

16) When they **SIZE UP THE SITUATION-** ask them why (PLANNING)

17) When they decide to **BUY SUPPLIES AT A LANDMARK-** ask them why (PLANNING/REFLECT & ADJUST)

18) When they decide to **TALK TO PEOPLE-** ask them why (PLANNING)

Appendix F

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

YES NO

21) 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)

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

Appendix G

Name: ______________________________

The Oregon Trail Extra Practice

Instructions: Play The Oregon Trail computer game on your own using the link https://classicreload.com/oregon-trail.html or on another online website a total of six more times (two times as each occupation). These do not have to be played all at once or in this order, they just need to all be played at some point before re-testing. Please record what happened while playing each round below and bring this paper back with you for your re-test on _____________________________.

Round 1 Date: _____________
Occupation: Banker
How long did you play for (minutes): __________
Did you make it to Oregon (circle one): Yes No
How many people survived (circle one): 0 1 2 3 4 5

Round 2 Date: _______
Occupation: Banker
How long did you play for (minutes): __________
Did you make it to Oregon (circle one): Yes No
How many people survived (circle one): 0 1 2 3 4 5

Round 3 Date: _______
Occupation: Carpenter
How long did you play for (minutes): __________
Did you make it to Oregon (circle one): Yes No
How many people survived (circle one): 0 1 2 3 4 5

Round 4 Date: _______
Occupation: Carpenter
How long did you play for (minutes): __________
Did you make it to Oregon (circle one): Yes No
How many people survived (circle one): 0 1 2 3 4 5

Round 5 Date: _______
Occupation: Farmer
How long did you play for (minutes): __________
Did you make it to Oregon (circle one): Yes No
How many people survived (circle one): 0 1 2 3 4 5

Round 6 Date: _______
Occupation: Farmer
How long did you play for (minutes): __________
Did you make it to Oregon (circle one): Yes No
How many people survived (circle one): 0 1 2 3 4 5

Appendix H

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."
- "No I don't want to look at a gravesite, that's weird."

Example responses of 1:

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

Example responses of 2:

- "I chose to look around just 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:

- "I'm going to change my food rations because I feel like they're eating too much and it's like a whole bunch of wasting food, and since I'm like really bad at the hunting game I can't really get anything so...I'm just going to like make it meager so they're not eating too much."
- "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 dysentery 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 wagon this time."

Appendix I


Map of the
Oregon Trail
OREGON
CITY
FORT WALLA WALLA
FINISH
THE DALLES
BLUE
MOUNTAINS
FORT BOISE
FORT HALL
SODA SPRINGS
INDEPENDENCE ROCK
SOUTH PASS
LARAMIE
CHIMNEY ROCK
FORT BRIDGER
START
INDEPENDENCE
FORTS
LANDMARKS
YOUR ROUTE
RIVERS
MOUNTAINS
Press SPACE BAR to continue