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Self-regulated Learning (SRL) Microanalysis for Mathematical Problem Solving: a Comparison of a SRL Event Measure, Questionnaires, and a Teacher Rating Scale

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by

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ABSTRACT

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The current dissertation examined the validity of a context-specific assessment tool, called Self-regulated learning (SRL) microanalysis, for measuring self-regulated learning (SRL) during mathematical problem solving. SRL microanalysis is a structured interview that entails assessing respondents' regulatory processes as they engage with a task of interest.

Participants for this dissertation consisted of 83 eighth grade students attending a large urban school district in Midwestern USA. Students were administered the SRL microanalytic interview while completing a set of mathematical word problems to provide a measure of their real-time thoughts and regulatory behaviors. The SRL microanalytic interview targeted the SRL processes of goal-setting, strategic planning, strategy use, metacognitive monitoring, attributions, and adaptive inferences. In addition, students completed two questionnaires measuring SRL strategy use, and one questionnaire measuring self-esteem. The participant's mathematics teacher completed a teacher rating scale of SRL for each participant. Mathematical skill was measured with three measures including a three item measure of mathematical problem solving skill completed during the SRL microanalytic interview, a fifteen item posttest of mathematical problem solving skill completed two weeks after the SRL microanalytic interview, and a standardized test of mathematics skill.

The primary objectives of this dissertation were to compare the newly developed SRL microanalytic interview to more traditional measures of SRL including two self-report questionnaires measuring adaptive and maladaptive SRL and a teacher rating scale of SRL. In addition, the current dissertation examined whether SRL microanalysis would diverge from a theoretically unrelated construct such as self-esteem. Finally, the primary interest of the current dissertation was to examine the relative predictive validity of SRL microanalysis and SRL questionnaires. The predictive validity was compared across three related but distinct mathematics outcomes including a short set of mathematical problem solving items, a more comprehensive posttest of MPS problem solving skill, and performance on a standardized mathematics test.

The results of this study revealed that SRL microanalysis did not relate to self-report questionnaires measuring adaptive or maladaptive SRL or teacher ratings of SRL. The SRL microanalytic interview diverged from the theoretically unrelated measure of self-esteem. Finally, after controlling for prior achievement and SRL questionnaires, the SRL microanalytic interview explained a significant amount of unique variation for all three mathematics outcomes. Furthermore, the SRL microanalytic protocol emerged as a superior predictor of all three mathematics outcomes compared to SRL questionnaires.

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Chapter 1: Introduction

Although a number of personal (e.g., aptitude, disabilities, or engagement) and environmental (e.g., school funding problems, socio-economic disadvantages, high rates of mobility, or teacher quality) factors have been identified as contributors to academic achievement, researchers in many fields have identified self-regulated learning (SRL) as a critical determinant of student success (DeCorte, Mason, Depaepe, & Verschaffel, 2011; Eccles & Wigfield, 2002; Fuchs & Fuchs, 2003; Schunk & Swartz, 1993a). In general, SRL has been defined as a variety of processes and beliefs that an individual can engage to optimize their behavior, motivation, and cognitions in relation to a task (Bandura, 1986; Zimmerman, 2000). In academic contexts, a vast literature base demonstrates a strong connection between SRL and a myriad of academic outcomes, such as reading comprehension, writing, and math-problem solving (Fuchs & Fuchs, 2003; Graham & Harris, 2005; Guthrie & Wigfield, 2000). Furthermore, intervention programs that consistently enhance student regulatory functioning, academic achievement, and learning have been developed in the past decade (Butler, Beckingham, & Lauscher, 2005; Cleary & Zimmerman, 2004; Glaser & Brunstein, 2007).

From an educator's or school-based practitioner's point of view, SRL is critical for many reasons beyond the established link between SRL and academic outcomes and the proliferation of SRL interventions. For example, as many as 25% of students referred for special education evaluations have underlying regulatory or motivation deficiencies. In addition, both teachers and school psychologists have identified the assessment of SRL as a key area of professional development training need and interest (Cleary, 2009; Cleary, Gubi, & Prescott, 2010). Researchers have echoed this sentiment with a recent emphasis on the development of new assessment methodologies that more adequately reflect contemporary views of SRL as a context-specific and dynamic construct which occurs in relation to specific events in time.

Although some new measurement methodologies have emerged, a great deal of research is needed to explore their utility for measuring SRL during authentic academic activities (Winne & Perry, 2000; Zimmerman, 2008). There is a particular need to examine the utility of a semi-structured interview called SRL microanalysis in academic domains (Zimmerman, 2008). Another emergent area of need in the SRL research literature is comparing traditional measures of SRL, such as questionnaires with more contemporary measures, such as behavioral traces, think alouds, and SRL microanalysis to identify the most effective and valid methods for measuring SRL (Winne & Jamieson-Noel, 2002; Zimmerman, 2008).

Self-regulation defined

Stated simply, self-regulation, also known as *self-regulated learning* (SRL) when applied to learning or academic contexts, is conceptualized as a cyclical process wherein individuals enact a variety of sub-processes (e.g., goal-setting, planning, task- and regulatory strategies, and reflection) to control, monitor, and regulate their cognitions, motivation, and behavior while engaged with a task (Bandura, 1986; Zimmerman, 2000). The construct of SRL entails a diverse set of related processes, such as self-efficacy, goal-setting, strategy use, and attributions, each of which have been examined and supported by a rich research base.

Many theorists believe that SRL is best understood as a set of inter-connected processes that operate in a recursive or cyclical fashion (Ames & Archer, 1988; Pintrich, 2000; Zimmerman & Schunk, 2011). For example, Zimmerman (2000) defined SRL in terms of a cyclical loop, characterized by three related, yet distinct phases of forethought, performance control, and self-reflection. In the *forethought* phase, an individual employs distinct processes before engaging in an academic task, such as setting goals and developing strategic plans. During performance or learning, also known as the *performance control phase*, individuals employ specific behaviors and strategies to optimize their learning and to keep track of their performance progress (e.g., use of strategies and self-monitoring). Finally, regulated individuals also engage in a systematic process of *self-reflection* whereby a number of sub-processes are enlisted such as self-evaluation, causal attributions, and or adaptive or reactive inferences (Zimmerman, 2000). This cycle is described as a feedback loop because the processes of each phase (forethought, performance, and reflection) exert an influence on the subsequent phases such that forethought processes impact subsequent performance control processes, which in turn, influence reflection. The cycle is considered complete when self-reflection processes influence forethought (Zimmerman, 2000).

Linking SRL and Mathematical Problem Solving

Mathematics is a multi-faceted academic domain that includes several important components such as completion of computations or knowledge of mathematical terminology, concepts, and mathematical operations. Computation refers to the processes involved in the actual solving of a mathematical problem (Rutherford-Becker & Vanderwood, 2009). Mathematical knowledge can refer to awareness of formulas, multi-step procedures, or understandings of underlying mathematical theory. Although educators can and often do isolate these aspects of mathematics for various tasks, in other cases, such as mathematical problem solving (MPS), students must synthesize their mathematical knowledge and computational skills to solve a mathematical problem.

Mathematics problem-solving (MPS), the academic task of interest in the proposed dissertation project, is among the most essential, yet complex facets of mathematics. Problem solving skills are an important area for study because it requires many mathematical skills, is highly related to general mathematical achievement (Bryant, Bryant, & Hammill, 2000; Geary, 2003; Lewis, 1989) and is considered the basis for developing critical thinking skills (Baroody, 2003; Hiebert & Wearne, 1993; NCTM, 2000). Furthermore, problem solving is a difficult skill for students to master because it requires a fluid synthesis of many core mathematics and general academic skills such as: reading, translating language into mathematical terms, and the mathematical knowledge and computation skills described previously (Bednarz & Janvier, 1996; Martin & Bassok, 2005).

Although SRL is related to many academic tasks, (MPS) was selected as the academic area of focus for the current study for several reasons. First of all, prior research has established a strong link between SRL and more effective problem solving. For example, regulated learners who strategically apply cognitive, metacognitive, resource, and task-specific strategies as well as set quality goals, plan, self-monitor, reflect, and adapt their approach throughout the problem solving process, tend to out-perform their less strategic peers (see Table 2.2) (Efklides, Kourkoulou, Mitsiou, & Ziliaskopoulou, 2006; Lucangeli & Cabrele, 2006; Montague, 2008;). Moreover, MPS was selected because current mathematical research suggests a need for measures similar to SRL microanalysis to aid educational professionals. Finally, minimal research has extended the SRL microanalytic measurement methodology to academic tasks, with no study (to the author's knowledge) applying SRL microanalysis to mathematics.

Measurement of SRL

Overview of SRL Measurement

Over the past couple of decades, SRL has been studied using a variety of measures, such as self-report questionnaires, (Pintrich, Smith, Garcia, & McKeachie, 1993) structured interviews, (Zimmerman & Martinez-Pons, 1988) teacher rating scales, (Cleary & Callan, 2013; Zimmerman & Martinez-Pons, 1986) behavior traces (Winne & Perry, 2000), direct observations (Corno, 2001), diaries (Randi & Corno, 1997), think-alouds (Azevedo,Greene, & Moos, 2007; Perry, 1998; Perry & Winne, 2006), and SRL microanalysis (Cleary & Zimmerman, 2001; Cleary, Zimmerman, & Keating, 2006; DiBendetto & Zimmerman, 2010; Kitsantas & Zimmerman, 2002).

In general, most SRL measures can be categorized into two major measurement classes, a*ptitude measures* or *event measures* (Winne & Perry, 2000). Although there are commonalities amongst these assessment classes, there is also great variation across and within each of these categories. In the following sections, the author will review aptitude measures and event measures, providing examples of each measurement class to illustrate key features, differences, strengths, and weaknesses of each measurement classification.

Aptitude measures**.** Aptitude measures come in many formats, but most commonly take the form of self-report questionnaires and teacher ratings. Self-report questionnaires have been particularly popular in SRL research and in educational practice while teacher rating scales have received respectively less attention. The popularity of self-report questionnaires is largely attributed to their relative ease of administration and scoring, their efficiency in terms of time and financial resources, and the wide availability of questionnaire measures (Jamieson-Noel & Winne, 2003; Pintrich et al., 1991;). On the other hand, teacher rating scales have received relatively less attention in the SRL literature, but some initial research suggests that teachers' ratings of student SRL are highly predictive of future achievement and may more accurately depict actual student regulation (Cleary & Callan, 2013; Dibendetto & Zimmerman, 2013).

A key feature of aptitude measurements, like self-reports, is that they tend to measure SRL as a global ability (aptitude) by relying on averaged or "aggregated" scores across several items that often target multiple events or heterogeneous instances of regulation. For example, most questionnaires or teacher rating scales require respondents to provide ratings to a number of statements that describe a single regulatory construct (e.g., a regulatory belief or behavior) across various tasks, academic domains, or contexts (Winne & Perry, 2000). For example, a questionnaire measuring the use of a specific SRL strategy such as "elaboration" may ask students to rate how often they elaborate in a number of slightly different contexts (e.g., taking notes, studying for an exam, doing homework, etc…). These ratings would then be averaged yielding a composite score that describes a student's general use of elaboration. Statistically speaking, this process is often considered advantageous since it enables an examination of the internal consistency of scales and subscales.

The interpretation of these aggregated scale scores is problematic because of the tendency to render SRL as a dispositional or global trait of an individual, rather than the multi-component process that is described in contemporary SRL theories. Moreover, recent research suggests that SRL is best understood as a dynamic process that adapts over time and is influenced by contextual factors (Cleary & Chen, 2009; Hadwin, Winne, Stockley, Nesbit, & Woszczyna, 2001; Lodewyk, Winne, & Jamieson-Noel, 2009; Urdan & Midgley, 2003). That is, individuals employ different SRL processes for different tasks and thus, the composite scores derived from aptitude measures may have little relevance to any one task (Hadwin et al., 2001; Lodewyk et al., 2009). The interpretation of SRL aptitude measurement is also problematic because these aggregated composite scores often lack a clear connection to particular instructional practices.

Among the many different types of aptitude measures, self-report questionnaires in particular have received criticism in recent years because respondents are required to report their behaviors, cognitions, or beliefs retrospectively (Dyson, 2003; Gresham, MacMillan, Beebe-Frankenberger, & Bocian, 2000; Heath & Glen, 2005; Schacter, 1999; Stone & May, 2002; Zimmerman, 2008). This is problematic given the large body of evidence that illuminates the fallibility of memory for one's own behaviors or cognitions. For example, research has depicted that questionnaires measuring SRL are often inconsistent with direct observations of how students actually regulate their thoughts and behaviors (Jamieson-Noel & Winne, 2003; Winne & Jamieson-Noel, 2002; Winne & Perry, 2000; Winne, 2010).

In response to these criticisms, researchers have developed and refined a variety of alternative assessment approaches (event measures) over the past decade that are better equipped than questionnaires to measure SRL as a dynamic, contextualized process. A few of the more common approaches include behavior traces, think-alouds (verbal protocols), direct observations, and SRL microanalysis (semi-structured interview).

Event measures. Event measures, the other major class of SRL assessments, differ from the more traditional aptitude questionnaires because the former tend to be more context-specific, fine grained, and are directly linked with behaviors or regulatory processes as they occur in real-time during relevant tasks (Gordon & Feldman, 2008; Stiles, Leiman, Shapiro, Hardy, Barkham, Detert, Llwwelyn, 2006; Winne & Perry, 2000; Zimmerman, 2008). An important characteristic of most event measures is that they are designed to capture SRL at select moments, in particular situations, or in relation to a single task (Winne & Perry, 2000). When measuring SRL as an event, for example, one might be interested *exclusively* in a student's SRL processes while solving mathematical problems, but not how that student prepares for a math exam because these two tasks entail very different contexts and demands.

Although the term “event measure” describes a category of related measures that share the above characteristics, there is a considerable amount of variation among these approaches. For example, one type of event measure, *behavior traces,* analyzes the observable artifacts left behind from studying behaviors such as highlighted text or instances of note taking that indicate the engagement in SRL processes (Winne & Perry, 2000). In contrast to behavior traces, *think aloud protocols* involve asking students to report their real-time cognitions while performing a task (Ericsson & Simon, 1980), such as when a student is asked to describe their thoughts and approaches to solving a mathematical problem. This dissertation describes a semi-structured interview, event measure known as SRL microanalysis.

SRL microanalysis. The primary focus of this dissertation project is a type of contextualized self-report measure known as SRL microanalysis. This measure adheres to a structured interview format involving the administration of context-specific SRL questions at specific points during task completion. SRL microanalytic protocols elicit information about students’ forethought, performance, and self-reflection phase regulatory processes while they are engaged in a narrowly defined task (Cleary, 2011).

Although SRL microanalytic protocols and aptitude questionnaires are technically both forms of self-report measure (i.e., students provide responses to specific questions or statements), they are quite different. Unlike questionnaires, SRL microanalytic protocols are customized around specific contexts and tasks (rather than global or general items), attempt to measure SRL processes as they unfold in real time (rather than retrospective student accounts), tend to rely on open-ended questions (rather than exclusively Likert scale items), and often use highly specific, single item measures to capture well-defined sub-processes of the SRL cyclical feedback loop (as opposed to multi-item subscales) (Cleary, 2011). SRL microanalytic protocols are also distinct from all other SRL measures because they are grounded theoretically in the three-phase cyclical model of SRL (see chapter two for more details) and attempt to directly examine the cognitive and metacognitive dimensions of SRL in a highly systematic and structured manner. The key features of SRL microanalysis are outlined below.

Core features of SRL microanalysis. SRL microanalytic protocols can be differentiated from all other SRL measurement forms by a number of features. First, it is important to understand that SRL microanalystic protocols are designed to capture the cyclical phase processes described in the three-phase model of SRL described by Zimmerman (2000). SRL microanalysis is closely linked with the three-phase model of SRL (Zimmerman, 2000) in that the processes to be measured are selected directly from the three-phase model and the question phrasing is derived from the definitions found in the model. Microanalytic question administration is also temporally linked with the three-phase model. For example, items measuring *forethought* processes (goal-setting, planning) are administered before task engagement, when forethought processes are most salient.

Although a more thorough description of SRL microanalysis will be provided in chapter two, some of the core components will be highlighted briefly (1) individualized administration, (2) selection of target SRL processes from Zimmerman's model of SRL, (3) task-specific questions targeting SRL as a context specific construct, (4) temporal sequencing of SRL microanalytic questions, and (5) verbatim recording and coding of participants' responses.

First, SRL microanalysis is administered to one examinee individually to control for social and normative influences. Second, constructs are selected from the three-phase model of

SRL (Zimmerman, 2000) and the respective microanalytic questions are developed directly from the operational definitions found within the SRL literature (Bandura, 1997; 2000). The three-phase model of SRL is grounded in social-cognitive theory, which assumes variation in SRL processes across contextual factors. Therefore, a third and related point is that SRL microanalytic questions are designed to measure SRL in relation to a specific task for which the context is known (Cleary, 2011). Due to the contextualized focus of social-cognitive theory and because SRL has been shown to often vary across contexts and tasks (Hadwin et al., 2001), SRL microanalytic protocols are comprised of several highly focused and independent items, most of which target a single SRL process individually.

A fourth point is that SRL microanalytic protocols also link the administration of the questions during the task (before the task, during the task, after the task) with the temporal properties of the three-phase model (forethought, performance, and self-reflection; Cleary, 2011). For example, microanalytic items measuring forethought processes will be administered before an individual engages with a task, when the forethought processes are most salient. By mapping item administration onto the three-phase model (i.e., administering forethought SRL questions before performance), researchers are able to make interpretations about theoretically-linked regulatory processes in relation to task performance.

Rationale of the Study

There is emerging evidence that SRL microanalytic protocols demonstrate strong psychometric properties for motoric tasks such as serving a volley ball, dart throwing, or shooting a basketball free-throw. Across such tasks, SRL microanalytic protocols have been shown to differentiate high and low achievers and predict future achievement (Cleary & Zimmerman, 2001; Cleary, Zimmerman, & Keating, 2006; Kitsantas & Zimmerman, 2002).

Since many SRL microanalytic measures consist of single items, reliability is most often calculated in terms of inter-rater reliability. Several studies have shown that SRL microanalytic measures display acceptable reliability (Cleary, Callan, & Zimmerman, 2012; Cleary & Zimmerman, 2001; Cleary et al., 2006; Kitsantas & Zimmerman, 2002).

In academic settings, the use of SRL microanalytic protocols has been sparse. For example, DiBenedetto and Zimmerman (2010) used this assessment approach to differentiate high achievers from low achievers in high school in terms of the quality of strategic plans when studying a text passage, the use of strategies during performance (e.g., the frequency of self-monitoring), and the nature of student self-reflections (e.g., attributions). Another application of SRL microanalysis with college students, showed that self-reflection processes measured with microanalytic measures were a key predictor of student success in school (Cleary, Callan, Peterson, & Adams, 2011). These studies aside, there is very minimal support for the use of SRL microanalytic assessment methodology in academic contexts, with no studies targeting mathematic skills. Thus, there is a need to advance our understanding of the applicability and validity of infusing SRL microanalysis into academic tasks such as mathematical problem solving.

As indicated previously, SRL and mathematics problem-solving skills are very much linked; however, very few studies have examined SRL during mathematics problem-solving. This study will attempt to examine what mathematics educators have been encouraging from researchers by examining the types of strategies that students employ during mathematics tasks as well as *how* students select, apply, and adapt specific strategies and SRL processes to meet task demands (Fuchs & Fuchs, 2003; Pape, Bel, & Yetkin, 2003; Resnick, 1988). From the author’s perspective, and that of other researchers, to more validly measure this dynamic process, researchers need to use event-related measures, such as SRL microanalysis, that are more sensitive to the specific characteristics and features of specific academic tasks or activities (De Corte, Verschaffel, & Eynde, 2000; Winne & Perry, 2000; Zimmerman, 2008). Although researchers have suggested that event-based assessment tools may be more adequate for measuring SRL as a contextualized process, minimal research directly compares the utility of different SRL assessment approaches. Given that self-report questionnaires continue to be the most widely used form of SRL measurement, and that there is emerging evidence for the utility of SRL event measures, it is of particular interest to determine how SRL questionnaires, teacher ratings, and event measures relate to one another and if SRL microanalysis predicts unique variation in academic tasks. The current dissertation addresses this research need by examining the validity of SRL microanalysis relative to more traditional questionnaire assessment tools.

The validation of SRL microanalytic protocols is also of importance because this assessment procedure is highly applicable to recent service delivery changes in the field of education. In recent years, the service delivery models used in schools tend to rely on a process-oriented assessment and intervention framework whereby educators rely on contextualized forms of assessment, such as functional behavior assessment, direct observations, and curriculum-based measurement, to identify students who struggle in school and ways to most effectively help them. This model advocates for continuous assessment to measure changes in student functioning as a result of intervention services or pedagogical adaptations (Bergan, Curry, Currin, Haberman, & Nicholson, 1973; Deno, 1985; Fuchs & Fuchs, 2006; Reschley, 2008). Microanalysis fits exceptionally well with this emerging model because it is context specific, more sensitive to very fine changes in SRL and thus is optimal for tracking intervention progress (Cleary, 2011; Cleary et al., 2008; Cleary & Zimmerman, 2004). Although this dissertation topic does not address the issue of how to use SRL microanalysis in terms of service delivery in school, it can bridge the academic gap in microanalytic research by determining the predictive and concurrent validity of SRL microanalysis for a problem solving task.

Purposes

Given the recent emphasis placed on SRL as a contextualized, dynamic process, there is a clear need, particularly in academic contexts, to develop measures capable of assessing SRL as a context-specific construct that occurs in real-time on specific tasks. Furthermore, research is needed to better understand which measures may be most effective for predicting achievement across a range of academic outcomes and whether there is convergence and divergence across different measurement tools. These emergent issues in the SRL literature are addressed in part by this study. Moreover, this study examines the predictive validity of a SRL microanalytic protocol in relation to MPS skill. Since very little research has explored whether event based measures can effective predictive more global, distal outcomes, this study will also explore whether SRL microanalysis displays predictive validity for general mathematical achievement outcomes.

For this study, a SRL microanalytic protocol was designed for the purpose of measuring students' SRL while they prepare for, complete, and reflect on a set of mathematical problem solving items. In doing so, several specific research objectives are addressed regarding the relationships between SRL microanalysis and more traditional measures of SRL and the predictive validity of SRL microanalysis as it relates to mathematical problem solving and more global mathematics skill. Specific research questions are addressed below:

(1) This study examined whether SRL microanalytic measurement converges with SRL questionnaires and teacher ratings that were designed to measure students' strategy use in the context of their mathematics class.

(2) In addition, this study examines if SRL microanalytic measurement diverges from theoretically unrelated constructs such as self-esteem.

(3) Finally, this study examines the predictive validity of SRL microanalytic protocol in relation to SRL questionnaires and prior achievement to determine if SRL microanalysis explains unique variation in students' achievement in MPS tasks and more general mathematics achievement (i.e., standardized test performance).

Chapter Two - Literature Review

Introduction

Over the past forty years, there has been a great deal of interest in SRL from both researchers and educational professionals (Boekaerts, Zeidner, & Pintrich, 2000; Butler, 1998; Clark, Gong, & Kaciroti, 2001; Kolovelonis, Goudas, & Dermitzaki, 2010). Self-regulated learning (SRL) research in academic settings has addressed several issues including the examination of achievement group differences in SRL processes and contextual factors that promote SRL (DiBendetto & Zimmerman, 2010; Perry & VandeKamp, 2000), development of intervention programs designed to teach or remediate regulatory skills (Butler et al., 2005; Cleary, Platten, & Nelson, 2008; Glaser & Brunstein, 2007), and even initiatives to improve the regulation of teachers (Bolhuis & Voten, 2001; Cardelle-Elawar et al., 2007; De la Fuente & Justicia, 2007). Of particular interest in recent years, however, has been the development of different types of assessment tools capable of measuring SRL (Boekaearts & Corno; 2005; Noell & Gansle, 2009).

Overview of Chapter

In this chapter, the author will address the key constructs and concepts related to this dissertation project. First, a definition of SRL and description of a comprehensive model of SRL based on a social cognitive perspective will be presented. The SRL processes of greatest pertinence to the current study will be highlighted and expanded upon. In doing so, a framework is provided to illustrate why SRL constructs such as goal setting, strategic planning, strategy use, metacognitive monitoring, causal attributions, and adaptive inferences are of exceptional importance for academic endeavors. Given that this dissertation will focus specifically on the measurement of SRL during MPS, the author will also explore the connection between SRL and mathematics. Furthermore, the author will highlight the importance of mathematics competence for students' academic and professional future, describe the skills necessary for effective problem solving, and how primary SRL processes are involved in problem solving. Finally, a major focus of this chapter will center on several important issues related to SRL assessment tools. In addition to providing an overview of a broad array of assessment tools for measuring SRL and the specific characteristics and features of SRL microanalysis, the author will conduct an analysis of how SRL microanalysis compares to several questionnaire and teacher report measures.

Self-Regulated Learning Defined

There are several theoretical models of academic SRL including social cognitive theory (Zimmerman, 2000), process-oriented model of metacognition (Pintrich, 1989), four-stage information processing model of SRL (Winne & Hadwin, 1998), and adaptable learning (Boekaerts & Niemivirta, 2000). While a great deal of diversity can be found from one perspective to another, there are a number of areas of overlap amongst core characteristics of the most popular theoretical perspectives (Mace, Belfiore, & Hutchinson, 2001; Weinstein, Husman, & Dierking, 2000; Puustinen & Pulkkinen, 2001). For example, many theorists agree that self-regulation is a cyclical process (Boekaerts & Niemivirta, 2000; Puustinen & Pulkkinen, 2001; Winne & Hadwin, 1998; Zimmerman, 2000) and that highly regulated students are those who actively engage in learning by means of multiple processes that optimize thoughts, feelings, and actions. Researchers also typically agree that standards and goals are used as benchmarks that direct learning and behavior. Finally most agree that SRL is influenced by a host of biological, contextual, developmental, and individual factors (Boekaerts & Corno, 2005).

Although every theoretical perspective entails strengths and weaknesses and the author does not posit that any one perspective should be considered superior to another for all purposes, the current study is conceptualized from a social cognitive perspective (SCT). From this account, SRL is understood as a process of self-generated thoughts, feelings, and behaviors that are strategically and continuously adapted to enhance performance and attainment of self-set goals (Zimmerman, 1989). Self-regulated learners actively employ cognitive, metacognitive, and behavioral processes in a strategic and proactive manner to optimize outcomes or may also respond reactively to adjust when encountering challenges (Bandura, 1986; Pintrich, 2000; Zimmerman, 2000). From a SCT perspective, specific SRL processes are organized within three broad phases (forethought, performance, and reflection) that operate in a cyclical fashion (Zimmerman, 2000). Before delving further into the specific characteristics and sub-processes of the three-phase cyclical model, the author will briefly review the broader SCT from which cyclical SRL was conceived.

Social Cognitive Theory and SRL

The roots of social cognitive theory (SCT) are most often recognized with the work of Albert Bandura in the 1970's (Evans, 1989) and were more fully solidified in the 1980's (Bandura, 1986). When SCT first emerged, it evidenced drastic differences from the behavioral and information processing schools of psychology that reigned superior at that time. Prior to the introduction of SCT, most psychological theories supported a unidirectional understanding of causation (Bandura, 1986; Evans, 1989). In other words, many believed that human behavior was the result of a single entity, such as the behavioral psychology explanation that actions arose as a result of the association between stimulus and response (Skinner, 1938; Watson, 1913), whereas information processing theorists were primarily concerned with internal cognitive processes (Luszyczynska & Schwarzer, 2005; Neisser, 1967). SCT can be distinguished from these theories across many assumptions. Some of the most pertinent differences in core assumptions include a triadic reciprocal understanding of causation, context-specificity, and the personal-agency of human behavior.

A core element of SCT and characteristic that distinguishes SCT from most other theories is a more inclusive theory of causation known as *triadic reciprocal determinism* (Bandura, 1986; Evans, 1989). Triadic reciprocal determinism indicates that behavior, cognition (and other personal factors), and the environment bi-directionally interact as determinants of human behavior such that each factor can simultaneously influence and be influenced by the other factors (Bandura, 1986). That is, behavior can affect cognition while behavior is reciprocally affected by cognition, or behavior can be influenced by cognitions that have been influenced by past behavior. Each factor does not necessarily influence the other factors simultaneously, the relationships among these three factors may not be equal in strength, and these factors need not occur concurrently to influence each other (Bandura, 1986; Bandura, 1989; Luszyczynska & Schwarzer, 2005).

The triadic reciprocal relationship between person, behavior, and environment is of importance for SCT, but regardless of the interaction amongst these factors, the mere inclusion of environmental causal factors is fundamental to SCT. That is, in comparison to many other major psychological frameworks, SCT is unique by its recognition that the environment in which an individual operates has a powerful impact on his/her thoughts and behaviors (Bandura, 1986). This environmental sensitivity, often referred to as "context-specificity," is a recognition that although an individual may possess a range of specific "*competencies"* (i.e., developed skills such as social skills), those competencies do not exist within a vacuum. Instead, the physical or social environment, the type of task, or even features of that task (e.g., difficulty) often influence the proficiency with which one applies these competencies or whether he/she chooses to apply them at all (Bandura, 1986). The context-specific nature of SCT has particularly important implications for SRL. When conceptualizing SRL from a SCT perspective, SRL should not be misconstrued as an exclusively global or trait-like construct of a person. Rather it may be best to recognize that SRL is comprised of both averaged competencies and context-specific application of those competencies (Bandura, 1986). That is, through a number of processes, individuals may acquire different skill sets, but may not always effectively or consistently apply them (Bandura, 1986).

Likewise, since the turn of the millennium, many researchers have strongly advocated the context-specific nature of SRL. Research supports this notion in that the types of strategies or regulatory processes that one employs often varies from one task to another and SRL tends to develop and adapt over time (Hadwin, Winne, Stockley, Nesbit, & Woszczyna, 2001; Pintrich, 2000; Urdan & Midgley, 2003; Zimmerman, 2000). Also, contextual factors such as the demand of a task in relation to one's skill level may determine the extent that students engage strategically or if they even have to at all (Cleary & Chen, 2009). The data supporting the context-specificity of SRL has become very difficult to ignore and as will be discussed in more detail shortly, this notion has been central to a more recent re-conceptualization of SRL measurement procedures (Boekaerts & Corno, 2005; Winnie & Perry, 2000).

(SCT) can also be distinguished from other theoretical models, particularly behavioral models, by an assumption of personal agency. That is, human behavior is goal-directed and therefore an individual can proactively act to rearrange his or her environment or personal situation (Bandura, 1986). For example, Bandura (1986) originally proposed that people can enact a number of behaviors, originally coined "*the capabilities*" to produce changes in their environment. The key "capabilities" included and ability to (1) use of symbols for the purpose of communicating or internalizing concepts (symbolizing capability), (2) anticipate consequences of potential actions, set goals, and plan actions that will enable the achievement of selected goals (forethought capability), (3) reflect on life experiences and cognitions while evaluating how adaptive one's choices were and whether future modifications are required (self-reflective capability), (4) to learn through observation of consequences of other's actions (vicarious capability), and finally (5) the capability to self-regulate (Bandura, 1986; Luszyczynska & Schwarzer, 2005). Although the final capability was titled the self-regulation capability, it should be noted that more current understandings of SRL is better reflected as a combination of all of the aforementioned capabilities. This "self-regulation capability" referred to the fact that human behavior is motivated by self-set standards, thus behavior is motivated to attain and evaluated against one's internal standards (Bandura, 1986). When current performance is inconsistent with internal standards an individual can "self-regulate" his or her cognitions, motivation, or behaviors by arranging facilitative environments, implementing cognitive strategies, and creating personal incentives to motivate behavior (Bandura, 1986). Bandura also postulated that SRL functioned via three sub-processes: self-observation, self-judgments, and self-reactions. Self-observation is a process of monitoring performance across time (Bandura, 1986). Self-observation, also referred to as self-monitoring, will be more fully elaborated upon in the discussion of Zimmerman's model. Self-judgment on the other hand, refers to a process of comparing performance to a set of internal standards. The comparison of performance against self-judgments sets the stage for the last process, self-reactions which consist of the feedback provided to oneself in relation to performance and self-judgments. Depending on whether performance is viewed as desirable or undesirable, self-rewards or punishments can be administered. Bandura's model predates the more current model of self-regulated learning that more directly relates to the proposed dissertation.

Zimmerman's (2000) Model of SRL

Building upon Bandura's work to define social cognitive theory, Zimmerman (2000) described a more comprehensive model of SRL that encompasses a cyclical feedback loop consisting of three major phases: forethought, performance control, and self-reflection (see Figure 2.1). Each phase of SRL is comprised of a number of sub-processes that collaboratively enable the regulation of motivation, cognition, and behavior. In the following section, the author will describe the three major phases while focusing additional attention to the processes that are of greatest importance to the current dissertation study.

Overview of three-phase model. The forethought phase consists of the processes and motivational beliefs that are salient before engagement with a task (e.g., goal-setting & strategic planning), performance control highlights the processes (cognitive and behavioral) that occur while an individual is engaged in performance (self-monitoring & strategy use), and self-reflection refers to the processes occurring immediately following performance or after receiving feedback (self-evaluation, causal attributions, satisfaction, & adaptive inferences; Zimmerman, 2000). These phases are described as cyclical because each phase influences the processes of the subsequent phase processes such that forethought processes influence performance processes, and performance influences reflection processes. Of greatest importance, however, to the notion of a "cyclical" feedback loop is that reflection phase processes hypothetically impact forethought processes during future learning and iterations of the loop (Zimmerman, 2000).

Figure 2.1

Zimmerman, (2000) Model of SRL.

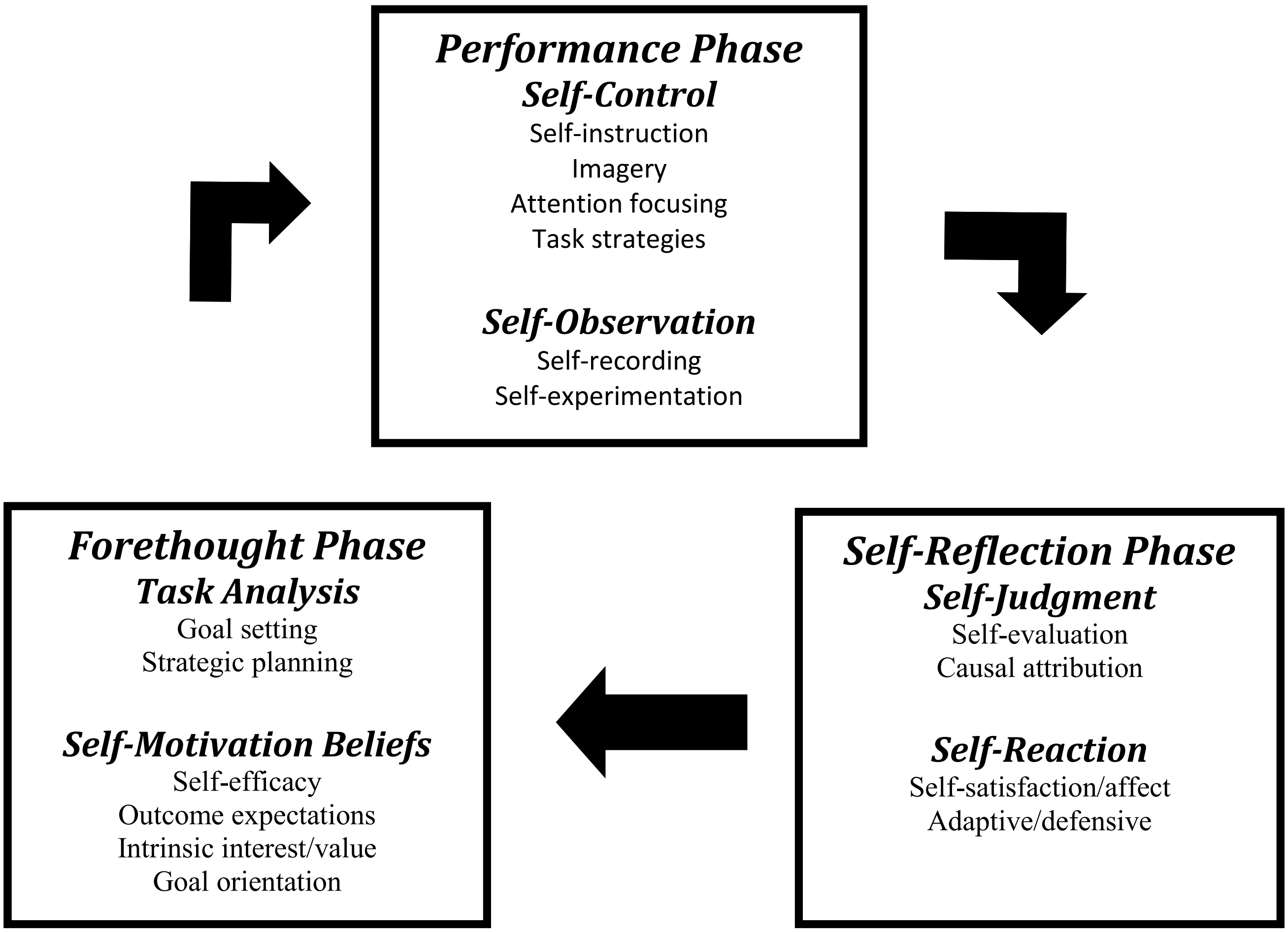

Table 2.1

Primary SRL processes of current study.

Forethought processes	*Performance processes*	*Self-reflection processes*
Goal setting	Strategy Use	Causal attributions
Strategic planning	Metacognitive monitoring	Adaptive inferences

Forethought.

SRL Forethought processes. The forethought phase is a combination of self-regulatory processes (e.g., goal setting and strategic planning) and motivational beliefs (e.g., self-efficacy, goal orientation, intrinsic interest, and outcome expectations; Zimmerman, 2000). Within forethought, there are two major self-regulatory processes collectively described as task analysis. Task analysis is the decomposition of task requirements wherein students set goals and decide upon actions necessary to reach those goals. That is, regulated learners first set goals, by selecting a desired outcome or making a conscious decision as to what constitutes a successful completion of the target task. Strategic planning, which often follows the goal setting process, is the selection or construction of a plan involving one or more specific strategies or tactics that are believed to increase the odds of obtaining one's goal (Zimmerman, 2000). Both forethought processes of goal-setting and strategic planning will receive particular attention in this dissertation project. Therefore, the author will provide a more extensive review of these constructs.

Goal-setting. Research suggest a strong link between goal types and improved achievement for many academic tasks, including mathematics (Cleary & Zimmerman, 2001; Church, Elliot, & Gable, 2001; Pajares & Graham, 1999). Setting goals is an important task within the larger three phase model of SRL because (during performance) it directs efforts and attention toward a desired outcome and serves as a bench mark against which one's performance can be evaluated against (during reflection). In regard to the latter point, setting goals in the forethought phase is useful because an individual can evaluate progress toward his or her selected goal over time. As a result, an individual can strategically reflect to make appropriate adjustments to strategic plans to maximize his or her successful attainment of selected goals.

Goals can be very diverse in focus. Outcome goals also known as *performance goals* are focused on the attainment of a certain level of performance, whereas *process goals* involve correctly performing a set of procedures. Process goals are considered more adaptive during earlier stages of skill development (Zimmerman, 2002) because it promotes the mastery of a skill or understanding content (Ames & Archer, 1988; Dweck, 1986). Later in skill development, it may become more appropriate for learners to shift their focus to more outcome or performance related goals (Zimmerman, 2002). Goals can focus on different time frames as well. Long term goals, which are often more ambitious, are referred to as distal goals. On the other hand, goals focused on shorter durations of time or even check points along the way toward distal goals are known as proximal goals.

Goals not only facilitate performance control and self-reflection processes but also reciprocally enhance the motivational beliefs of the forethought phase. For example, accomplishing distal or proximal goals or making progress toward a goal (possibly accomplishing a proximal goal along the path of a distal goal) theoretically produces an increase in motivation. This motivational boost may take the form of an increase in self-efficacy to accomplish more distal goals (long term goals) or to accomplish other future goals (Bandura & Schunk, 1981).

Strategic planning. Effective planning wherein students select the specific tactics and strategies to enlist is an important regulatory process that is linked to future achievement (DiBendetto & Zimmerman, 2010; Kitsantas & Zimmerman, 2002). In the three phase model, this process is known as strategic planning. Strategic planning is not merely applying a set of strategies because no single strategy is optimal for all tasks, situations, or individuals. Instead, strategic planning is best understood as a process of matching strategies and regulatory processes to current task demands and modifying those plans as necessary (Weinstein & Mayer, 1986). As part of a strategic plan, students may choose to enact a number of regulatory strategies (cognitive and metacognitive strategies), task specific strategies, or even invent their own strategies to address task demands (Zimmerman, 1989). Employment of strategies often enhances performance by controlling motivation, facilitating cognitions, or coordinating task execution. However, the benefit of strategic planning is not limited to the effect of later strategy use but can also serve a motivational function since a well-developed plan of action can increase efficacy for success.

Forethought motivational beliefs. Motivation is a term that has historically been used to describe the processes that guide the development of behavior preferences, arouse and instigate behavior, give direction and purpose to behavior, and reinforce behavior to persevere (Reeve, 2005). Motivation and SRL are related in the sense that SRL is a broader construct within which motivation is subsumed. Although motivation is necessary for effective SRL, motivation alone does not sufficiently produce desired outcomes. Instead, SRL phase processes coupled with adequate motivation is deemed most advantageous because this combination is more likely to lead to the instigation and maintenance of SRL. Motivational beliefs have had a prominent impact in SRL theories and from a social cognitive point of view, motivational beliefs are considered a component of the forethought phase because motivation plays a significant role subsequent effort and quality of engagement (Christenson, Reschly, Appleton, Berman-Young, Spanjers, & Varro, 2008; Zimmerman & Cleary, 2009).

Some of the most prominent motivation beliefs in the three phase model are self-efficacy, outcome expectations, interest, and goal orientation. *Self-efficacy,* which is described as the beliefs one holds about his or her capabilities to organize and execute the courses of action required to produce given attainments, (Bandura, 1997) is essential in promoting student engagement in learning, plays a role in effort and task persistence, and can promote achievement (Linnenbrink & Pintrich, 2003; Schunk, & Swartz, 1993a). The role of self-efficacy has been implicated as a key process underlying overcoming phobias (Bandura, Jeffery, & Gajdos, 1975), the development of depression (Holahan & Holahan, 1987), and athletic performance (Daroglou, 2011) to name just a few. Of greatest interest to this dissertation, self-efficacy has a strong link to academic outcomes such as mathematics achievement (Hackett & Betz, 1989; Lent, Lopez, & Bieschke, 1993; Usher & Pajares, 2006; 2008). *Outcome expectations,* which is a distinct motivational belief, consist of an individual's judgments of the most probable consequences that will result from performing a particular behavior (Bandura, 1986). *Interests* are understood as the patterns of likes, dislikes, and indifferences regarding particular activities or tasks. *Goal orientation* describes one's predisposition to set certain types of goals (e.g., performance goals or outcome goals).

Performance control. During learning or when performing a task, there are a number of things that highly regulated persons will do to optimize performance, such as engaging in *self-control* and *self-observation* (Zimmerman, 2000).

Self-control. Self-control is a general category of actions and tactics that manage motivation, affect, attention, or even motoric execution of the task. Some of the more common self-control tactics include: attention focusing, self-instruction, implementing task-specific strategies, or common SRL strategies (Zimmerman, 2000). Research has identified several common SRL strategies that are observed across many academic settings such as organizing and transforming information, seeking information or assistance, environmental structuring, setting self-consequences, or rehearsing appear frequently in academic pursuits (Zimmerman &

Martinez-Pons, 1986). Given that task-specific strategies differ from one task to another and that individuals are capable of inventing their own strategies, the list of potential strategies is nearly limitless.

Self-monitoring. Self-monitoring also known as self-observation will receive primary attention in the proposed dissertation project. Self-monitoring is a systematic monitoring of performance such as recording task performance over time or maintaining metacognitive awareness of one's actions and performance. Self-monitoring is essential to the larger SRL system and task performance in many respects. At its core self-monitoring enables a person to gather performance data against thus enabling evaluation and modification of performance. Monitoring fosters self-awareness of behaviors or cognitions, a precursor to modifying inadequate strategic plans or actions (Bandura, 1991). Additionally, self-monitoring is directly linked to motivation given that a desire to observe an improvement in performance is usually accompanied by consistent monitoring over time. Hence, this desire to improve should result in increased effort expenditures (Bandura, 1991).

Self-reflection. During the final phase of the cyclical loop, self-regulated learners engage in several self-reflective processes, which are subsumed within one of two categories: self-judgments and self-reactions. Self-judgments are comprised of (1) *self-evaluations*, where an individual evaluates his or her performance based on internal and external standards and (2) *causal attributions* or the perceived cause of successful or unsuccessful performance. Judgment of one's performance is most often followed by some form of cognitive and affective reaction. In the cyclical feedback loop, these *self-reactions* include an individual's level of *satisfaction* (i.e., the degree to which one is pleased or displeased with performance outcome(s)). If an individual is dissatisfied with performance, he or she may consider necessary strategic adjustments (*adaptive inferences*) to remediate the deficits in performance. In the case that such self-reactions influence future performance or forethought (i.e., goal setting or planning) the three phase cycle of SRL is considered to be complete (Zimmerman, 2000).

Two reflection phase processes (i.e., attributions and adaptive inferences) are of particular interest in this dissertation project because of their central role in determining adaptations for future motivation, forethought, and performance in relation to future performance situations. Bandura (1986) postulated such processes to be so essential that it was suggested that all other regulatory processes, are of little use unless followed by effective self-reflection. For this reason, additional attention will be devoted to describing attributions and adaptive inferences.

Attributions. Causal attributions refer to an individual's perception of the cause of the outcomes in a particular activity (Weiner, 1979) and are of primary interest to the proposed study because of the prominent role they play in determining future motivational beliefs, regulation, mental health, and behaviors (Robertson, 2000; Ross, Rodin, & Zimbardo, 1969). The impact of attributions has been noted across a wide variety of fields beyond academics and SRL. For example, attributions importance is noted for: academics, (Dweck, 1975; Schunk 1990), athletics (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman; 2002), and psychology (Robertson, 2000; Weiner, 1979).

The construct of attributions first emerged with the work of Heider (1958) that examined individual's perceptions of the cause of an event. Heider found that people tended to focus on either internal or external factors (Heider, 1958). Several years later, additional research by Weiner and colleagues more fully conceptualized an *attribution theory*, which outlined the primary qualitative features of attributions, identified the most prevalent forms of attributions, and hypothesized potential consequences and benefits of producing various attribution types (Weiner, 1979). Although the target of an attribution can be nearly limitless, Weiner (1979) suggested that individuals most commonly attribute outcomes to one of four major categories: ability, effort, task difficulty, or luck and proposed that attributions can be classified across three dimensions: stability (stable or unstable over time), locus (internal or extern to the individual), and controllability (controllable or uncontrollable) (Weiner, 1979). To provide an example of how different attribution types might be classified across these dimensions; an ability attribution is considered an internal, stable, and uncontrollable attribution because ability is an internal characteristic of a person (internal), relatively unchangeable over time (stable), and under little control of the individual (uncontrollable). In comparison, an effort attribution would be considered an internal, unstable, and controllable attribution.

The controllability of attributions is of primary importance to the proposed study because more controllable attributions have been linked to greater success in achievement settings and more productive SRL (Dweck, 1986; Dweck & Leggett, 1988; Schunk, 1990). That is, in academic settings more controllable attributions enhance: academic SRL (strategy use, goal setting, monitoring) (Thomas & Mathieu, 1994), motivational beliefs such as self-efficacy, persistence, & affect (Schunk, 1990), and task performance (Borkowski, Weyhing, & Carr, 1988; Clifford, 1986; Robertson, 2000).

Adaptive inferences. The construct of "adaptive inference" is yet another important reflection process that is essential to the current dissertation project. Adaptive inferences describe the strategic adjustments to regulatory behaviors or strategies that are deemed necessary following a performance or learning task (Zimmerman, 2000). Such a process of modifying one's approach is essential to the cyclical nature of the three phase model because it serves as a fulcrum point at which one has the opportunity to improve strategic plans or select more effective strategies that may ultimately result in enhanced achievement (Zimmerman, & Martinez-Pons, 1992). On the other hand, it is possible that an individual will engage in maladaptive forms of regulation such as rejecting responsibility or detracting from the task. In addition, it is further possible that students may neglect to identify the adaptive inferences needed to improve future performance. Research has suggested that students who generate adaptive inferences following a performance situation tend to achieve higher and regulate more effectively than peers who neglect to or generate defensive inferences (Cleary, et al., 2012; Schoenfeld, 1985; Zimmerman, 2000). Defensive inferences describe another set of thoughts or behaviors that one might generate following performance. These defensive inferences although strategic, in that they will protect students' self-worth, may be termed as forms of maladaptive SRL because they often hinder later performance.

Table 2.2

Review of Primary SRL Processes.

Forethought processes	*Performance processes*	*Self-reflection processes*
Goal setting	Strategy Use	Causal attributions
Strategic planning	Metacognitive monitoring	Adaptive inferences

Maladaptive regulation. SRL is not only the types of things that students engage to optimize their performance, but also consists of many maladaptive practices or ineffective strategies that students may use. Although the current dissertation will not address the entirety of maladaptive regulation, one subscale implemented in this study identifies students' use of maladaptive academic practices (Self-Regulation Strategy Inventory; SRSI-SR), and therefore it is important to mention several aspects of maladaptive regulation. Maladaptive regulation may take several forms such as self-handicapping (Urdan & Midgley, 2003; Zimmerman, 2000), procrastination (Burka, 2008), defensive pessimism (Martin et al., 2001) failing to seek help when needed, or forgetting important materials may also be considered maladaptive regulation. Self-handicapping is the engagement in activities that prevent or seriously hamper an individual's attempts to accomplish important academic activities (Urdan & Midgley, 2003). Procrastination is a subtype of self-handicapping, in which students put off work until the remaining time to finish a project is so inadequate that their final performance is greatly hindered (Burka, 2008). Essentially defensive pessimism is a trade off in which a student prefers to knowingly fail rather than experience an "unwanted" or unplanned failure. As a result, failure is less detrimental to one's self-worth because failure was his or her goal.

Mathematical Problem Solving and SRL

The current study examines the measurement of SRL in the context of mathematics. The next portion of this chapter will describe the rationale for selecting mathematics for this dissertation, different aspects of mathematics, the primary mathematical focus of this study, mathematical problem solving, and the relationship between SRL and problem solving tasks. .

Selection of Mathematics

Mathematics was chosen as the academic domain of interest in this dissertation for several reasons. First, mathematics achievement is currently a national concern amongst educators because math achievement in the United States lags behind students of other leading nations. Statistics gathered from the National Center for Education Statistics convey that fourth grade students in the United States were ranked as 11th out of 38 countries in overall math performance and in the 8th grade, students in the United States ranked 10th in overall math (Aud, Hussar, Planty, Snyder, Bianco, Fox, Frohlich, Kemp, Drake, 2010). At a national level, students' competence in mathematics is an important factor in a nation's ability to compete in fields such as engineering, technology, and pharmacology. These professional fields are generally considered essential to a maintaining our nation's position as a world leader (Forgione, 1999). Mathematics is also a source of difficulty for individuals when choosing a career path or course of study in college because poor mathematical skills severely limits career options and has been identified as a large barrier to college completion for many students (Forgione, 1999).

Description of Mathematics

Mathematics itself is a diverse area of study with research exploring a variety of individual components such as computation, fluency, or problem solving. Computation in mathematics refers to the processes involved in the actual solving of a mathematical problem (Rutherford-Becker & Vanderwood, 2009). Mathematical fluency, another area of study in the field of mathematics, refers to the speed with which one calculates answers to simple mathematical problems (Widaman, Little, & Geary, 1992; Zentall, 1990).

Mathematical problem-solving, a familiar task that most encounter on a frequent basis during their education, generally consists of one or more sentences of text or a combination of text and graphics that describe a real life application of mathematics. MPS has important implications for mathematics in general because it is strongly correlated with mathematics achievement (Bryant, Bryant, & Hammill, 2000; Geary, 2003; Lewis, 1989). Moreover, many advocate for the development of MPS skills because the application of mathematics to real world problems builds invaluable mathematical and critical thinking skills (Baroody, 2003; Hiebert & Wearne, 1993; Knapp, Shields & Turnbull, 1992). MPS is also one of the most challenging mathematics tasks to master. For example, students need strong computational skills and a conceptual understanding of mathematics to deconstruct a problem and devise an effective plan to strategically apply the necessary computational procedures (Bryant, Bryant, & Hammill, 2000; Geary, 2003; Lewis, 1989). Further, students' attempts to complete mathematical word problems are often derailed by deficits in: understanding mathematical symbols, effectively decoding the semantics of a word problem, using cues in the problem to construct a plan for solution and translating that plan into a mathematical equation (Bednarz & Janvier, 1996; Carpenter, Corbitt, Kepner, Lindquist, & Reys, 1981; Martin & Bassok, 2005).

Over the last several decades, a great deal of research attention has been devoted to the study of MPS. In fact, a number of frameworks for approaching MPS tasks have been posited. For example, mathematicians suggest that MPS should be deconstructed into a series of four steps: (1) Understand, (2) Plan, (3) Solve, and (4) Check (Polya, 1990). First a student must *understand* what the problem is asking. During this step students identify what data is provided, what is known about the problem, what are the parameters of the problem, and if a solution objective can be identified for the problem. To facilitate this process, students will often create a visual representation or write down the pertinent data (Polya, 1990). The next step in the problem solving process is to *create a solution plan* for the problem (Polya, 1990). During this time, the problem solver will attempt to make a connection between the known and unknown "conditions" of the problem. To connect these conditions, students may construct an equation or select the specific mathematical operations required for problem solution. Students may consider similar problems they have solved in the past or restate the problem in different terminology to facilitate planning processes (Polya, 1990). Next, students engage in the "solve" step of problem solving wherein the computations will be carried out. Finally, checking one's work and solutions to ensure accuracy is an essential component of the problem solving process. To do this, students re-examine the solution, determine if it is possible to check their results mathematically, or if the correctness of an answer can be identified from a glance (Polya, 1990). As can be seen, MPS is a complicated process. Although, there have been advancements in our understanding of this process, such as Polya's model (1990), more recent research has underscored the conceptual overlap between MPS and SRL sub-processes.

Linking Mathematics Problem Solving and SRL

There is a great deal of potential overlap between SRL and the problem solving process (Efklides et al., 2006; Lucangeli & Cabrele, 2006; Montague, 2008; Zimmerman, 2002). For example, proficiency in MPS is believed to be less a function of aptitude and more so related to one's metacognitive skills and the appropriate deployment of strategies, the latter of which is dependent on adaptive levels of motivation (Van Luit & Kroesbergen, 2006). To better illustrate, the author will describe the relationship between a number of SRL processes, motivational beliefs, and effective problem solving.

Motivational beliefs. Self-efficacy, outcome expectations, and interest, are strongly related to mathematics achievement. Self-efficacy is believed to exert an influence on achievement through the promotion of active engagement in learning, increased effort and task persistence, influences choices for the activities with which one engages (Linnenbrink & Pintrich, 2003; Schunk, 1995; Bandura, 1997) and has been shown to be highly correlated to mathematics achievement (Siegel, Galassi, & Ware, 1985; Trice, Elliot, Pope, & Tryall, 1991; Usher & Pajares, 2006; 2008). Applications of social cognitive career theory for science and mathematics (STEM) related career fields has shown that outcome expectations are indirectly linked to achievement in math and science in that outcome expectations positively enhance interests, intentions, and goal-setting (Fouad & Smith, 1996; Lent, et al., 1993). In mathematics, interests are in turn related to self-efficacy, outcome expectations, and achievement since individuals tend to develop interests for and thereby direct more effort toward activities for which they perceive themselves competent or expect desired outcomes (Bandura, 1986; Cleary & Chen, 2009; Lent, Larkin, & Brown, 1989). Given these research findings, students are benefitted by the possession of an adaptive motivational profile when approaching mathematical tasks. Unfortunately, many students report poor motivation for math (Ashcraft & Krause, 2007; Coalition for Psychology in Schools and Education, 2006; Grigal, Neubart, Moon, & Graham, 2003; Ma & Cartwright, 2003) or actively avoid math to cope with anxiety that has become associated with math tasks (Ashcraft & Krause, 2007). These facts may suggest the need for a better understanding of students' motivational beliefs when approaching mathematics.

SRL processes. Although, many students erroneously perceive MPS to be a process of memorizing formulas, procedures, or rigid rules (Fuchs & Fuchs, 2003; Pape et al., 2003) mathematics educators emphasize the importance of approaching mathematic problems in a strategic manner wherein students flexibly apply conceptual knowledge and regulatory strategies to facilitate problem completion (De Corte, et al., 2011; Fuchs & Fuchs 2003; Graham & Harris, 2005; Guthrie & Wigfield, 2000). It is in this notion that the application of SRL to problem solving comes into focus. Students who are highly regulated are often more capable of approaching problem solving tasks in a strategic manner. SRL processes from each of the phases of the three-phase model are intertwined with problem solving tasks (see Table 2.2) and will be described briefly.

Table 2.3

SRL Processes during Mathematical Problem Solving Steps.

	Problem Solving Steps			
	Understand	Plan	Solve	Check
SRL Process				
Goal Setting	• Read • Paraphrase Identify main information			
Strategic Planning		• Develop solution plan • Estimate the solution • Estimate the procedures needed		
Self-monitoring	• Self-monitor understanding			• Monitor process (check decimals, right signs, operations) • Monitor performance (compare solution & estimate, check computations)
Self-Control	• Visualization (Draw a picture)	• Visualization (Draw a picture)	• Self-instruction, self-question, self-evaluation • Guess & Check • Work backwards • Look for a pattern	• Check work (see above)
Adaptive Inferences			• Adapt solution plan when ineffective	

Forethought processes. As described in the first part of this chapter, SRL forethought processes entail the things that an individual does just prior to performance (Zimmerman, 2000). Consistent with this notion, there are a number of SRL processes that, if enacted prior to solving a mathematical problem, may enhance performance. For example, during the first two steps of problem solving as defined by Poyla (1990) (i.e., understand the problem & develop a solution plan), engagement in task analysis (SRL forethought) processes facilitates the understanding of the problem. For example, setting high quality goals prior to the computational phase of problem solving focuses one's energy and attention on an outcome, which not only helps to organize actions but also provides a referent with which one can evaluate their progress. In an ideal situation students will set specific and process oriented goals, rather than vague outcome oriented goals, because this should better direct students to understand the problem for which they are engaging. That is, high quality goals help consolidate the conceptualization of what the problem is asking, provides a benchmark against which one can continuously evaluate problem solving progress (Locke & Latham, 2006; Zimmerman, 2000), and may solidify strategic engagement during later computations. For example, individuals who focus on performance outcomes such as grades or an extrinsic reward (outcome goals) rather than the processes required to solve the problem (process goals) tend to display more superficial learning strategies, poorer engagement, reduced effort, maladaptive achievement behaviors, and poorer achievement outcomes (Church, et al., 2001; Ironsmith, Marva, Harju; Eppler, 2003; Meece, Blumenfeld, & Hoyle, 1988; Pintrich & De Groot, 1990).

Strategic planning is also of importance to the problem solving process, especially as students are in the earlier phases of problem solution (Martin & Bassok, 2005). There is some overlap between the SRL process of strategic planning and the second step of Polya's (1990) model of problem solving (create a solution plan). These processes are similar in that the main purpose is for students to thoughtfully consider what steps might facilitate problem solution. At the same time, these processes are not entirely synonymous because from an SRL perspective, students might not only choose the specific mathematical operations or some task specific strategies, but may *also* identify methods by which they will manage motivation, affect, cognition, and metacognition, in addition to mathematical operations. Research supports this in that expert problem solvers tend to devote more time to planning before beginning computations (Schoenfeld, 1985). Therefore, as has been found in other domains such as reading and studying DiBendetto & Zimmerman, 2010) the extensiveness of one's strategic plans prior to solving math problems may be predictive of MPS achievement. Moreover, the assessment of strategic planning in real time may be of particular importance because the quality of strategic plans may not only serve as an indicator of planning behaviors but also the extent to which students understand the problem requirements and how efficiently they apply knowledge and skills to address that problem.

Performance control processes. A number of performance control processes such as monitoring and self-control can enhance the solution of word problems. First of all, students implement a variety of strategies to optimize their performance. There are three primary categories of strategies that students may use: metacognitive strategies, cognitive strategies, and resource strategies (Perels, Dignath, Schmitz, 2009). The primary purpose of metacognitive strategies are to facilitate planning, monitoring, and regulation (Perels, et al., 2009). Some frequently used metacognitive strategies when solving mathematical problems might include: self-questioning, self-instruction, self-evaluation, and self-monitoring (Montague, 2003; Montague, 2008). Cognitive strategies include a variety of behaviors aimed at making cognitive processes more efficient such as transforming or organizing information (Pressley, Borkowski, & Schneider, 1987). Finally, resource strategies help to improve students' use of effort, time, and attention (Perels, et al., 2009).

In total, these three types of strategies facilitate problem completion through increased awareness and facilitation of cognitive processes, but students may also use a number of math specific (problem solving) strategies. For example, visual aids or drawing, paraphrasing the problem, identifying the important information by underlining, eliminating useless information, estimating the answer, working backwards, using a guess and check technique, and checking computations and operations have all been shown to be extremely beneficial when attempting to solve word problems (Montague, 2003; 2008). Several strategy instruction programs have instructed students to follow some variant of a common cognitive strategy heuristic to guide them to strategically approach and resolve a mathematics word problem (Butler, et al., 2005; Casel & Reid, 1996; Graham & Harris, 2003). One such example includes: (1) read the problem, (2) translate the problem into your own words, (3) visualize the problem through the use of a drawing or diagram, (4) hypothesize how to solve the problem, (5) make an estimation of the correct answer, (6) compute the problem, and (7) then check whether they have successfully computed the problem (Butler, et al., 2005; Casel & Reid, 1996; Graham & Harris, 2003; Montague, 2003). This MPS strategy is of primary importance to the current dissertation. Particularly, the aspects of a similar MPS strategy will serve a primary role in the coding and scoring of responses to microanalytic interview questions. Greater detail regarding the problem solving strategy can be found in chapter three of this dissertation.

Self-monitoring. Self-monitoring is an SRL performance control process that is highly important to the solution of word problems. Although self-monitoring is most essential to the performance control phase of the three phase model, it is important to note that monitoring likely presents multiple times throughout the solution of a word problem. Monitoring exerts a strong influence on achievement situations because it not only acts as a primary data source upon which post performance reflections can be based, but also acts as a source of continuous data that can guide decisions to continue or adapt one’s approach while still performing. Such an iterative monitoring and adapting process known as self-experimentation is believed to be essential to problem solution. For example, students who fail to monitor may become lost, confused, or fail to solve the problem successfully (Schoenfeld, 1985). Some might argue that effective problem solvers may monitor nearly continuously as a means of establishing if all the necessary mathematical steps have been completed or if one is making progress toward a solution. To do this, students might self-question by asking, *"what is the question asking for, what might I do to answer this question, am I making progress, does my answer seem to fit with my earlier estimates, does this answer / process make sense."*

Research supports this assertion because effective problem solvers are engaged more frequently and continuously throughout the problem solving process (Overtoom, 1991; Schoenfeld, 1985) and modify their solution approach when their current solution approach is not producing desired results (Schoenfeld, 1985). On the other hand, novices tend to monitor their progress less efficiently (Schoenfeld, 1985).

More frequent monitoring during problem solution not only is facilitative of problem solution but it has also been shown that expert problem solvers are more aware of, able to articulate, and justify their solution methods (Gurova, 1985). Hence, this heightened awareness from self-monitoring behaviors greatly increases the accuracy with which students can predict their performance on math items. Research has provided backing for this notion in that expert problem solvers are significantly more accurate than novices when asked to estimate which problems were solved correctly (Gurova, 1985). For this reason, it is possible to approximate the quality of student self-monitoring by examining the accuracy with which a student predicts their own performance. Using this proxy variable is ideal because it provides a measure of one's use of self-monitoring processes. Moreover, this methodology may be advantageous because it does not disrupt the natural flow of self-monitoring or prompt a student to engage in self-monitoring.

This contrasts more commonly used think-aloud methodologies that are more intrusive to self-monitoring processes.

In terms of the cyclical nature of SRL, the performance phase processes such as self-control and self-monitoring are important and also influence the reflection phase in that it serves as a primary source of feedback or information upon which one may self-reflect.

Self-reflection processes. Less is known about the ways in which individual SRL processes, such as causal attributions and adaptive inferences, relate to MPS and even less is known about the real-time effect of these processes during MPS problem. Although research has shown that expert performers more frequently engage in reflective processes during MPS as compared to novices (Overtoom, 1991) there is a gap in the literature about the specific processes that occur. For example, researchers have discovered that novices tend to adhere strictly to their original solution plan even when it is clear that they are not reaching a solution (Schoenfeld, 1985), which implies a deficit in adequate reflection. In contrast, experts frequently modify their approach in relation to the data provided by regular monitoring (Schoenfeld, 1985). The pattern of frequent behavioral change noted amongst expert problem solvers suggests that they have engaged in reflection processes such as attributing their struggles to a particular aspect of their solution path (causal attribution) and identified modifications necessary to improve performance (adaptive inferences). Despite the possibility of such inferences from prior research, more research may be necessary to gather richer data about how SRL reflection processes interact during problem solving.

As can be seen, there is a great deal of overlap between SRL processes and mathematical problem solving, yet there is still much to be learned. Advancing our understanding of the connection between SRL and problem solving would be advantageous to educators because mathematics researchers indicate that mathematics education can be advanced by infusing SRL components into mathematical instruction (De Corte, et al., 2000; Pape, et al., 2003; Treffers, De Moor, & Feys, 1989). Currently, a gap exists in the literature regarding how students regulate while they are engaged with authentic mathematics tasks. Likewise, adequate measurement tools that would enable such research are largely unavailable. Thus, there is a particular need to develop and validate new measurement tools that are capable of addressing SRL as the online and dynamic process that presents during problem solving activities (Carnine, 1997; Cifarelli, Goodson-Espy, Lim Chae; 2010).

This gap is of crucial importance because SRL, in relation to mathematics, is not merely the number of strategies that a student knows or how many formulas he or she has memorized; but instead SRL is more adequately illustrated in the adequacy with which a student selects processes, strategies, or mathematical knowledge to address the demands of a mathematical task. In light of this recognition, many researchers have advocated for a reconsideration of SRL measurement in relation to mathematics.

Measurement of Self-Regulated Learning

Historical Overview

The measurement of SRL has become an increasingly important topic in the research literature and in education circles over the past decade. A variety of measures have been used to measure SRL over the last couple of decades, such as self-report questionnaires, (Pintrich, Smith, Garcia, & McKeachie, 1993) structured interviews, (Zimmerman & Martinez-Pons, 1988) teacher rating scales, (SRSI-TRS; Cleary & Callan, 2013; RSSRL; Zimmerman & Martinez-Pons, 1986) behavior traces (Winne & Perry, 2000), direct observations (Turner, 1995; Corno, 2001), diaries (Randi & Corno, 1997), think-alouds (Azevedo & Greene, 2007; Perry & Winne, 2006), and SRL microanalysis (Cleary & Zimmerman, 2001; DiBendetto & Zimmerman, 2010; Kitsantas & Zimmerman, 2002). Amongst these measures self-report questionnaires have clearly been the most popular amongst researchers and practitioners (Cleary, 2009; Dinsmore et al., 2000).

In the SRL literature, the measures used have consistently adapted over time along with changing theoretical conceptualizations of SRL. In the early stages of SRL research (the 1970s and 80s), metacognition was at the forefront of attention and thus most measures targeted components of metacognitive knowledge such as self-awareness, and declarative, procedural, and conditional knowledge of appropriate task strategies (Boekaerts & Corno, 2005). Around this time many researchers believed that regulation was a relatively stable trait of an individual that would express itself in a similar fashion across contexts and situations (Boekaerts & Corno, 2005). Not surprisingly, the measures of the time, mostly questionnaires and interviews, depicted SRL as a stable trait that generalized across contexts. Around the 1990s, SRL researchers suggested that regulation was not universal across all domains and that it actually was a more contextualized construct. As a result, researchers began developing and using questionnaires and interviews that could be customized to a particular domain of interest (Boekaerts & Corno, 2005), such as the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, et al., 1993) and the Self-Regulated Learning Interview Scale (SRLIS; Zimmerman & Martinez-Pons, 1988). Despite the recognition that SRL is a contextualized phenomenon and the resulting improvement in the assessment tools to be domain-specific, many researchers continued to question the validity and appropriateness of self-report questionnaires (Winne & Perry, 2000). More recently, researchers have begun developing a number of assessment procedures (e.g., behavior traces, direct observations, think alouds, and SRL microanalysis) that are believed to more adequately capture the contextualized and fluid nature of SRL. Collectively many of these new types of measures share a focus on real-time measurement of SRL in relation to a single task of interest. The emergence of this new group of measures prompted Winne and Perry (2000) to differentiate two distinct categories of SRL measurements, *aptitude* forms of SRL measurement and *event* forms of measurement.

Types of SRL Assessments

The type of measurement one selects to study SRL has a significant impact on the type of data produced. In the current dissertation, measures from both of the major SRL measurement classes (aptitude and event measures) were employed thereby enabling a comparison. In particular, two aptitude measures, self-report questionnaires and teacher rating scales, and one event measure, SRL microanalysis were used. In the next section of this dissertation, the author provides a description of these measurement classes as well as information regarding the specific measurement formats used in this dissertation.

SRL Aptitude Measures

Possibly the most important distinction amongst SRL measures is between aptitude and event measures because it largely determines whether or not the measure is sensitive to very fine differences in SRL due to contextual factors. One of the primary differences between aptitude measures and event measures is whether SRL is aggregated over multiple instances of regulation (aptitude measures) or if the measurement is focused on regulation during a single event (event measures).

Table 2.4

Differences Between Aptitude and Event SRL Measures.

Measure Category	*Objectives*	*Example Measure(s)*	*Item Features*	*Scale features*
Aptitude Measure	Measure SRL as global trait or disposition of individual	Questionnaires	Likert items, forced choice format	Retrospective or hypothetical contexts, composite scores
		Teacher Ratings	Likert ratings	Generalized observations Subscales
Event Measure	Measure SRL as it occurs in relation to a single, well defined task	SRL Microanalysis	Open- & closed-ended questions Free response or forced choice	Real-time measurement

The most common types of aptitude measures such as self-report questionnaires, (MSLQ; Pintrich, et al., 1993; LASSI; Weinstein & Palmer, 2002; SRSI-SR; Cleary, 2006) structured interviews (SRLIS; Zimmerman & Martinez-Pons, 1988) and teacher rating scales (SRSI-TRS; Cleary & Callan, 2013; RSSRL; Zimmerman & Martinez-Pons, 1986) generally aggregate multiple events or instances of regulation by enlisting a number of items about an individual's regulation across multiple contexts. For example, a SRL questionnaire designed to measure strategy use for mathematics might include items about the strategies that students use to focus attention during class, complete homework, take tests, take notes, seek help when needed, etc... Then, for interpretive purposes, a general composite of mathematics strategy use would be calculated by averaging the student's ratings for all of the items. Although this information may be useful for some purposes, it is often difficult to translate the data collected by aptitude measures to inform instructional practices. For example, the aggregated composite score may indicate that a student does not report adequate strategy use for mathematics, however, these composite scores tell very little about how this student uses specific strategies during specific tasks such as homework completion, test taking, etc…

Self-report questionnaires. Self-report questionnaires are a type of aptitude measure but are also members of an even larger category of self-report measures. Since there is potential for confusion, the authors would like to point out that the term self-report should not be considered synonymous with questionnaires. Self-report measures could be more broadly defined as any measure that relies on student generated data. This category may include questionnaires, interviews, think-alouds, and others as well. Self-report questionnaires are but one form of self-report measure, yet they are the most frequently used measure of SRL (Cleary, 2009; Dinsmore et al., 2010). Self-report questionnaires have traditionally been useful for providing a general picture of how students use SRL within a particular domain. Much of the SRL literature to date is based on the use of questionnaires and we owe a great deal of our understanding of the link between SRL and positive academic outcomes to questionnaire measures (Boekaerts & Corno, 2005). Researchers have noted an extensive list of strengths and weaknesses of self-report questionnaires (Ericcson & Simon, 1984; Ericcson & Simon, 1986).

Strengths and Weaknesses of Questionnaires. There are a number of advantageous qualities of questionnaire measures that have contributed to their popularity such as strong psychometric properties (e.g., high internal consistency, concurrent validity, and predictive validity). Further, self-report questionnaires are also desirable because they are easy and efficient to administer and score and are relatively cost effective. However, the validity of self-report questionnaires has also been questioned for a number of reasons. First and foremost is the fact that questionnaires often fail to correspond with what students actually do (Jamieson-Noel &

Winne, 2003; Winne & Jamieson-Noel, 2002; Loeber, Green, & Lahey, 1990; Winne & Jamieson-Noel, 2002). For example, Winne and Jamieson-Noel, (2002) compared direct observations of SRL strategy use conducted by a trained observer and a questionnaire measuring SRL strategy use and found that these accounts were often inconsistent. That is, a trained observer documented instances of SRL strategy use during task engagement, and then immediately following the completion of that task, asked students to indicate the strategies that they had just employed by completing a self-report questionnaire. The results not only displayed that questionnaire reports were inconsistent with observations, but that students' report of strategy use often negatively correlated with actual observations (Winne & Jamieson-Noel, 2002).

A number of issues have been identified as contributors to the poor correspondence between questionnaires and actual behavior. The main issue of concern is the use of subscale composite scores that aggregate regulatory behaviors across multiple contexts. As discussed earlier in the aptitude section, data is aggregated in the sense that self-report questionnaires require students to respond to many items relating to SRL across contexts. The interpretation of the averaged subscale score is not informative because the resulting composite score value does not describe *how* SRL may vary across each context (i.e., tasks, environment, or difficulty). That is, the interpretation of a subscale score, erroneously suggests that SRL presents uniformly across all of the contextual variations addressed by the scale (Winne & Perry, 2000; Zimmerman, 2008).

Another criticism of questionnaires is that they often require individuals to retrospectively report their behaviors or cognitions. Retrospective reporting is a potential risk to the validity of a measure because human memory is particularly susceptible to biases, cognitive distortions, or other memory errors (Schacter, 1999). For example, students may fail to encode an experience accurately, may fail to retrieve information even if it is encoded correctly, or the encoding or retrieval processes themselves can alter one's memory of an event (Schacter, 1999).

In addition, these types of measures often do not include specific situational referents in the items. For example, an item may state "I organize information" referring to a common SRL strategy of organization. However, such an item does not situate a respondent to discern the specific context to which he or she is reporting and since strategy or tactic deployment varies across contexts responses to questions that lack situational referents are often vague and problematic.

A final major criticism of questionnaires is that many students lack the requisite metacognitive knowledge needed to accurately self-report their behaviors or cognitions (Dyson, 2003; Gresham et al., 2000; Stone & May, 2002; Vaughn et al., 1992). In other words, a certain level of self-awareness is required of students to accurately report their behaviors or cognitions. Also, since metacognition is a large factor in SRL, a circular problem arises wherein the accuracy of reporting is directly affected by the same skill being assessed. Thus, self-reports may be more or less accurate for various achievement groups wherein the populations of greatest need of developing SRL skill (typically lower achievers with deficits in metacognitive awareness) often struggle most significantly to accurately complete a questionnaire (Dyson, 2003; Heath & Glen, 2005; Stone & May, 2002; Vaughn et al., 1992).

Adaptive and Maladaptive Scales

Self-report questionnaires have also been developed to measure both adaptive and maladaptive regulatory processes. In general, *adaptive questionnaires* can be thought of as scales targeting positive SRL processes, such as using effective strategies, planning, goal-setting, and so on. In comparison, *maladaptive questionnaires* target ineffective SRL processes such as procrastination, avoidance, distractibility, self-handicapping, and many others. This is important because, as discussed in the earlier adaptive inferences section, there are situations when individuals not only fail to display positive regulatory behaviors (e.g., setting an outcome goal for a test) but actually display negative or maladaptive regulatory behaviors, such as avoiding work, procrastinating, or allowing oneself to get distracted from work completion (Zimmerman, 2000). From the author's perspective and based on the empirical literature, it is not only important to examine the type of effective strategies and processes that a student employs, but also maladaptive regulatory processes (Cleary, 2006; Weinstein & Palmer, 2002). For this reason, both adaptive and maladaptive rating scales will be included in the current study.

Teacher Rating Scales

Researchers and practitioners have most frequently relied on students as the primary source of data, but it is also possible and important to gather information from external data sources such as teachers, parents, or researchers. Teacher ratings have received less attention, relative to self-reports, in the SRL literature. However, teacher ratings have been used extensively and effectively to measure externalizing behaviors in both clinical and educational settings (Conners, Sitarenios, & Parker, 1998; Reynolds, & Kamphaus, 2004; Reynolds & Richmond, 2005). Teacher ratings are important because they offer an alternative data source with which researchers and practitioners can triangulate their evidence (Kamphaus & Frick, 1987; Loeber et al., 1990). Another pivotal aspect of teacher ratings of SRL is that when compared to self-report questionnaires, they tend to be regarded as a more objective and accurate measure of student behaviors. Teacher ratings in other academic purposes have borne out this argument displaying strong predictive capabilities of teacher ratings for class grades, standardized test performance, or academic skills (Al-Hroub & Whitebread, 2008; Gould & Shaffer, 1985; Kamphaus & Frick, 1987; Perry & Meisels, 1996). Some initial data has supported the use of a teacher rating scale for measuring SRL, the Self-Regulation Strategy Inventory – Teacher Rating Scale (SRSI-TRS; Cleary & Callan, 2013). Specifically, this measure has been shown to be highly predictive of future achievement, accounting for 24% of unique variation in course grades after controlling for prior achievement, self-report of motivational beliefs, and self-report of strategy use and displaying extremely high reliability (α=.964) (Cleary & Callan, 2013). Given the criticisms of self-report questionnaires, teacher ratings of SRL may be of particular importance to include into an assessment battery of SRL.

SRL Event Measures

In contrast to aptitude measures, event measures focus on SRL in relation to a single event in time, are often administered during the event of interest. Therefore, SRL event measures allow for real-time measurement of SRL and also produce data that is highly contextually specific. In other words, unlike aptitude measures, event measures are built around a "target event" so that researchers can clearly isolate how students regulate during that particular task. Moreover, researchers can carefully identify and design tasks to control contextual factors to increase the specificity of the data gathered. Event measures can be developed around virtually any activity for which a clear before, during, and after components can be identified. Thus, it is important to first identify a target event with clear temporal properties (e.g., before, after) because this more adequately enables researchers can clearly discern if any observed instances of regulation occurred in relation to that particular task or if the regulation occurred in relation to a non-relevant task. An additional feature of event measures is that they often measure SRL while students are authentically engaged in the target task of interest. For example, students may be prompted to report thoughts while reading, doing math problems, or while studying. This is an important aspect of event measures because it allows researchers to measure the real time application of SRL.

A handful of event measures have gained some popularity, including: behavior traces (Winne & Perry, 2000) direct observations (Turner, 1995; Corno, 2001), diaries (Randi & Corno, 1997); think-alouds (Azevedo & Greene, 2007) and SRL microanalysis (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). Each event measure shares the core features discussed in the preceding paragraph but also are unique in some respects as well. To better understand the variations in SRL event measures and to depict the nature of event type measures, the author will describe two measures (behavior traces and think-alouds) before describing the primary measure of interest, SRL microanalysis.

Behavior traces. Behavior traces are a SRL event measure that gathers information about student SRL by analyzing observable artifacts (traces) left behind by SRL processes (Winne & Perry, 2000). For example, a "traces" such as highlighted or underlined text, or notes written in the column of a passage, would be examined for this measurement form because these behaviors are indicative of SRL. From an information processing framework, these traces provide information about several aspects of regulation that occurred. For example, from an information processing lens, metacognitive and cognitive procedures are necessary to highlight text in a book. Upon reading a passage of text and deciding to highlight a portion of it, the student theoretically engaged SRL processes such as metacognition to identify the relative prominence of that text in relation to their learning goal. They also realized the value of facilitating the later relocation of this information and thus self-regulated their learning by highlighting the text. That is, the student used the strategy of highlighting to facilitate later identification of that information. Also, that student might choose to further regulate by adding notes in the column of the page to connect this information to previously learned information (elaboration), or may use a memory strategy like creating an acronym to facilitate retrieval of this information later (Perry & Winne, 2006; Winne & Perry, 2000).

Think-aloud protocols. Think aloud protocols are another type of SRL event measure that researchers have implemented with great success (Azevedo, et al., 2011; Ericsson & Simon, 1984). During think aloud measurement, students are asked to verbalize a continuous stream of cognitive and behavioral processes while performing a task (Azevedo et al., 2007; Ericsson & Simon, 1984). Verbalizations are recorded and later coded to convey the quality and types of regulatory processes utilized by the students. Some think aloud protocols exhibit a relatively unstructured format where an examiner interjects only to prompt students to continue reporting their cognitions should there be a prolonged silence. On the other hand, think aloud protocols can also be extremely structured where an examiner will provide specific prompts based on situational contingencies such as the respondents verbalizations or task performance.

Think-aloud protocols have been used for a number of tasks such as studying for a test, reading, or even MPS (Azevedo & Greene, 2007; Cifarelli, et al., 2010; Perry & Winne, 2006; Rosenzweig, Krawec, & Montague, 2011). The use of think-aloud event measures is an example of how using contextualized measures can be greatly beneficial to furthering the understanding an academic task. Think-alouds have added greatly to the SRL and MPS literature (Cifarelli, et al., 2010; Rosenzweig, et al., 2011). Just as a small example, using a think-aloud protocol, Cifarelli et al. (2010) illuminated a connection between more stable beliefs about mathematics and what a student does while actually solving math problems. Students who view mathematics as the conceptual application of knowledge rather than simply applying step-by-step formulas, tended to use higher level strategies during problem solution and students possessing more efficacious beliefs on average displayed more complex problem solving strategies and greater task persistence (Cifarelli et al., 2010). The usefulness of these event measures further highlights the potential for using other SRL event measures such as SRL microanalysis.

SRL Microanalysis

SRL microanalysis is a structured interview event measure designed to access specific beliefs, attitudes, and regulatory processes while an individual is engaged in a target behavior. SRL microanalysis is a hybrid assessment tool because it is technically a type of self-report measure but also is classified as an event measure because it: (1) measures SRL in relation to a single event and (2) measures behaviors, cognitions, or affective responses as they occur during authentic tasks and in real time (Cleary, 2011). However, microanalysis can be distinguished from most other event measures in terms of the use of highly specific and theoretically grounded questions that are administered at particular times during engagement (Cleary, 2011). There are several core features of SRL microanalysis that collectively distinguish it from all other SRL measurement forms. The author will highlight these features in the following paragraphs.

Core Features of SRL Microanalysis. SRL microanalytic protocols are a unique measurement format apart from most other SRL measurements in many respects. A key point to emphasize is that SRL microanalysis is grounded theoretically in the three phase model of SRL (Zimmerman, 2000). To maintain this theoretical grounding, a number of features must be present to be considered SRL microanalysis. These components, which were briefly introduced in chapter one, include: (1) individualized administration, (2) selection of target SRL processes from Zimmerman's model of SRL, (3) task-specific questions targeting SRL as a context specific construct, (4) linking the three-phase cyclical phase model and the temporal task dimensions to question administration and (5) verbatim recording and coding of participants' responses.

Individualized administration. *SRL* microanalytic questions are generally administered during an interview between one interviewer and one interviewee to reduce the effects of social influences and biases, thereby maintaining the integrity of responses (Cleary, 2011). Given that the presence of one's peers may alter responses or performance on a task, the individualized nature of the interviews is considered advantageous because it eliminates the influence of social environmental factors that can alter the contextual makeup of a performance situation. Although individualized administration is most typical, some applications have explored the utility of group administration of SRL microanalysis (Cleary, et al., 2008).

Selection of target SRL processes. The constructs measured by SRL microanalysis are selected directly from the three phase model of SRL (Zimmerman, 2000) and the respective wording for the microanalytic interview questions are derived directly from the operational definitions found within the SRL literature (Bandura, 1997; Zimmerman, 1989; 2000; Zimmerman & Martinez-Pons, 1988). For example, to microanalytically measure the construct of causal attributions for two missed basketball free-throws a researcher would first refer to the definition of causal attributions (i.e., "a person's perceptions about the reason(s) for a particular performance or outcome; Weiner, 1979) and they would adapt the wording to address the context of the measurement. As a result, the microanalytic interview question might be, "What is the main reason why you missed your last two free-throws?"(Cleary & Zimmerman, 2001). As can be seen, not only was this construct selected directly from the three phase model, but the microanalytic item wording directly corresponds to the definition of causal attributions.   The selection of constructs from this well researched theoretical model and adapting operational definitions, the construct validity of SRL microanalytic items is greatly strengthened and also provides a strong theoretical framework with which to interpret findings and develop hypotheses.

Although it is possible to measure a single SRL process or motivational belief, it is best to use SRL microanalysis to measure multiple constructs to more adequately measure the cyclical nature of SRL (Zimmerman, 2000). Therefore, researchers are encouraged to select at least one construct from each of the three phases (Cleary; 2011; Cleary, et al., 2012).

Task-specific questions targeting SRL as a context specific construct. Since the three phase model of SRL is grounded in social cognitive theory which assumes that SRL varies across contextual factors, it is important that SRL microanalytic protocols are designed to measure SRL in relation to a particular context. For example, a SRL microanalytic protocol may be designed to focus on a single, well-defined task such as shooting a basketball free-throw, but would not address more global basketball skills. This not only allows for contextualized data, but also produces a wealth of very fine grained data about SRL in relation to a particular task.

It is important that before designing SRL microanalytic measures, researchers first select a well-defined task with a clear before, during, and after. As noted earlier in the chapter, well-defined tasks are essential because these more adequately enables researchers to isolate instances of SRL that pertain exclusively to the target task of interest. If one selects an ill-defined task, a number of difficulties may arise such as difficulty discerning if SRL occurred in relation to the task of interest or a task that occurred immediately before or after the task. Moreover, ill-defined tasks would present difficulties for the next core feature to be discussed (temporal sequencing of item administration).

Another feature that ensures the context-specificity of SRL microanalysis is that SRL microanalytic measurement generally enlists only one item per self-regulatory process. The use of single item measures presents a stark contrast with questionnaires which use many items to measure a single construct. Although single item measurement is very different to more commonly used measurement formats, this feature is essential to SRL microanalysis because it minimizes aggregation and thus de-contextualization of SRL that occurs when computing composite scores. Moreover, although single item measurement may sound contrary to contemporary test-design theories that emphasize internal consistency estimates, a rich literature has shown single item measures to be highly predictive of achievement and to have strong inter-rater reliability (Cleary et al., 2012).

Temporal sequencing of SRL microanalytic questions. Another hallmark feature of SRL microanalysis is the link between question administration and the temporal dimensions of the task. SRL microanalysis was designed to tap an individual's cognitions, metacognition, and behaviors in relation to a particular task of interest while one is actually engaged in that task. Since SRL microanalysis is grounded in the cyclical model of SRL (Zimmerman, 2000) that is comprised of processes that occur at three distinct time points in relation to an event (before, during, & after), it is possible to "temporally link" question administration to the points in time that they are of greatest importance. That is, SRL microanalytic questions are administered at the precise moment that the individual should theoretically be engaged with that process. Hence, to measure forethought processes or motivational beliefs such as self-efficacy, strategic planning, goal setting, a SRL microanalytic protocol is constructed so that items measuring these forethought processes are administered during the forethought phase (i.e., before a performance attempt). In comparison to other SRL measures, this feature is advantageous because it is not based on retrospective reporting, and thus mitigates concerns associated with memory errors. Finally, this approach allows for real-time or in-the-moment measurement of regulation which many mathematicians have suggested to be better suited for identifying how students engage complex academic tasks such as mathematics problem solving.

Verbatim recording and coding of responses. Although some items, such as those measuring motivational beliefs will use a closed-ended format, microanalysis most often uses very brief and open-ended questions (Cleary, 2011). Open-ended questions require an examiner to record verbatim and later code responses into meaningful categories (Cleary, 2011). Therefore, it is also required to develop an extensive coding manual and scoring scheme to guide the interpretation of responses later. Open-ended questions can be advantageous because they are less leading than the item format found on many self-report questionnaires. That is, open-ended SRL microanalytic questions are believed to be less susceptible to response biases that can occur when an examinee can identify the more socially desirable responses as is often the case with questionnaires.

Uses and psychometric support for SRL microanalysis. A primitive or narrow form of microanalysis was first developed in the 1970s by Albert Bandura as a method to track changes in self-efficacy beliefs of phobic individuals during the course of an anxiety reduction therapy session (Bandura & Adams, 1977; Bandura, Reese, & Adams, 1982). During these studies, Bandura and colleagues asked participants to provide their efficacy beliefs to engage in tasks that increasingly induced stress in relation to a phobia of snakes. More recently, the focus of microanalysis has been expanded to a wide range of constructs and has been used for a variety of purposes, such as differentiating expertise levels and predicting future performance for purposes as diverse as: developmental and counseling psychology (Bandura & Adams, 1977; Bandura, Reese, & Adams, 1982; Gordon & Feldman, 2008), motoric processes such as shooting a free-throw (Cleary & Zimmerman, 2001; Cleary, et al., 2006) or serving a volleyball (Kitsantas &

Zimmerman, 2002), venepuncture procedures (Cleary & Sandars, 2011), and only recently, academic tasks such as reading and studying (DiBenedetto & Zimmerman, 2010) and test reflection (Cleary, et al., 2011; Cleary, et al., 2008). Although a comprehensive review of all applications of microanalysis is not possible due to space limitations, some data has amassed to suggest that SRL microanalysis has strong psychometric properties (i.e., reliability and validity).

Reliability of microanalytic protocols. Developing additional microanalysis protocols and establishing their reliability and validity is an important step in determining the practicality of using microanalysis for educational purposes. The reliability of microanalysis appears strong since many studies have reported high levels of inter-rater agreement. For example, goal setting (*Kappa* = .95; Cleary & Zimmerman, 2001), strategic planning (*Kappa* = .91; Cleary & Zimmerman, 2001; DiBenedetto & Zimmerman, 2010), performance monitoring (α=.70; Chen, 2003), attributions (*Kappa* = .89 to .98; Cleary, Zimmerman, & Keating, 2006; Kitsantas & Zimmerman, 2002), adaptive inferences (r=.93; DiBendetto & Zimmerman, 2010), and internal consistency of self-efficacy (α= .89; Kitsantas & Zimmerman, 1999).

Validity of microanalytic protocols. The validity of microanalytic protocols is also of importance. Several studies have reported data to support the validity of microanalytic protocols in terms of differential, predictive, concurrent, and convergent, and construct validity (See Table 2.4). Studies exploring the differential validity of microanalysis have shown that high achievers set more specific and process oriented goals (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002), have higher self-efficacy (Kitsantas & Zimmerman, 2002) are more strategic in their engagement (DiBendetto & Zimmerman, 2010), are more accurate in their estimation of their performance (Chen, 2003) make more adaptive causal attributions (Cleary & Zimmerman, 2001; DiBendetto & Zimmerman, 2010; Kitsantas & Zimmerman, 2002), and provide more effective adaptations in response to failure (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002).

Table 2.5

Overview of SRL Microanalysis Validity.

Study	Type of Task	Validity
Cleary and Zimmerman, 2001	Free-throw	Differential Convergent
Kitsantas & Zimmerman, 2002	Volleyball Serve	Differential Predictive
Cleary, Zimmerman, and Keating, 2006	Free-Throw	Convergent
DiBendetto and Zimmerman, 2010	Reading & Studying	Differential Convergent
Cleary, Callan, Peterson, and Adams, 2011	Reflecting on a test	Predictive Concurrent

Research has also shown that microanalytic measures can reliably predict task performance. For example, Kitsantas and Zimmerman (2002) displayed that a composite score of SRL microanalytic processes predicted a very large and significant amount (90%) of variation in the task of interest. Furthermore, some research provides initial results to suggest that SRL microanalysis may predict future performance better than aptitude questionnaires. For example, Cleary et al., (2011) used a SRL microanalytic protocol to examine students self-reflective thought processes upon the return of a course exam. In this study, microanalysis of self-reflection (satisfaction, attributions, adaptive inference) was a large and significant predictor of future test performance accounting for 23% of the variation in course grades, even after controlling for self-report on a popular questionnaire measure (MSLQ) (Cleary et al., 2011). In addition, individual

SRL microanalytic items can also serve as strong predictors of later achievement. Just one example can be found within the aforementioned study where a causal attributions item accounted for a significant amount of the variation (9.4%) in future achievement above and beyond the self-report questionnaire (Cleary et al., 2011).

The convergent validity of SRL microanalysis protocols has been explored by examining the correlations between SRL phase processes. For example, Cleary, Zimmerman, & Keating, (2006) found significant positive relationships between attributions, adaptive inferences, and self-evaluations. Further, generation of more adaptive attributions significantly predicted greater strategy use (Cleary et al., 2006) or the type of strategy reported (Cleary & Zimmerman, 2001). Strategic planning and goal–setting as measured by SRL microanalysis is significantly correlated to performance phase processes such as strategy use and self-monitoring (Cleary & Zimmerman, 2001; DiBendetto & Zimmerman, 2010). In addition, performance phase SRL microanalytic measures such as *monitoring and strategy use* significantly correlate with self-reflection phase processes such as satisfaction, attributions, and self-evaluations (DiBendetto & Zimmerman, 2010).

Purpose of this study

The primary purposes of this study are to develop and validate a microanalytic protocol in terms of convergent, divergent, and predictive validity. In relation to the predictive validity of SRL microanalysis, a potential criticism of event measures such as SRL microanalysis could be that such highly specific and fine grained analyses may lack generalizability to other meaningful academic outcomes. Historically, SRL microanalytic research has usually been compared to outcome measures that are highly specific to the focus of the SRL protocol. Thus, a further understanding of how SRL microanalysis may relate to more global outcomes could be of importance. In relation to academic domains, it could be of pertinence to identify if SRL microanalysis may be related global indicators of academic achievement such as standardized test scores or course grades. The current dissertation addresses this potential criticism of SRL event measures by examining the relationship between event based measures (i.e., SRL microanalysis) and aptitude measures (questionnaires) and examining the predictive utility of SRL microanalysis for both highly specific outcomes and more global, generalized outcomes as well.

Chapter 3 – Methodology

Participants

The sample consisted of 83 eighth grade students attending several middle schools in a large, Urban school district in the Midwestern region of the United States. The sample was selected from a larger population of students enrolled in eight sections of eighth grade mathematics classes. In total, approximately 208 students were enrolled in these classes with 103 students returning completed consent-assent forms. Final analyses were conducted with 83 students rather than 103 due to missing data (discussed in chapter 4). The sample of participants consisted of 45 males (44%) and 58 females (56%). Demographic data collected from the school district indicated that the sample was 49% Hispanic-Latino, 46% African-American, two percent Caucasian, and two percent Asian-American. The majority of the sample (89%) met eligibility requirements for free or reduced lunch. Due to the verbal requirements of the SRL microanalytic interview and the necessity to articulate oneself effectively, non-fluent English speakers such as English Language Learners and students receiving special education services were not included in this study.

Recruitment Procedures

The primary researcher attended eight classrooms to recruit students for the study. During recruitment, the researcher explained to the students that the research project would consist of one 25-30 minute, individualized testing session and one posttest session with an entire class of students. As part of the individual test sessions students would answer some interview questions while they do a few math problems, and then complete a few surveys about their thoughts and behaviors in math classes. The primary researcher explained that a posttest session would occur during their regular mathematics class about two weeks after the individual interview. The posttest would require students to complete a set of math problems similar to those administered during the testing session. Informed consent forms were explained and distributed during the initial recruitment meeting. Only students who returned informed consent documents signed by their parents and themselves were allowed to participate in this study.

Measurement

Measures of SRL

Several measures were used to assess student SRL; student self-report questionnaires, a teacher rating scale, and SRL microanalytic questions.

Self-Regulation Strategy Inventory Self-Report (SRSI-SR). The SRSI-SR is a 28-item measure of self-regulation with three subscales; Managing Behavior and Environment, Seeking and Learning Information, and Maladaptive Regulatory Behavior (Cleary, 2006). For the purpose of this study, the SRSI-SR was customized slightly to reflect cognitions and behaviors specific to student's mathematics class. Although the original format of the SRSI-SR is comprised of three subscales, for ease of use with eighth grade students, the current study collapsed the Managing Behavior and Environment subscale and the Seeking and Learning Information subscales to generate a single composite scale of adaptive SRL (Cleary & Chen, 2009). Prior research has shown this combined adaptive SRL composite to be reliable ($\alpha = .89$) and highly predictive (Cleary & Chen, 2009). This scaled used 5-point Likert scale ranging from 1 (almost never) to 5 (almost always). The Maladaptive SRL subscale has also shown acceptable reliability ($\alpha =.67$) and high predictive validity (Cleary, & Chen, 2009). Example items for the Adaptive SRL subscale include, "I make pictures or drawings to help me learn math concepts," "I tell myself to keep trying when I can't learn a topic or idea", and "I try to study in a place that has no distractions (e.g., noise, people talking)." High scores on the Adaptive SRL composite indicate that the student reported using adaptive regulatory behaviors to manage their behavior and environment on a frequent basis. On the other hand, the Maladaptive SRL subscale, served as an indicator of negative regulatory behaviors. Example items for this subscale include, “I wait to the last minute to study for math tests,” “I give up or quit when I do not understand something”, or “I avoid asking questions in class about things I don’t understand." High scores on the Maladaptive SRL subscale indicate that students engage in maladaptive regulatory behaviors on a frequent basis. The SRSI-SR has been shown to reliably differentiate between high and low achievers in urban (Cleary, 2006) and suburban contexts (Cleary & Chen, 2009).

Self-Regulation Strategy Inventory-Teacher Report Scale (SRSI-TRS). The SRSI-TRS is 13-item measure of regulation developed to parallel the student version of the SRSI (Cleary & Callan, 2013). The teacher report scale was designed to measure the frequency of students’ regulated behaviors, such as self-control, help seeking, and motivated behaviors, in classroom contexts. Consistent with the other measures used in this study, the teacher rating scale was also customized to reflect behaviors specific to a mathematics class. This measure uses a 5-point Likert scale ranging from 1 (almost never) to 5 (almost always) and was shown to have high internal reliability ($\alpha = .97$; Cleary & Callan, 2013). Initial results suggest that the SRSI-TRS is highly predictive of academic achievement and has been shown to display convergent validity with the student self-reports (Cleary & Callan, 2013). High scores on the teacher rating scale indicate of frequent displays of adaptive regulatory behaviors by students in the mathematics classroom setting. An example of an item that can be found on the TRS is, “The student asks insightful questions in class.” Including this scale in the assessment battery was important because it provided a measure of student SRL that did not rely on student self-report data.

SRL microanalytic measurement. Several microanalytic questions were used to examine students' forethought (i.e., goal-setting and strategic planning), performance control (i.e., performance-monitoring), and self-reflection phase processes (i.e., attributions and adaptive inferences) during a mathematics problem-solving practice session. SRL microanalytic items measuring forethought processes were administered before students began a mathematics problem solving practice session, performance control items were administered immediately after performance but before performance feedback was administered, and self-reflection items were administered following problem-solving performance feedback.

Coding and scoring of SRL microanalytic responses. SRL microanalytic questions are generally open-ended in format, and therefore prior research has developed a process for transforming students' qualitative responses into metric values. The metric data that is generated is preferable because it enables a wider range of statistical analytic procedures. The data transformation process entails two separate but related steps of (1) coding and (2) scoring, which are both guided by prior SRL research and theory. Except for the Metacognitive Monitoring items, the SRL microanalytic items used for the current study were open-ended and thus the coding and scoring processes were of primary importance for this study.

Coding. Guided by prior SRL, SRL microanalytic, and MPS research, the author created a structured manual for coding student's responses. Prior SRL research was first examined to highlight important features of each SRL measured in this dissertation. For example, research in the area of goal-setting has identified the distinction between outcome and process goals and the level of specificity of one's goals to be of importance (Schunk, Pintrich, & Meece, 2008; Zimmerman, 2008b). In lieu of this research, student's responses to the SRL microanalytic Goal-Setting item were categorized as process-specific, process-general, outcome-specific, or outcome-general (see appendix B for details and examples). However, since it is possible that students could generate responses to the SRL microanalytic Goal-Setting item that did relate to any one of these categories, it was also important to include three additional categories of other, non-task, or no-goal (see appendix B for details and examples). In contrast, research suggests that students who identify effective strategies while planning, solving, or reflecting about a task performance tend to outperform their peers who do not use such strategies. In consultation with the MPS research literature, the author identified strategies that are would facilitate achievement on an MPS task (see appendix B). This list of strategies, "the MPS strategy," served as the basis for coding students' responses for the SRL microanalytic Strategic Planning, Strategy Use, Attributions, and Adaptive Inferences items. Again, the author included the categories of other, non-task, and none to capture responses that did not fit into the MPS strategy category.

Scoring. After student's responses were coded into one or more categories, it was necessary to assign a quantitative value to response categories. Using prior research, (Cleary et al., 2011) a standardized process for scoring the responses was generated (see appendix C). For example, since research suggests that process-specific goals are more adaptive than the other goal-setting coding categories, process-specific goals would be assigned the greatest quantitative value. As a brief summary, the scoring for goal-setting was as follows: process-specific equals three, process-general equals two, outcome-specific equals two, and outcome-general equals one. Given that it is considered less adaptive to generate no goal or to generate a "non-task" goal (i.e., goals that are irrelevant to the current task), these categories were assigned a value of negative one. However, negative value responses were not assigned for an item if any other code-able response was provided. For example, a student would not be penalized if he or she provided an adaptive response and also stated a maladaptive response. Finally, goals that simply did not fit into the coding system categories (i.e., other) were assigned a value of zero

The scoring processes for the strategic planning, strategy use, attributions, and adaptive inferences were driven by the number of MPS strategies listed. Therefore, a score of one point was assigned for each aspect of the MPS strategy that was identified by a response. Similar to the goal-setting item, responses that indicated task irrelevant responses (i.e., non-task) or a "don't know" response were considered the least adaptive and were assigned a score of negative one point. Again, negative values were not assigned if at least one other adaptive response was present. "Other" responses were given a score of zero.

Forethought - goal-setting. Consistent with prior research, (Cleary & Zimmerman, 2001) goal-setting was measured using a single, contextualized question. Prior to solving the math problem worksheet, students were allowed to briefly preview the math word problems. The problems were left in view to allow the student to preview but not begin solving the problems. Immediately after the preview, the examiner read the goal-setting question, "Do you have a goal in mind as you prepare to practice these math problems? If so, what is it?" Participant responses were recorded verbatim and coded independently by two coders into one of the following categories: process-*specific, process-general, outcome-specific, outcome-general, other, non-task, and no goal* (see appendices B and C). A similar coding scheme has been used in prior research (Cleary & Zimmerman, 2001), which yielded high levels of inter-rater reliability (kappa = .95). Furthermore, a similar item has been shown to significantly differentiate expertise levels in motoric contexts and has been shown to correlate with other regulatory beliefs (Cleary & Zimmerman, 2001).

Forethought - strategic planning. This one item forethought measure examined the nature of students' approach to solving the math problems. Immediately after the goal-setting item, participants were asked, "Do you have any plans for how to successfully complete these math problems?" This item is a variation of a similar microanalytic question that has been used in prior research (DiBenedetto & Zimmerman, 2010). Prior research has shown a similar strategic planning microanalytic measure to exhibit high inter-rater reliability and to differentiate between experts, non-experts, and novices (kappa = .91) (Cleary & Zimmerman, 2001; DiBenedetto & Zimmerman, 2010). All responses were coded independently by two raters using a coding scheme developed from mathematics literature, expert consensus opinion, prior coding schemes, and pilot testing. The possible coding categories included: *MPS strategy, other, non-task, and don't know / no plan* (see appendices B and C). Similar to prior research, (DiBenedetto & Zimmerman, 2010) the score for this question entails the total number of appropriate strategies reported by the students.

Performance control - strategy use. Immediately after completing the first word problem during the math problem-solving practice session, the interviewer prompted, "Tell me all of the things that you did to solve this problem" to determine the quality and number of strategies enlisted by the student to complete the word problem. If a code-able response was provided, the examiner would prompt with, "Is there anything else that you did?" for a maximum of two prompts. Prior research has shown a similar item to differentiate expertise levels and predict future performance (Zimmerman & Kitsantas, 2002). Responses were recorded verbatim by the interviewer and then later coded by two independent raters using a coding scheme developed from mathematics literature, expert consensus opinion, prior coding schemes, and pilot testing.

The possible coding categories included: *MPS strategy, other, non-task, and don't know / no plan* (see appendices B and C).

Performance control – performance monitoring/calibration. Immediately after completing the three mathematics word problems, students' metacogntive monitoring was assessed with another type of microanalytic measure. For each of the three problems, the examiner asked: "how sure are you that you solved this problem correctly?" Students then responded on a 7-point Likert scale ranging from 1 to 7 with the following anchors, 1(Not Sure), 3(Somewhat Sure), 5(Pretty Sure), and 7(Very Sure) for each individual math item. Students were provided with both a visual depiction of the scale and were read the anchors along the 7-point Likert scale to aid in their ratings. A similar methodology has been used in prior research has been found to possess acceptable reliability ($\alpha = .70$) and to differentiate achievement groups (Chen, 2003). However, of primary interest was to examine the level of students' calibration or the consistency with which their performance estimates compared to their actual performance on the mathematical problems. Using guidelines put forth by Pajares and Miller (1997) two separate score were calculated (i.e., calibration bias score and calibration accuracy; Pajares & Miller, 1997; Schraw, 1995; Keren, 1991). Calibration bias refers to the direction of the error in student's estimations as compared to actual performance. To compute the calibration bias score, student's word problem performance (1 "correct" or 7 "incorrect") for each word problem was subtracted from their confidence levels for each math problem. For example, if the student reported minimal confidence in their performance (1), and answered the item incorrectly (1), the resulting calibration bias score reveals no bias ($1 - 1 = 0$). However, if the student provided high levels of confidence for their performance (7) but answered the item incorrectly (1), the calibration bias score for that item would reveal a large, positive bias, also known as overestimation (7 – 1 = 6). Negative calibration bias scores indicate that the student provided lower confidence estimates than their performance, the bias score would reveal under-estimation (e.g., 3 – 7 = -4). This procedure resulted in three values that were subsequently averaged to produce a total the calibration bias score. In contrast, *calibration accuracy* refers to the magnitude of judgment error without regard to the direction of the judgment error (i.e., overestimation or underestimation). This value was computed by subtracting the absolute value of each of the three calibration bias scores from a value of six.

For ease of interpretation, scores for the calibration items were reversed such that high scores on this scale indicate that the student was more accurate in their prediction. The mean score across all three subsequent values was used for analysis purposes.

Self-reflection - causal attribution. A single item microanalytic attribution question was administered after students completed all mathematics problems. In reviewing the three word problem worksheets, the examiner identified the first *incorrectly solved problem*. While presenting the item to the student, the examiner stated, “You answered this item incorrectly. “Why do you think you were unable to get the right answer for this problem?” The examiner inquired, “Is there another reason?” after each response for a maximum of two times or until the participant did not provide an additional attribution response. Each response was recorded verbatim and independently coded by two raters into one of seven categories: *MPS strategy, other, non-task, and don’t know / no attribution* (see appendices B and C). The coding scheme was determined from pilot testing, review of relevant research, and from existing coding schemes.

A similar item has been used in prior microanalytic research and has shown acceptable reliability and validity (Cleary, Zimmerman, & Kitsantas, 2006; Kitsantas & Zimmerman, 2002;

Kitsantas, Zimmerman, & Cleary, 2000). Inter-rater reliability coefficients for similar measures have been extremely high ranging from .89 to .98 (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). Further, the use of similar items in prior research has differentiated between achievement groups (Kitsantas & Zimmerman, 2002) and displayed high convergent validity such that more adaptive attributions were correlated with higher self-efficacy, greater task skill, more positive self-reactions, and greater task interest (Kitsantas & Zimmerman, 1999).

Self-reflection - adaptive inferences. This one-item measure of adaptive inferences was administered following the attribution question. That is, the examiner assessed adaptive inferences following a failure experience for the last item that the examinee answered incorrectly, by asking, "If you were given another chance to do a similar math problem, what would you need to do to do well?" Similar to the procedures used for the strategic planning item, responses were recorded verbatim and coded independently by two raters. Responses were coded in to the following categories: *MPS strategy, other, non-task, don't know / no-adaptive inferences* (see appendices Band C). This adaptive inference item is a slight variation on an item used in prior research that has shown extremely high inter-rater reliability (r = .93) and has been shown to differentiate between achievement groups (DiBendetto & Zimmerman, 2010).

Measures of Personality

Self-Esteem Questionnaire (SEQ). The Self-Esteem Questionnaire (Dubois, Felner, Brand, Phillips, & Lease, 1996) consists of 42 items that employs a 4-point Likert scale ranging from (1) *strongly disagree* to (4) *strongly agree*. There are six subscales measuring different facets of student self-esteem including: peer relations (8 items), family (8 items), school (8 items), sports/athletics (6 items), body image (4 items), and global feelings of self-worth (8 items). Two subscales were administered for this study (peer relations and body image subscales). The peer relations subscale includes eight items and identifies a student's self-esteem feelings in relation to their social relationship. A sample item from this subscale is, "I have as many close friends as I would like to have." This scale has been shown to have high internal reliability (α =.85). The body image subscale consists of four items and describes an examinee's content with their physical appearance. A sample item from this subscale is, "I am happy with the way I look." This scale has also been shown to possess high internal reliability (α =.82). High scores on these subscales indicate greater reported self-esteem. These subscales were chosen because they are theoretically un-related to the academic SRL processes being measured by the SRL rating scales and SRL microanalytic interview being administered in this study.

Dependent measures – Problem solving achievement

Math achievement was measured by three distinct indices that varied across breadth and the proximity to the testing session specificity: (a) performance on three MPS items completed during the microanalytic interview (Interview MPS), (b) a 15-item MPS posttest (Posttest MPS) that tapped a wider range of MPS skill than the Interview MPS measure, and (c) a norm-referenced test of global math skill, the Measure of Academic Progress (MAP).

Interview MPS. Students completed three MPS items during an interview with a trained graduate student. This measure of MPS skill consisted of items that were intended to tap into a range of math skills. The researcher enlisted the expertise of mathematics experts to select and order three MPS items from easiest to hardest problems. Collectively, the researcher and math experts judged that the first MPS item tapped math skills that should have been developed well before the eighth grade. The second item was judged as more difficult than the first item and it was expected that this item would present difficulty for many students while higher achieving students would succeed on this item. The third item was judged to be the most demanding MPS task and tapped a skill range that was well beyond the math skills expected of an eighth grade student. A fourth "challenge" MPS item was initially included in this measure but later removed. This item was only to be administered if a student completed the three MPS items correctly. However, no student completed all three items completely correctly and thus, the challenge item was removed. A copy of the items included in this measure can be found at the end of this document (Appendix A). Performance on the Interview MPS items was determined with a rubric created in collaboration between the primary researcher and a middle school math teacher. Points awarded for each problem ranged from 1-7 with 1 representing an incorrect response that evidenced major flaws in the problem solving procedures and 7 representing a correct answer that evidenced no flaws.

Posttest MPS. Students completed a 15-item problem solving measure (α=.77) approximately two weeks after the microanalytic interview. This outcome measure served as the problem-solving specific mathematics achievement outcome and an indicator of student MPS skill. The Posttest MPS consisted of 15 algebraic word problems (see Appendix D). The items ranged in difficulty to best target an array of student mathematical abilities. Normative data regarding prior items from the National Assessment of Educational Progress (NAEP) was enlisted to guide the selection and development of MPS items across a variety of mathematical and developmental skill ranges. The items included on the Posttest MPS were judged to range from MPS items that most fourth grade students should answer correctly to MPS items that would present a challenge for many 12th grade students. MPS skill ranges between these two extremes were tapped including items that were considered easy, moderately difficult, and difficult for each of MPS skill levels of fourth graders, eighth graders, and 12th graders. Two content area experts were enlisted for the selection of the mathematics items. Similar to the

Interview MPS grading procedures, performance on the Posttest MPS items was determined by a rubric created in collaboration between the primary researcher and a middle school math teacher.

Global math achievement - Measure of Academic Progress (MAP). The Measure of Academic Progress (MAP) is a norm-referenced computer-adaptive test designed to measure achievement of elementary and secondary school students in five areas: reading, language, mathematics, general science, and science concepts. For the purpose of this study, only performance on the mathematics section is of interest and therefore the researchers examined only students' mathematics composite scores. The mathematics composite is divided into eight sub-areas: number/numeration systems, operations/computation, equations/numerals, geometry, measurement, problem solving, statistics/probability, and applications. Each sub-area is tapped by a minimum of 7 items. MAP scores are reported in 'RITs' (Rasch units) which range from 140 to 300. The MAP test is has strong reliability and validity support. Specifically, the reliability of the MAP test is established via test-retest reliability (.77 to .94) and small conditional standard errors of measurement. The MAP test has strong differential validity and concurrent validity with other achievement measures such as the ALT (Cizek, 2005). The MAP test is administered three times per school year (Fall, Winter, and Spring) and performance on the second (winter) administration is used as a measure of general mathematics achievement.

Procedures

Materials

Materials required for this study included: lined paper and pencils with an eraser for students to work out the mathematics problems, the mathematics problem worksheet, the SRL microanalytic interview, an audio recorder, and questionnaires. Students completed the mathematics problems, the SRL interview, and self-report measures during a single 25-30 minute session. The SRL microanalytic interview protocol was strategically embedded during the before, during, and after dimension math problem-solving activity. Thus, the math problem-solving task used in this study involved students solving three algebra problems that are administered as part of a SRL microanalytic protocol. Before detailing the nature of the mathematics problem-solving activity and embedded microanalytic assessments, the author will first describe some of the preliminary procedures related to the development of the microanalytic protocol and coding procedures that occurred prior to the study.

Preliminary Procedures

In terms of preliminary work, a SRL microanalytic protocol was created to assess student SRL during solving of algebraic word problems. This SRL microanalytic protocol consisted of six SRL microanalytic measures targeting goal-setting, strategic planning, strategy-use, metacognitive monitoring, causal attributions, and adaptive inferences. The protocol was designed in such a way that the SRL microanalytic items would be administered while participants engaged with a three-item MPS task (see Appendix A).

Nature of the MPS task. The SRL microanalytic protocol was administered in relation to a set of three multistep word problems that comprised the Interview MPS measure. A range of item difficulties were included to tap a wider array of skill levels and increased the probability that students of differing abilities experienced at least one instance of problem solving failure. The researcher was interested in ensuring that all participants were unsuccessful on at least one item because problem-solving failure was essential because SRL microanalytic self-reflection items were targeting participant reflections following a failure experience. The MPS task was set up so that the MPS items increased in difficulty with the question that was judged to be easiest first and the most difficult item last. At the time that students were expected to solve the MPS items, they were provided each MPS item individually and blank scrap paper to work out operations. There was not a set time limit for the problem solving activity.

Pilot testing of SRL microanalytic protocol. Next, the SRL microanalytic protocol was piloted with a small sample of middle school students of varying achievement levels. Prior to piloting, there were several questions regarding the best format and administration for some of the microanalytic questions. For example, the author questioned whether the best approach would be to ask students to report their strategic plans for each individual MPS item or if participants should report their strategic plan during a single instance before solving any MPS problems. Through piloting the author determined that asking students to report strategic plans for each MPS item may inflate the use of forethought regulation by prompting students that planning activities were expected. In addition, pilot testing allowed for fine tuning of MPS item wording and the data collected from the piloting procedures was instrumental in guiding the development of a coding and scoring template.

SRL Microanalytic Interviewer training. Prior to data collection, several graduate students were trained to administer the SRL microanalytic interviews. At the time of training, all graduate students had previously completed at least one graduate level course in standardized assessment procedures. Further, examiners were provided explicit and intensive training in SRL microanalytic interview procedures. Following explicit training, all students practiced administration with the lead researcher until all scripts, prompts, and response contingencies were completed with 100% accuracy.

Overview of MPS Practice Session Procedures

The next section describes the procedures that occurred during the data collection phase of this dissertation project. To ensure clarity, the author will describe the procedures in relation to the MPS practice session, which is the same time that students completed the SRL microanalytic interview. Specifically, the author will describe the procedures that occurred immediately before the MPS practice session, during the MPS practice session, and after the MPS practice session. Before describing these procedures the author should note that it was not

Table 3.1

Summary of Procedures Before, During, and After MPS Practice Session.

Data Collection Phase	Procedures
Before MPS Practice	(1) Interviewer meets student (2) Interviewer accompanies student to private interview location (3) Interviewer introduces task, reviews consent, answers questions
During MPS Practice	(1) Student previews MPS items (2) Forethought SRL microanalysis questions administered (3) Student completes MPS items (4) Performance Control SRL microanalysis questions are administered (5) Interviewer presents first incorrect MPS item (6) Self-Reflection SRL microanalysis questions are administered
After MPS Practice	(1) Student completes SRL self-report questionnaires (2) Student completes self-esteem questionnaire (3) Interviewer returns student to class (4) Teacher completes ratings of student SRL (5) Posttest MPS items are administered two weeks later

possible for all participating classrooms to be targeted for data collection simultaneously. Rather, research assistants' availability was matched with participants across three individual classrooms. Research assistants were not scheduled to conduct interviews with students in the fourth classroom until all interviews were completed for one of the first three classrooms. To ensure uniformity of experience across all participants, the author made sure that the time interval between the SRL microanalytic interview administration and Posttest MPS was approximately equivalent for all participants.

Before the MPS practice session. Before the MPS practice session, a trained graduate student accompanied a participant from their classroom to an individual office. The graduate student then introduced the nature of the task to individual students, detailed the general purpose, re-emphasized primary informed consent policies, and answered any questions that the participant may have had.

During the MPS practice session. After addressing any questions or concerns of the participant, the MPS practice session began. The MPS practice session consisted of students completing three mathematics words problems and responding to several SRL microanalytic interview questions before, during, and after completing the problems. Thus, the SRL micronalytic interview was purposefully embedded at different parts of the practice session in order to evaluate the different phase-specific regulatory processes (forethought, performance, and self-reflection). During the MPS practice session, the examiner recorded all student responses verbatim and interviews were audio recorded to ensure transcribing accuracy. All interviews were conducted individually with students in a school office or classroom that was not occupied by any other students or school staff. An individualized assessment approach is consistent with prior microanalytic research (Cleary, 2011, Cleary, et al., 2012) and served to eliminate the potential adverse impact of social norms and peer comparisons. After completing the mathematics problems and responding to all SRL microanalytic items, the MPS practice session was finished. Each individualized MPS practice session lasted approximately 20 to 30 minutes.

Administration of the SRL microanalytic protocol. In the next section, the author will provide a more detailed description of the administration procedures for the SRL microanalytic protocol. The SRL microanalytic protocol was administered during the MPS practice session.

Each SRL microanalytic question was administered at a specific time during task engagement, in relation to the set of algebra problems, so that the temporal dimensions of the feedback loop (i.e., forethought, performance, self-reflection) was linked to the temporal dimensions of the task (i.e., before, during, and after; Cleary, 2011; Zimmerman, 2000).

Before task – forethought microanalysis. Prior to students beginning mathematical computations, the examiner administered two forethought phase questions (goal setting & strategic planning). Immediately before students attempted to solve the math problems, the examiner presented a worksheet of mathematics word problems. The examiner instructed the student to preview the questions but not begin any mathematical computations. Immediately after previewing, the examiner assessed goal-setting for the problem solving task. Following the goal-setting item, the examiner administered the strategic planning item. The goal-setting item was administered prior to the strategic planning item because according to the three phase model, students typically select a desired outcome prior to deciding what they will do to arrive at that outcome (Zimmerman, 2000).

During task - performance microanalysis. Next, the examiner provided the student with a pencil and paper, and instructed him or her to begin working on the algebra problems. The examiner provided each mathematical problem individually and then stated, "Go ahead and do this problem." Given that math problem-solving is linked to the performance phase of the three-phase cyclical loop, the examiner administered the performance monitoring item immediately after students have finished solving the mathematics problem, but before they receive feedback on the task. Although performance phase questions are typically administered during a task, they were administered immediately after performance because this procedure does not disrupt the examinees' natural engagement in performance monitoring or prompt it to occur. This approach is supported in prior research (Kitsantas & Zimmerman, 2002), and is considered appropriate because the time lag between task performance and assessment was so minimal. Furthermore, the timing of the performance monitoring item is considered appropriate because accurate prediction of performance immediately after problem completion is highly contingent upon the utilization of monitoring processes during performance.

After task - reflection microanalysis. Self-reflection phase processes take place following performance or when performance feedback is made available. In this study, two self-reflection phase processes (i.e., attributions and adaptive inferences) were assessed following the completion of the three algebra problems and administration of the performance monitoring item. Using an answer key, the examiner immediately checked the students' answers, directed their attention to the first mathematic problem answered incorrectly, and then administered the microanalytic attribution question. Student reflection focused on the first incorrectly answered item rather than later, more difficult items, because student attribution responses may be skewed (i.e., toward item difficulty responses) if failure is reflected upon a math item that greatly exceeded their skill level. In the case that the examinee correctly solved all mathematics items, the student was not administered this item and was dropped from this question and subsequent analyses.

Immediately following the attribution question, the adaptive inferences question was administered. After the adaptive inferences question, the microanalytic interview was complete and students were provided instructions to complete the survey measures.

After the MPS practice session. Following the solution of math word problems and answering all SRL microanalytic questions, students completed several self-report inventories (i.e., SRSI-SR-Adaptive, SRSI-SR-Maladaptive, and Self-Esteem Questionnaire). Although the author considered counterbalancing the order of administration for the microanalytic protocol and self-report surveys, it was decided that administering self-report surveys prior to microanalysis would be problematic because of the potential influence of the questionnaire items on student responses to the open-ended microanalytic interview questions. In other words, the self-report questionnaires used in this study could have primed students to provide answers during the SRL microanalytic interview that they may not have otherwise listed during the SRL microanalytic interview.

Approximately two weeks after the completion of the MPS practice session, students completed the Posttest MPS task during class time. As opposed to the individual testing session that was used for the SRL microanalytic interview and Interview MPS, the Posttest MPS was administered in group format to a classroom of participants. The Posttest MPS was proctored by the lead researcher during which time students were provided an hour to complete the posttest items. Although student's performance on MPS items completed during the SRL microanalytic interview (Interview MPS) were examined as one indicator of MPS skill, a posttest of MPS skills was included to provide a more comprehensive measure of MPS skill that was not measured concurrently with SRL microanalytic measurement.

Moreover, the Posttest MPS is considered of importance for three primary reasons. First, the context of completing the Posttest MPS as a group is a more authentic academic task in comparison to the Interview MPS. That is, completing math problems while in a classroom of multiple students is a more authentic academic performance situation than an individualized interview in a separate classroom. In addition, although unlikely, it could be argued that the microanalytic interview prompts may slightly influence students' performance or engagement in SRL processes. Therefore, using a posttest not directly linked to the SRL microanalytic interview and that provided no such prompts, protected against this potential confound. Finally, due to the individualized format of the interviews, some students completed the interview at an earlier date than other students. For this reason, the posttest MPS was useful in preventing the potential confound of information sharing between interviewees.

The teacher completed the teacher rating scale (SRSI-TRS) for each student participant during the time when SRL microanalytic interviews and Posttest MPS were being conducted for their students.

Coding and Scoring Procedures. Following the completion of all problem solving interviews, self-report questionnaires, MPS posttests, and teacher ratings, the SRL microanalytic protocols were coded and scored by two independent, trained coders. The coders were blind to the study design and objectives and used a comprehensive coding and scoring scheme to guide their coding of participant responses. The two coders were blind to the study design and objectives.

Prior to coding, the primary researchers created a coding manual (See appendix B) that described possible coding categories, criteria for inclusion, and examples of all categories. The two graduate students were then provided extensive training in the coding procedures consisting of explicit instruction in the coding manual and several coding practice sessions. Upon achieving perfect reliability during practice coding sessions, the graduate students began coding of the interviews collected for this study. Each protocol was coded independently by both of the graduate students and the primary researcher. The final codes for data analytic procedures consisted entirely of the coding results of the graduate students with the exception of instances of disagreement between the two coders. In these cases, the primary researchers' coding was used to determine final codes. The inter-rater agreement rates were high for all items (see Table 3.2).

Table 3.2

Inter-rater reliability of SRL microanalytic measures

SRL Microanalysis Measure	Percent Agreement
Goal Setting	98.6%
Strategic Planning	96.3%
Strategy Use	96.8%
Attributions	96.4%
Adaptive Inferences	94.3%

Note. The Metacognitive Monitoring items were not included in the inter-rater reliability analyses because these items are metric scales and do not require coding. The values in this table reflect the inter-rater agreement between the two graduate student researchers prior to coding adjustments in cases of coding disagreement.

Analyses & Research Questions

The following section presents the primary research objectives of the current study as well as selected statistical procedures and a priori hypotheses where relevant.

Convergence and Divergence: SRL Microanalysis, Questionnaires, and Teacher Ratings

A primary purpose of this study was to examine whether SRL microanalytic protocols converged with student self-report SRL questionnaires and teacher ratings of student SRL and if they diverged from student reports of theoretically unrelated constructs. The convergent and divergent validity of SRL measurement tools is represented by three specific research questions outlined in Table 3.3.

Table 3.3

Convergence and Divergence of SRL Measurement Tools

Research Objective	Statistics	Hypotheses
Convergence: • SRL microanalysis • SRL questionnaires (SRSI-A & SRSI -M)	• Pearson correlations between SRL microanalytic measures and SRL questionnaires (SRSI-Adaptive & SRSI-Maladaptive)	• Positive correlation between SRL microanalytic measures and SRSI-Adaptive. • Negative correlation between SRL microanalytic measures and SRSI-Maladaptive
Convergence: • SRL microanalysis • SRL teacher ratings (SRSI-TRS)	• Pearson correlations between SRL microanalytic measures and SRL teacher ratings (SRSI-TRS)	• Positive correlation between SRL microanalytic measures and SRSI-TRS
Divergence: • SRL microanalysis & self-esteem • SRL questionnaires & self-esteem • Teacher ratings & self-esteem (SEQ)	• Pearson correlations between SRL-microanalytic measures and self-esteem questionnaire • Pearson correlations bewteen SRL questionnaires (SRSI-Adaptive & Maladaptive) and self-esteem • Pearson Correlations between teacher ratings (SRSI-TRS) and SEQ	• Non-significant correlation between SRL microanalytic composites and self-esteem • Non-significant correlation between questionnaires and self-esteem • Non-significant correlation between teacher ratings and self-esteem

Note. SRSI-A = Self-Regulation Strategy Inventory - Adaptive subscale. SRSI-M = Self-Regulation Strategy Inventory - Maladaptive subscale. SRSI-TRS = Self-Regulation Strategy Inventory – Teacher Rating Scale. SEQ = Self-Esteem Questionnaire.

Predictive validity of SRL microanalysis

Another key objective of the current dissertation was to examine the predictive validity of the SRL microanalytic protocol relative to other SRL measurement tools, such as self-report questionnaires and the teacher rating scale. This study examined if SRL microanalysis explained unique variation in mathematics achievement across three types of achievement measures. Two of the achievement measures were similar (Interview MPS and Posttest MPS) in that they both

Table 3.4

Unique Predictive Validity of SRL Microanalysis

Research Question(s)	DV	Statistics
1. Interview MPS Performance Do SRL microanalytic measures explain unique variation in interview MPS performance after controlling for prior math achievement and adaptive and maladaptive strategy use as reported on a self-report questionnaire?	Interview MPS Performance • MPS items • Completed during microanalytic Interview • Limited range of MPS skills targeted.	Hierarchical Regression STEP 1: Prior Achievement • 7th Grade WKCE STEP 2: Questionnaires ○ SRSI-Full Scale STEP 3: SRL Microanalysis
2. Posttest MPS Performance Do SRL microanalytic measures explain unique variation in posttest MPS performance after controlling for prior math achievement and adaptive and maladaptive strategy use as reported on a self-report questionnaire?	Posttest MPS Performance • 15 MPS items • Completed two weeks after Micro-interview • More comprehensive measure of MPS skill.	Hierarchical Regression STEP 1: Prior Achievement ○ 7th Grade WKCE STEP 2: Questionnaires ○ SRSI-Full Scale STEP 3: SRL Microanalysis
3. MAP Do SRL microanalytic measures explain unique variation in standardized math performance (MAP score) after controlling for prior math achievement and adaptive and maladaptive strategy use as reported on a self-report questionnaire?	MAP Scores • District-wide standardized exam • Many items across range of mathematics skills. • Completed two – three weeks after Micro-interview	Hierarchical Regression STEP 1: Prior Achievement ○ 7th Grade WKCE STEP 2: Questionnaires ○ SRSI-Full Scale STEP 3: SRL microanalysis

addressed MPS skill. As indicated previously, the authors elected to include both, however, the Posttest MPS is considered the primary MPS outcome of interest given the relative superiority in measurement independence, authenticity to academic performances, and breadth of MPS skill in comparison to the Interview MPS measure. The third mathematics achievement task consisted of a standardized mathematics test that will provide a more global indicator of students' mathematics achievement (MAP Scores). Three research questions are presented in Table 3.4.

Table 3.5

Hypothesis for Predictive Validity Analyses.

Dependent Variable	Hypotheses: SRL Questionnaire	Hypotheses: SRL Microanalysis
Interview MPS (Proximal MPS)	Not predictive of Interview MPS	Significantly predictive of Interview MPS
Posttest MPS (Distal MPS)	Not predictive of Posttest MPS outcomes	Significantly predictive of Posttest MPS outcomes
MAP Score (General Math Skill)	Significantly predictive of MAP scores	No a priori hypothesis (Exploratory analysis)

Note. Hypotheses: SRL Questionnaires indicates the a priori hypotheses established for the two SRL questionnaires used in this study (SRSI-Adaptive & SRSI-Maladaptive). Hypotheses: SRL Microanalysis indicates the a priori hypotheses established for the SRL microanalytic measures used in this study.

CHAPTER FOUR
Results

This chapter examines the results from the data analytic techniques performed. Before engaging in statistical analyses to address the research questions, a factor analysis was conducted to determine the most appropriate composition of SRL microanalytic composite scores. Preliminary analyses were also conducted to assess the adequacy of measures, check statistical assumptions, and examine missing data.

Following the preliminary analyses, several statistical procedures were conducted to examine: (1) the level of convergence between SRL microanalytic items and both SRL self-report questionnaires and teacher ratings of student SRL, and (2) the level of divergence between SRL microanalysis and an unrelated construct (i.e., self-esteem), (3) the predictive validity of two SRL microanalytic composite scores across three achievement outcomes (Interview MPS, Posttest MPS, and MAP test scores (i.e., a standardized test) after controlling for other measures of SRL and prior achievement.

Preliminary Analyses

Examination of Assumptions

Assumptions of normality. The distribution was examined for each of the primary variables of this dissertation. An initial Kolmogorov Smirnov (KS) analysis identified some concern regarding the normality of several measures in the current study including Goal-Setting, Strategic Planning, Strategy Use, Calibration Accuracy, Attribution, Adaptive Inferences, Interview MPS, and the Posttest MPS (see Table 4.1). To follow up the Kolmogorov-Smirnov test, the skewness, kurtosis, and histograms were examined for each variable of concern. An examination of the skewness and kurtosis values further identified concern with the microanalytic strategy use measure (see Table 4.2). Since this item was derived from a categorical variable with relatively few potential categories, a transformation to adjust for non-normality would be of little use. In consultation with a statistician, it was determined that the correlational analyses and regression analyses planned for the current dissertation are sufficiently robust in regard to violations of normality to proceed with inferential statistics.

Missing data. Of the 103 participants who originally returned completed informed consent forms, seven students were unavailable to meet with the graduate researchers to complete an SRL microanalytic interview due to absences and thus were dropped from the study completely. One student transferred schools between the microanalytic interview and Posttest MPS and thus was removed from final analyses. Ten students were removed from the regression analyses due to unavailable prior achievement data which was provided by the school district. Finally, two students were removed from the regression analyses due to partially missing SRL questionnaire or teacher rating data. A total of 83 students were included in final analyses.

Assumption Testing for Regression Analyses

Several additional assumptions of regression analyses (normality of residuals and homoscedasticity) were conducted to determine the appropriateness of interpreting significance tests. The results indicated that the assumptions of both normality of residuals and homoscedasticity were met. Normality of residuals was examined via a visual analysis of Q-Q plot. Homoscedasticity was evaluated by visual analysis of constant variance of residuals scatterplot. Thus, the results gathered from analyses can be appropriately interpreted.

Table 4.1

Test of Normality of Primary Research Variables.

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	Df	Sig	Statistic	Df	Sig
Goal-Setting	.201	82	.000***	.856	82	.000***
Strategic Planning	.192	82	.000***	.853	82	.000***
Strategy Use	.295	82	.000***	.749	82	.000***
Calibration Bias	.078	82	.200ǂ	.989	82	.722
Calibration Accuracy	.118	82	.009**	.968	82	.046
Attribution	.286	82	.000***	.836	82	.000***
Adaptive Inferences	.196	82	.000***	.901	82	.000***
Self-Esteem Questionnaire	.089	82	.200	.969	82	.056
SRSI – Adaptive	.049	82	.200ǂ	.990	82	.809
SRSI – Maladaptive	.083	82	.200ǂ	.968	82	.044*
SRSI – Total	.069	82	.200ǂ	.984	82	.415
SRSI-Teacher Rating Scale	.073	82	.200ǂ	.982	82	.358
Interview MPS	.141	82	.001**	.912	82	.000***
Posttest MPS	.124	82	.005**	.960	82	.016*
MAP score	.092	82	.162	.975	82	.126

Note. Sig = p-value of statistical test.
* $p < .05$. ** $p < .01$. *** $p < .001$.
ǂ Indicates the lower bound of the true significance.

Table 4.2

Skewness and Kurtosis of Variables Identified as Significant by KS Test of Normality

	Skewness	Kurtosis
Goal-Setting	-.147	-1.354
Strategic Planning	.692	.793
Strategy Use	1.125	1.384
Calibration Accuracy	.151	-.857
Attributions	-.241	-1.057
Adaptive Inferences	.190	-.456
Interview MPS	.469	-.930
Posttest MPS	.479	-.126

Note. The cutoff for skewness and kurtosis values is > 1 for both variables.

SRL Microanalytic Composite Scores

Although composite scores are generally not created for the interpretation of SRL microanalytic measures, the author elected to develop composite scores for the purpose of this dissertation to make the analyses more parsimonious. Further, creating composites scores enabled a more adequate examination of the relations among different SRL measures. The composite scores used in this study were generated based on SRL theory and factor analytic data (see Tables 4.3 and 4.4).

An exploratory factor analysis of students' responses to the six SRL microanalytic interview questions was conducted. A principal component analysis was used because the primary purpose of the factor analysis was to identify and compute composite scores for the underlying factors tapped by the SRL microanalytic interview. The initial results displayed some instances of cross loading of the Adaptive Inferences item and the Goal-Setting items. Given that the cross-loading values were above a value of .4, the author elected to remove these two items and compute a second factor analysis. The second factor analysis which examined the SRL microanalytic items of Strategic Planning, Strategy Use, Calibration Bias, Calibration Accuracy, and Attributions. The results suggested a two factor solution, with the Attribution item not loading onto either factor. After removing the attribution question, a third and final factor analysis was computed to determine the precise factor loadings for the Strategy Planning, Strategy Use, Calibration Bias, and Calibration Accuracy items. A two-factor solution was selected based on the leveling off of eigen values observed on a scree plot. The first factor explained 37% of the variance and the second factor 33% of the variance. Cumulatively, this two-factor solution explained 71% of the total variance.

Using a varimax rotation factor loading matrix, the researcher identified the components of the two-factor structure to the microanalytic measures which coincided with SRL theory. The first factor consisted of two SRL microanalytic measures: Calibration-Bias and Calibration Accuracy. Since both calibration measures are a proxy for the extent to which a student had monitored performance during solution, this composite was labeled *Metacognitive Monitoring*.

The Strategic-Planning and Strategy Use SRL microanalytic measures loaded onto the second factor. Given that these two free-response SRL microanalytic questions were coded to reflect the extent to which students focused on the mathematics problem-solving strategy before and during completing the MPS task, the researcher labeled this factor *Strategic Approach*. These two composite scores were used in the analyses presented in this dissertation.

Table 4.3

Total Variance Explained by SRL Microanalysis Factors

	Initial Eigenvalues			*Rotation Sums of Squared Loadings*		
Component	*Total*	*% of Var.*	*Cum %*	*Total*	*% of Var.*	*Cum %*
1	*1.49*	37.14	37.14	1.46	36.86	36.86
2	*1.36*	33.90	71.04	1.37	34.17	71.04
3	*0.67*	16.77	87.80			
4	*0.49*	12.19	100			

Note. Extraction Method: Principal Component Analysis with a Varimax rotation. % of Var = percent of variation. Cum % = cumulative percentage of variation.

Table 4.4

SRL Microanalysis Rotated Component Matrix

	Component	
	Metacognitive Monitoring	*Strategic Approach*
Strategic Planning	.031	.815
Strategy Use	-.010	.831
Calibration Bias	.855	.090
Calibration Accuracy	.862	-.067

Note. Extraction Method: Principal Component Analysis. Rotation Method: Varimax Rotation with Kaiser Normalization. Rotation converged in 4 iterations

Power Analysis

Prior to data collection, a power analysis was completed to ensure sufficient statistical power to detect a true statistical difference. The analyses to be conducted for this study included one-tailed bivariate correlations and hierarchical multiple regressions. In total four predictors were to be entered into the hierarchical regression models. After completing a statistical power analysis (using: Statistical Calulators Version 3.0 Beta: A-priori Sample Size Calculator for Hierarchical Multiple Regression™) it was determined that the study parameters produced a sufficient beta level at or above 0.80 (p = .05) to detect a medium effect. Therefore, the author could conclude that there was an 80% probability of detecting a medium size effect using the current sample size.

Inferential Statistical Analyses

Before addressing the primary research questions of this dissertation study, the correlations between the key variables of interest are presented in Tables 4.5 and 4.6, respectively. Table 4.5 presents data regarding the relationships among all of the primary variables in this study. In Table 4.6, the author presents data regarding the relationships amongst SRL processes as measured by SRL microanalysis in addition to the correlations between the SRL microanalytic measures and mathematics outcomes in this study.

Research Objective #1: Convergence and Divergence amongst SRL measures

A broad objective of the current study was to examine whether SRL microanalytic data converged with SRL information gathered from aptitude measures (i.e., self-report questionnaires and teacher ratings of student SRL) and diverged from student reports of unrelated constructs (i.e., self-esteem). Two specific research questions were addressed regarding the convergence between SRL microanalytic composites, SRL questionnaires, and SRL teacher ratings scales. Although the primary interest was to examine the validity of SRL microanalytic measurement, the author also considered and computed bivariate Pearson correlations between the SRL questionnaires (SRSI-Adaptive & SRSI-Maladaptive), and the SRL teacher ratings (SRSI-TRS; see Table. 4.7).

Table 4.5

Correlations Among Key Variables of Interest.

	SA	MM	SRSI-A	SRSI-M	TRS	SEQ	I-MPS	P-MPS	MAP
Strategic Approach	1	.02	.03	-.09	.11	-.01	.23**	.20*	.15
Metacog monitor		1	-.15	.11	.01	-.07	.60***	.35**	.30**
SRSI-Adaptive			1	-.34**	.25*	.4***	-.09	-.10	-.10
SRSI-Maladaptive				1	-.21*	-.35***	-.03	-.20*	-.10
SRSI-TRS					1	.12	.14	.31**	.40***
Self-Esteem Quest.						1	-.12	-.07	-.07
Interview MPS							1	.64***	.56***
Posttest MPS								1	.84***
MAP									1

Note. Bivariate correlations utilized a one-tailed significance test. SA = microanalysis Strategic Approach composite. MM = microanalysis Metacognitive Monitoring composite. SRSI-A = Self-Regulation Strategy Inventory-Self-Report-Adaptive Strategy Use composite. SRSI-M = Self-Regulation Strategy Inventory Self-Report- Maladaptive Strategy Use subscale. SRSI-TRS = Self-Regulation Strategy Inventory Teacher Rating Scale. SEQ= Self-Esteem Questionnaire. I-MPS = Interview mathematical Problem Solving performance. P-MPS = Posttest Mathematical Problem Solving performance. MAP = MAP test score.

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

Table 4.6

Correlations Between SRL Microanalytic Measures and Outcome Variables

	GS	SP	SU	CB	CA	ATT	AI	I-MPS	P-MPS	MAP
Goal-Setting	1	.22*	.19*	-.19*	-.22*	.10	.17	-.03	.07	.08
Strategic Plan		1	.39***	.01	-.02	-.16	.12	.11	.22*	.21*
Strategy Use			1	.11	-.08	-.01	-.1	.27**	.112	.05
Calibration Bias				1	.39***	.06	-.26**	.63***	.26**	.22*
Calibration Acc					1	-.06	-.23	.37***	.34**	.29**
Attributions						1	.12	.11	.11	.11
Adaptive Infer.							1	.-26**	.05	-.01
Interview MPS								1	.64***	.56***
Posttest MPS									1	.84***
MAP										1

Note. Bivariate correlations utilized a one-tailed significance test. GS = microanalytic goal-setting item. SP = microanalytic strategic planning item. SU = microanalytic strategy use item. CB = microanalytic calibration bias item. CA = microanalytic calibration accuracy item. ATT = microanalysis attributions item. AI = microanalysis adaptive inferences item. I-MPS = Interview Mathematics Problem Solving Performance. P-MPS = Posttest Mathematics Problem Solving Performance. MAP = MAP Test Score.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4.7

Convergence and Divergence of Primary Measurements.

	SA	MM	SRSI-A	SRSI-M	SRSI-TRS	SEQ
Strategic Approach	1	.02	.03	-.09	.11	-.01
Metacog Monitor		1	-.15	.11	.01	-.07
SRSI- Adaptive			1	-.34**	.25*	.40***
SRSI- Maladaptive				1	-.21*	-.35***
SRSI- TRS					1	.12
Self-Esteem Quest.						1

Note. Bivariate correlations utilized a one-tailed significance test. SA = microanalysis Strategic Approach composite. MM = microanalysis Metacognitive Monitoring Composite. SRSI-A = Self-Regulation Strategy Inventory Self-Report-Adaptive Strategy Use Subscale. SRSI-M = Self-Regulation Strategy Inventory Self-Report-Maladaptive Strategy Use Subscale. TRS = Self-Regulation Strategy Inventory-Teacher Rating Scale. SEQ= Self-Esteem Questionnaire.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Research Question #1- Convergence of SRL Microanalysis and SRL questionnaires. Do SRL microanalytic composite scores measuring Strategic Approach and Metacognitive Monitoring correlate positively with a SRL self-report questionnaire measuring adaptive SRL (SRSI-Adaptive) and correlate negatively with a SRL self-report questionnaire measuring maladaptive SRL (SRSI-Maladaptive)?

To address the first research question, bivariate correlations were computed between the measures of interest (see Table 4.7). All correlation analyses implemented a one-tailed significance test because the author had established a priori hypotheses regarding the direction of the relationships between the variables of interest.

Since the SRL microanalytic questions and questionnaires were designed to measure the extent to which students were strategic and employed metacognitive skills in mathematical contexts, the author hypothesized that the SRL microanalytic composites would correlate significantly and positively with the adaptive SRL questionnaire (SRSI-Adaptive) and correlate significantly and negatively with the maladaptive SRL questionnaire (SRSI-Maladaptive).

Contrary to expectations, the SRL microanalytic composite score did not correlate significantly with either of the SRL questionnaires (see Table 4.7). The microanalytic Strategic Approach composite did not correlate significantly with the questionnaire measuring adaptive SRL (r = .029) and did not correlate with the questionnaire measuring maladaptive SRL (SRSI-Maladaptive; r = -.09). The SRL microanalytic Metacognitive Monitoring composite also did not correlate significantly (r = -.152) with the adaptive SRL questionnaire (SRSI-Adaptive) nor did this composite correlate maladaptive SRL questionnaire (SRSI-Maladaptive; r = .105).

Research Question #2 – Convergence of SRL Microanalysis and Teacher Ratings of SRL. Do SRL microanalytic composite scores (Strategic Approach and Metacognitive Monitoring) correlate significantly with a teacher rating of SRL (SRSI-TRS)?

To address this research question, bivariate correlations were computed between the SRL microanalytic composites and SRL teacher rating scale. Similar to the first research question, all correlational analyses utilized a one-tailed significance test because the author established a priori hypotheses that the SRL microanalysis composites should correlate in a positive direction with the SRL teacher rating scale.

The results did not support the author's hypotheses. The SRL microanalytic Strategy Approach composite was not significantly correlated with the teacher ratings of SRL (r = .11). Moreover, the SRL microanalysis Metacognitive Monitoring composite did not significantly relate to the teacher ratings (r = .01; (SRSI-TRS; see Table 4.7).

Convergence between SRL questionnaires and SRL teacher ratings. Although the primary interest in this study was the convergent validity of SRL microanalysis, the author also examined the relationship between the SRL questionnaires and SRL teacher rating scales. It was hypothesized that the SRL questionnaires measuring adaptive SRL (SRSI-Adaptive) would correlate significantly and positively with the teacher ratings of SRL (SRSI-TRS) and the questionnaires measuring maladaptive SRL (SRSI-Maladaptive) would correlate significantly and negatively with the SRL teacher ratings (SRSI-TRS). The results showed convergence between the self-report questionnaires and teacher rating scale. The questionnaire subscale measuring adaptive strategy use (SRSI-Adaptive) displayed a small to medium (Cohen, 1988), statistically significant, and positive correlation with the teacher rating scale ($r = .25$). The SRL questionnaire measuring maladaptive strategy use (SRSI-Maladaptive) displayed a small, statistically significant, and negative correlation with the teacher rating scale ($r = -.21$; SRSI-TRS; see Table 4.7).

Divergent Validity

The author also examined whether the SRL microanalytic data diverged from theoretically dissimilar constructs. To accomplish this research objective, the author computed bivariate correlations between each of the SRL microanalytic composite scores and the questionnaire measuring self-esteem (Self-Esteem Questionnaire; SEQ). The author also examined whether SRL information gathered from questionnaires and teacher ratings diverged from students' self-esteem.

Research Question #3 - Divergence of SRL Measurement and Self-Esteem. Do the SRL microanalytic composites (Strategic Approach and Metacognitive Monitoring) display divergent validity with a theoretically unrelated construct such as self-esteem?

To address this research question, the author computed bivariate correlations between each SRL microanalytic composite and the questionnaire measuring self-esteem (SEQ). Since these measures are theoretically divergent, the author hypothesized that the results would display small non-significant correlations between the SRL microanalytic composite scores and the SEQ. Consistent with the hypotheses, the SRL microanalytic composite scores did not correlate significantly with the measure of self-esteem (See Table 4.7). Moreover, the observed relationships between the SRL microanalytic Strategic Approach composite and self-esteem questionnaire (SEQ) was negligible in value (r = -.01). In addition, the relationship between the Metacognitive Monitoring composite and self-esteem questionnaire (SEQ) was also very small (r = -.07; see Table 4.7).

Divergence of SRL questionnaires, teacher ratings, and self-esteem. Although the primary interest was examining the divergent validity of SRL microanalytic measures, the author also computed bivariate Pearson correlations between the SRL questionnaires, SRL teacher ratings, and Self-Esteem Questionnaires.

Since SRL and self-esteem are theoretically divergent, the author hypothesized that these measures would also not correlate significantly with the self-esteem questionnaire. The author's expectations were partially supported. The teacher rating scale displayed a small, non-significant relationship with the self-esteem questionnaire (SEQ; r = .12). Interestingly, the correlations between self-esteem and the self-report questionnaires measuring adaptive and maladaptive SRL (i.e., SRSI Adaptive and Maladaptive) were statistically significant. The SRSI-Adaptive subscale displayed a significant, positive correlation (r = .40) that was between medium in size (Cohen, 1988). The SRSI-Maladaptive subscale displayed a significant, negative relationship that was also of medium size (r = -.35; see Table 4.7; Cohen, 1988).

Research Objective #2: Predictive Validity of SRL Microanalysis

Another key objective of the proposed dissertation was to examine the predictive validity of a SRL microanalytic protocol after controlling for student mathematics achievement and student self-report measures (i.e., questionnaires) targeting both adaptive and maladaptive regulation. The predictive validity of the microanalytic questions was examined across three types of mathematics outcomes: (1) Interview MPS, (2) Posttest MPS, and (3) MAP Scores (Standardized mathematics exam).

Three similar research questions were addressed using hierarchical regression analyses. The questions varied based on the specificity of the achievement measurement and the level of proximity between the administration of the dependent variable and the microanalytic interview session. In each analysis, the predictors were entered into the regression model in three separate blocks in order to examine changes in R^2. Student's prior achievement, as measured by WKCE math scores from the prior school year, was entered into the first block of the regression model. In the second block, a composite of two self-report questionnaires measuring both adaptive and maladaptive self-regulation was entered into the model along with prior achievement. The questionnaires (SRSI-Adaptive and SRSI-Maladaptive) were compiled into a single composite score (SRSI-Total) to maximize statistical power by reducing the total number of predictor variables. The microanalytic composites were entered into the regression in the final block of the regression analyses thereby enabling the researchers to determine the predictive utility of SRL microanalytic measurement after controlling for prior achievement and questionnaire report. Although the author was primarily interested in the predictive validity of the microanalytic composite scores, given that SRL questionnaires continue to represent the most frequent form of

SRL measure, he elected to include the questionnaire as a separate block to determine if they could account for unique variance over and above prior achievement.

Research question #4: Interview MPS performance. Do SRL microanalytic composite scores (Strategic Approach, Metacognitive Monitoring) explain unique variation in Interview MPS after controlling for prior math achievement and student responses to self-report questionnaires?

The results (see Table 4.8) revealed that prior achievement explained a medium about significant amount of variation in Interview MPS performance (ΔR^2 =.096) in the first block of the regression analysis ($F_{1, 82}$ = 8.62 p < .01). The addition of the SRL self-report questionnaire in the second block did not explain a significant amount of unique variation in interview MPS performance ($F_{2, 81}$ = .000, p = .95). In the third and final block of the regression analyses, the two SRL microanalytic composites accounted for a large, significant amount of unique variation (ΔR^2 =.34) in Interview MPS performance after controlling for prior achievement and self-report questionnaire responses ($F_{4, 79}$ = 23.1, p < .001). Using a one-tailed test of significance, three predictors emerged as significant predictors of Interview MPS in the final model of the regression. The SRL microanalysis Metacognitive Monitoring and Strategic Approach composites emerged as statistically significant predictors of Interview MPS performance. After controlling for all other variables in the final model, the SRL microanalytic Metacognitive Monitoring composite individually accounted for a large amount of the variance (sr^2 = .36) in Interview MPS and the Strategic Approach composite individually explained a small to medium amount (sr^2 = .04) of the variation in Interview MPS performance. In addition, prior achievement emerged as a significant predictor of achievement and explained a small to medium amount of variation in Interview MPS (sr^2 = .05) after controlling for all other predictors (see Table 4.8).

Table 4.8

Regression Predicting Interview MPS with SRL Questionnaires and SRL Microanalysis

Variable	*Zero order correlation*	*Semipartial correlation (sr^2)*	*B*	*T*	ΔR^2
Block 1					.096**
7th grade WKCE-Math	.31	.31(.096)	.31	2.94**	
Block 2					.00
7th grade WKCE-Math	.31	.31(.096)	.31	2.92**	
SRSI-Total	.01	.01(.001)	.01.	.06	
Block 3					0.34***
7th grade WKCE-Math	.31	.22(.046)	.18	1.97†	
SRSI-Total	.01	.06(.03)	.04	.49	
Micro: SA	.22	.20(.039)	.16	1.78†	
Micro: MM	.60	.60(.358)	.57	6.59***	

Note. Block 1: Total/Adjusted R^2 = .096/.085; Block 2: Total/Adjusted R^2 = .10/.07; Block 3: Total/Adjusted R^2 = .43/.40 sr^2 = semi-partial squared represents the proportion of unique variance in Interview MPS scores accounted for by specific predictor after controlling for all other variables. SRSI-Total = Self-Regulation Strategy Inventory Self-Report Total composite score. Micro: SA = microanalysis Strategic Approach composite score. Micro: MM = microanalysis Metacognitive Monitoring composite score. *B*= Beta.
* $p < .05$. ** $p < .01$. *** $p < .001$. † $p < .05$ with one-tailed test of significance.

Research Question #5: Posttest MPS Performance. Do SRL microanalytic composite scores (Strategic Approach and Metacognitive Monitoring) explain unique variation in Posttest MPS performance after controlling for prior math achievement and student responses to self-report questionnaires?

The regression analysis revealed that prior achievement explained a large and significant amount of variation in students' Posttest MPS performance in the first block of the regression (ΔR^2 = .21) ($F_{1, 82}$ = 21.26, $p < .001$). The addition of the self-report questionnaire in the second block of the regression analysis did not explain a significant amount of unique variation in Posttest MPS performance ($F_{2, 81}$ = .78, p = 0.38).

Table 4.9

Predictive Utility of SRL Microanalytic Measurement for Posttest MPS Performance

Variable	*Zero order correlation*	*Semipartial correlation (sr^2)*	*B*	*T*	ΔR^2
Block 1					.21***
7th grade WKCE-Math	.46	.46(.180)	.46	4.61***	
Block 2					.01
7th grade WKCE-Math	.46	.46(.176)	.46	4.60***	
SRSI-Total	.09	.10(.009)	.09	.89	
Block 3					0.09**
7th grade WKCE-Math	.46	.41(.142)	.39	3.9***	
SRSI-Total	.09	.13(.004)	.11	1.16	
Micro: Strategic App	.18	.08(.007)	.07	.67	
Micro: MM	.36	.34(.117)	.30	3.1**	

Note. Block 1: Total/Adjusted R^2 = .21/.20; Block 2: Total/Adjusted R^2 = .22/.20; Block 3: Total/Adjusted R^2 = .31/.28. sr^2 = semi-partial squared represents the proportion of unique variance in Posttest MPS scores accounted for by specific predictor after controlling for all other variables. SRSI-Total = Self-Regulation Strategy Inventory Self-Report Total composite score. Micro: SA = microanalysis Strategic Approach composite score. Micro: MM = microanalysis Metacognitive Monitoring composite score. *B*= Beta.
* p < .05. ** p < .01. *** p < .001.

In the third block of the regression analysis, the addition of the SRL microanalytic measures resulted in a significant and medium increase in variation explained (ΔR^2 = .09) ($F_{4, 78}$ = 5.01, p < .01). In the final model, two predictors, SRL microanalysis Metacognitive Monitoring composite and prior achievement emerged as significant predictors of Posttest MPS. After controlling for all other predictors Metacognitive Monitoring individually accounted for a medium amount of variation (sr^2 = .12) and prior achievement individually accounted for a medium amount of variation (sr^2 = .14) (see Table 4.9).

Research Question #6: Global, Standardized Math Performance. Do SRL microanalytic composite scores (Strategic Approach, Metacognitive Monitoring, and Reflection) explain unique variation in students' performance on a standardized test of mathematics skill (i.e., MAP) after controlling for prior mathematics achievement and student responses to self-report questionnaires?

Using similar hierarchical regression procedures employed in prior analyses, the authors found that prior achievement explained a medium and significant amount of variation (ΔR^2 = .24) in MAP performance ($F_{1, 82}$ = 25.72, p < .001) in the first step of the regression analyses. Similar to the previous regression analyses with more narrow and contextualized MPS outcomes, the addition of the self-report questionnaire measuring SRL strategy use did not explain a significant amount of unique variation in MAP performance ($F_{2, 81}$= .05, p = .82). When using a one-tailed test of significance, the addition of the SRL microanalytic measures in the third block of the regression resulted in a small but significant increase in variation explained (ΔR^2 =.053; ($F_{4, 78}$ = 2.91, p < .05) (see Table 4.12). The Metacognitive Monitoring composite emerged as a significant predictor of MAP performance in the final model of the regression (see Table 4.10). After controlling for all other predictors, the Metacognitive Monitoring composite explained a small to medium, significant amount of variation in MAP performance (sr^2 = .07). In addition, prior achievement was a significant predictor of MAP scores in the final model of the regression individual explaining a medium to large amount of variation in MAP performance (sr^2 = .21).

Table 4.10

Predictive Utility of SRL Microanalysis Using a Standardized Broad Measure of Math Skill.

Variable	*Zero order correlation*	*Semipartial correlation (sr^2)*	*B*	*T*	ΔR^2
Block 1					.24***
7th grade WKCE-Math	.49	.49(.241)	.49	5.07***	
Block 2					.00
7th grade WKCE-Math	.49	.49(.241)	.49	5.04***	
SRSI-Total	.03	.03(.001)	.02	.23	
Block 3					.05*
7th grade WKCE-Math	.44	.46(.207)	.45	4.51***	
SRSI-Total	.03	.05(.001)	.04	.43	
Micro-SA	.13	.01(.001)	.01	.11	
Micro-MM	.30	.26(.069)	.23	2.41*	

Note. Step 1: Total/Adjusted R^2 = .24/.23; Step 2: Total/Adjusted R^2 = .24/.22; Step 3: Total/Adjusted R^2 = .29/.26. sr^2 = semi-partial squared represents the proportion of unique variance in MAP scores accounted for by specific predictor after controlling for all other variables. SRSI-Total = Self-Regulation Strategy Inventory Self-Report Total composite score. Micro: SA = microanalysis Strategic Approach composite score. Micro: MM = microanalysis Metacognitive Monitoring composite score. *B*= Beta.
* $p < .05$. ** $p < .01$. *** $p < .001$.

CHAPTER 5

Discussion

The majority of the prior SRL microanalytic research has explored motoric or athletic tasks (Cleary and Zimmerman, 2001; Kitsantas and Zimmerman, 2002). The current study is important because it is an extension of the SRL microanalytic methodology to the academic task of MPS. The primary purpose of this dissertation was to extend this prior research by developing and evaluating the psychometric properties of a SRL microanalytic protocol for measuring SRL during mathematical problem solving. Given the scarcity of data on this topic, the current study contributes to an area of need in the SRL literature and SRL microanalytic measurement literature. The current dissertation is among the first studies to compare a SRL event measure (e.g., SRL microanalysis) to SRL aptitude measures (e.g., questionnaires and SRL teacher rating scales) for the purpose of examining convergence. In addition, to the author's knowledge, no other study has examined the divergent validity of SRL microanalytic measurement. This dissertation examines if SRL microanalysis divergences from the theoretically unrelated construct of self-esteem. The current dissertation is also unique in that the predictive validity of SRL microanalysis was examined across multiple outcomes that ranged from highly task specific to more general academic outcomes.

In the following chapter, the authors will discuss the current research findings, how these findings relate to prior research, implications of the findings, the limitations of this study, and potential future research endeavors.

Convergence between SRL Measurement Methodologies

Initially the author had hypothesized to find significant relationships between SRL microanalysis, SRL questionnaires, and the SRL teacher ratings. The rationale for this hypothesis was based primarily in the conceptual overlap of the measures implemented. That is, all of the measures targeted students' use of strategies and metacognitive processes within mathematical contexts. The observed results contrasted the author's hypotheses in several respects. First, the SRL microanalytic composite scores did not correlate significantly with the self-report questionnaire measuring adaptive strategy use (SRSI-Adaptive) or the questionnaire measuring maladaptive strategy use (SRSI-Maladaptive). In addition, neither of the SRL microanalytic composite scores correlated significantly with the SRL teacher rating scale. Although SRL microanalysis was the primary interest in this dissertation, the author also examined the relationships between SRL questionnaires and SRL teacher ratings. The results revealed a small to medium (Cohen, 1988) but significant correlation ($r = .25$) between the adaptive SRL questionnaire and SRL teacher ratings (SRSI-TRS). The maladaptive SRL questionnaire also displayed a small, significant, and negative correlation ($r = -.21$) with the teacher rating scale.

Given the purported conceptual overlap among the different type of SRL measures, the fact that SRL microanalysis did not relate to the self-report questionnaires or the teacher rating scale was surprising. Since these results did contrast the author's initial hypotheses, it is important to consider a few potential explanations for the lack of convergence such as the questionable validity of SRL questionnaires and the contextual-sensitivity of SRL strategy use.

In light of prior research that has raised many concerns with the validity of self-report questionnaires measures, it is reasonable to consider that the lack of convergence between SRL microanalysis and SRL questionnaires could be explained in part by methodological issues of using SRL questionnaires. As discussed previously in this dissertation (chapter one and chapter two) several studies have called attention to concerns with using questionnaires such as the reliance on retrospective reporting, lack situational referents, de-contextualized subscale scores, and potential for self-report biases (Dyson, 2003; Jamieson-Noel & Winne, 2003; Schacter, 1999; Winne & Jamieson-Noel, 2002). Moreover, some research suggests that students' responses to questionnaires may be inconsistent with their actual behaviors (Jamieson-Noel & Winne, 2003; Winne & Jamieson-Noel, 2002; Winne & Perry, 2000; Winne, 2010). For example, Winne and Jamieson-Noel (2002) compared students' questionnaire responses regarding strategy use to direct observations of their actual strategy use. In that study, students' reporting of strategy use and the observations of trained observers often lacked correspondence and even displayed an inverse relationship in some cases.

In comparison to the prior research that examined the convergence of direct observations and SRL questionnaires, this study was different because SRL microanalysis and SRL questionnaires are both types of self-report measures. That is, the student served as the source of data for SRL microanalysis and SRL questionnaires. For this reason, the author expected to find significant, albeit small, correlations between SRL microanalysis and SRL questionnaires. However, the observed relations in the current study were negligible.

Another factor that may explain the lack of convergence is that SRL microanalysis and SRL questionnaires may actually be measuring different aspects of SRL or repertoires of strategies. Research supports the notion that strategic engagement presents differently from one task to another (Hadwin et. al., 2001) and that students will even adjust strategy use depending on the difficulty of a task (Cleary & Chen, 2009; Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). In chapter two, the author provided an overview of SRL aptitude measures and event measures. Although there are several factors that differentiate these two types of measures, the core difference is that aptitude measures such as questionnaires were designed to measure more global domain-specific aspects of SRL (Winne & Perry, 2000). In contrast, SRL event measures such as SRL microanalysis place a primary emphasis on the contextual-specificity of SRL and thus measure SRL in relation to a single event. While SRL microanalysis or other SRL event measures tap into a repertoire of strategies for an individual task, SRL questionnaires usually target a students' repertoire of strategies for an entire academic domain of mathematics. Since students likely have different repertoires of strategies that they apply to a task and an academic domain, the relationship between SRL event measurement of strategy use and questionnaire measurement of strategy use may not be expected to be very strong. It is also possible that the relationship between event and aptitude measures may be dependent upon the extent to which the task targeted by the event measure is representative of the domain targeted by the questionnaire. Solving a set of MPS items, although an important mathematics task, is only a small fraction of the global picture of the many tasks that occur in a mathematics classroom.

Although there does appears to be some precedent to explain why SRL microanalysis and SRL questionnaires may not be expected to correlate, the lack of correspondence between SRL microanalysis and SRL teacher rating scales is less clear. Amongst the SRL literature, there has generally been less attention devoted to teacher rating scales in comparison to the extensive research of SRL questionnaires. Moreover, the literature comparing SRL event measures and SRL teacher rating scales is even more limited than the research comparing event measures to questionnaires. Apart from the current dissertation, only one other study, to date, has compared SRL microanalysis and SRL teacher rating scales (DiBenedetto & Zimmerman, 2013). The results from the current dissertation and the latter study are somewhat contradictory.

DiBenedetto and Zimmerman (2013) compared a SRL microanalytic protocol and a teacher rating scale measuring SRL. The authors developed a SRL microanalytic protocol to measure students' SRL across a (1) study session on tornados and (2) subsequent test about tornados. The methodology used by DiBenedetto and Zimmerman (2013) was very similar to the methodology of the current dissertation. For example, the microanalytic protocol examined four SRL processes of strategic planning, strategy use, metacognitive monitoring, and a self-reflection phase process known as self-evaluation. The strategic planning question was administered before students began studying the materials about tornados to determine the types of strategies that students intended to use during the upcoming study session. Next, the SRL microanalytic strategy use items were administered while students studied about tornados to identify the types of strategies used to prepare for the test. Next students took a short test that tapped their knowledge of tornados and conceptual knowledge of tornado formation. Similar to the current dissertation, two metacognitive monitoring items were used to compare performance predictions to actual performance. These items were administered just after completing the test but before performance feedback. Tests were then scored, presented to each participant, and a SRL microanalytic self-evaluation item was administered to evaluate how well students believed that they had learned the content in the study materials.

Similar to the current dissertation, no significant correlations were found between teacher ratings of student SRL and SRL microanalytic measurement of strategic planning ($r = .22$) or strategy use ($r = .24$). The results of the current dissertation and DiBenedetto and Zimmerman (2013) differed, however, in regard to the relation between the SRL microanalytic Metacognitive Monitoring and SRL teacher ratings. DiBendetto and Zimmerman (2013) found a significant correlation between SRL microanalytic measurement of Metacognite Monitoring and teacher ratings of SRL ($r = .48$) but the current dissertation did not ($r = .01$). The findings across these two studies highlight a few points worthy of discussion.

It is interesting that in both studies, the results showed a poor level of correspondence between SRL microanalytic items targeting strategy use and teacher ratings of strategy use. The pattern of poor correspondence between measures of strategy use seems to further support a hypothesis that SRL microanalytic strategy items and aptitude measures of SRL strategy use are not measuring the same thing. From the perspective of the author, this lack of convergence may be explained by the context-specificity of strategy use. Since strategy use varies so greatly across tasks, measurement of strategy use during the solution of three MPS items may not be expected to converge with teachers ratings of how students generally regulate their learning during their mathematics class.

A second point to discuss is that the findings of these two studies were mixed in regard to the relationship between SRL microanalytic metacognitive monitoring and teacher rating scales. The current dissertation did not find a relationship between these two measures but DiBenedetto and Zimmman (2013) did. Although these studies were methodologically very similar, there were a few differences that may explain the mixed results. First, these studies targeted different academic tasks. The current dissertation examined SRL in relation to the solution of three MPS items whereas DiBenedetto and Zimmerman (2013) examined SRL in relation to studying and test-taking. The author hypothesizes that the mixed results could be attributed to the fact that, relative to the MPS task of the current dissertation, the studying and test taking task examined by DiBenedetto and Zimmerman (2013) is more similar to the classroom activities that a teacher may observe. Not only do teachers frequently observe students engaged in studying or test-taking tasks but the effects of metacognitive monitoring during test-taking may also make an impression on teacher's ratings of SRL. For example, increased metacognitive monitoring during studying and test-taking is predictive of test achievement (DiBenedetto & Zimmerman, 2013), but may also increase instances of SRL in a classroom that teachers may observe. For example, students who engage in more effective metacognitive monitoring during studying and test-taking could be more likely to ask questions during class about upcoming tests, misunderstandings, or errors. Since teacher ratings of SRL overlap with these help-seeking types of behaviors, it is possible that the task focus of these two studies could explain the mixed results.

The sample of participants is another difference between the current dissertation and DiBendetto and Zimmerman (2013). The sample in DiBenedetto and Zimmerman (2013) were 11th grade students attending a private high school and the sample was primarily Caucasian. The sample of the current dissertation consisted of eighth grade students attending an urban, public school district and the majority of the sample in this study identified as Latino (49%) or African American (46%). Prior research has suggested inconsistencies in how teachers rate the externalizing behaviors of students from minority backgrounds as compared to Caucasian students (Puig, Lambert, Rowan, Winfrey, Lyubansky, & Hannah, 1999; Reid, Riccio, Kessler, DuPaul, Power, & Anastopoulos, 2000; Stevens, 1980). The sample in the current dissertation only included a few Caucasian participants and therefore it is not possible to determine if teacher ratings varied significantly across racial demographics. Future research should examine whether the student race may play a role in teacher reporting of SRL. The age difference between these two samples should also be considered given that SRL generally begins emerging in middle school years and the behavioral patterns of middle school students and high school students may be quite different.

The author has offered some hypotheses to explain the lack of convergence between SRL measurement formats in the current dissertation; however, it is important to note the current data is insufficient to draw any definitive conclusions. Additional research is needed to further examine the relationship between SRL event and aptitude measures. Future research should include data to directly compare various SRL measures and observations of students' actual behaviors.

Divergent Validity

To the author's knowledge, no prior research has attempted to establish the divergent validity of SRL microanalytic measures. It is not only essential to determine if relationships emerge between SRL microanalsysis and the theoretically related constructs, but also if a measure does not relate to theoretically divergent constructs. In the current study, the author compared SRL microanalytic measurement of student SRL to self-report of self-esteem because global aspects of self-esteem, such as student's feelings about their body image and feelings about their peer relations are theoretically unrelated to the frequency with which students use strategies in academic settings.

The findings supported the author's hypotheses and the differential validity of SRL microanalysis in that the microanalytic composite scores did not correlate significantly with the measure of self-esteem (r = -.01; r = -.07). Although examining the divergence of the SRL questionnaires and teacher rating scales relative to the self-esteem measure was not the primary purpose of the current dissertation, it is interesting that the SRL self-report questionnaires correlated significantly with self-esteem (r = .4) and (r = -.35) for the SRSI-Adaptive and SRSI-Maladaptive scales respectively. In contrast, the teacher rating scale did not significantly correlate with self-esteem (r = .12).

The divergence of SRL microanalysis and self-esteem for body image and peer relationships is important because microanalysis is intended for measuring contextualized SRL and therefore should not be related to more global self-concept constructs such as self-esteem.

Since SRL microanalysis is a type of self-report measure it is also important that it diverged from students' general feelings of self-worth. There is always a potential for self-reported data to be susceptible to self-serving cognitive distortions and biases which could lead to inaccurate data. This study displays that SRL microanalysis did not relate to self-esteem, which can play a role in cognitive distortions and biases. This is positive support for SRL microanalysis but is not sufficient to conclude that SRL microanalysis is impervious to cognitive distortions. Additional research should explore the relationship between SRL microanalysis and other theoretically divergent constructs that could play a role in self-report distortions or biases.

The adaptive and maladaptive SRL questionnaires did not diverge from self-esteem. These results could be the result of measurement error or could be a function of the fact that questionnaire formatting was used for both of these measures. However, it is interesting that students who feel better about their physical image and peer relations were more likely to report using a greater number of adaptive academic strategies and fewer maladaptive academic strategies. It could be interesting for future research to conduct a more thorough investigation of SRL questionnaires, self-esteem, and actual strategy use to determine if students who possess greater self-esteem over-estimate their strategic engagement.

Finally, the divergence of teacher ratings of SRL and self-esteem provides some limited support for the validity of the SRL teacher rating scale. Additional research should examine the divergent validity of SRL teacher ratings with other student characteristics that could influence teacher ratings of SRL such as personality traits.

Predictive Validity

Another objective of the current dissertation project was to examine whether students' responses to SRL microanalytic interview questions during a MPS task can predict achievement across a range of mathematics outcomes after controlling for prior achievement and SRL questionnaires. The predictive validity of SRL microanalytic measures was explored across three mathematical outcomes including two measures of MPS skill (Interview MPS & Posttest MPS) and one measure of more global mathematics achievement (MAP). It is of interest to note that two of the outcome measures, Posttest MPS and MAP scores, were particularly important because they were not directed linked to the MPS practice session included as part of the study. In contrast, the Interview MPS measure was a more task-specific outcome because it was made up of the three problems that students were asked to complete while they were administered the microanalytic interview questions.

The results of this study support the utility of using SRL microanalytic measures to predict mathematics outcomes that are both specific to the measurement context as well as more generalizable domain level outcomes. The SRL microanalytic measures emerged as a significant predictor across all three mathematics outcomes after controlling for prior achievement and questionnaire reports. In contrast, the self-report questionnaires failed to emerge as a significant predictor for any of three mathematics outcomes examined in the current study.

The SRL microanalytic Metacognitive Monitoring composite predicted achievement across all three mathematics outcomes, whereas the Strategic Approach composite was a significant predictor of performance on the Interview MPS task only. In particular, the SRL microanalytic composite scores displayed the strongest predictive validity for the Interview MPS task accounting for a large significant increase in variation (34 percent) explained even after controlling for prior achievement and SRL questionnaire reporting. In the final model of the regression, the SRL microanalytic Metacognitive Monitoring composite was the strongest predictor of Interview MPS performance individually explaining 36 percent of the variation in

Interview MPS while controlling all other variables (*sr^2* = .36). The Strategic Approach composite was also a significant predictor of Interview MPS and individually explained 4% of the variation in Interview MPS performance while controlling all other variables (*sr^2* = .04).

SRL microanalytic measurement was also predictive of achievement for a more comprehensive measure of MPS skill, the Posttest MPS. The Metacognitive Monitoring composite emerged as the only SRL predictor of Posttest MPS explaining about 12% of the variation in Posttest MPS (sr^2 = .117). The Strategic Approach composite nor the questionnaires emerged as a significant predictor of Posttest MPS.

Most research examining SRL microanalysis measures has focused on the predictive validity using outcomes that are directly linked to the task embedded within the SRL microanalytic protocol (e.g., MPS) with relatively less research exploring whether event measures can predict of more global outcomes (e.g., MAP). To address this issue, the author compared the predictive validity of both SRL microanalysis and SRL questionnaires across different achievement outcomes that varied by the levels of specificity and link to the target task. Therefore, the author wanted to also examine whether specific types of SRL measures predict more global mathematics achievement outcomes (i.e., MAP scores). The SRL microanalytic Metacognitive Monitoring composite did result in a significant increase in variation and individually explained 6.9 percent of the variation in MAP scores after controlling for all other variables.

Overall, the results support the predictive validity of the SRL microanalytic protocol designed to measure SRL during MPS. Moreover the results suggest that the current SRL microanalytic protocol can predict mathematics outcomes that are both specific to the measurement context as well as more generalizable domain level outcomes.

In regard to the MPS specific outcomes, the findings of current dissertation are consistent with prior SRL microanalytic research for both academic and motoric examinations which has consistently shown SRL microanalysis to be predictive of task specific outcomes for motoric tasks (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002; Cleary et al., 2006). These results also support the emerging literature showing that SRL microanalytic measurement is predictive of academic performances. Although this is the first application of SRL microanalysis to mathematics and MPS, the predictive validity of students' Strategic Approach and Metacognitive Monitoring during MPS tasks is consistent with the mathematical research literature that suggests a strong relationship between the use of SRL and MPS specific strategies and achievement on MPS tasks (Butler et al., 2005; Casel & Reid, 1996; Graham & Harris, 2003; Montague, 2003).

The findings of the current study are particularly noteworthy since the SRL microanalytic measures emerged as significant predictors even after controlling for prior achievement and SRL questionnaires. This study displayed that SRL microanalysis can provide unique information about student functioning for which prior achievement did not explain. A second important point to highlight is the relative superiority of SRL microanalysis over questionnaire measurement. The SRL questionnaires did not emerge as a significant predictor for any of the mathematical outcomes in this study, while SRL microanalytic measurement was significantly predictive for all three measures. Cleary et al. (2011) also compared SRL questionnaires and SRL microanalysis in terms of predictive validity for future exam performance. In this study, they found that SRL microanalysis was a superior predictor of future exam performance in comparison to SRL questionnaires. Both Cleary et al. (2011) and the results of the current dissertation support the relative predictive superiority of SRL microanalysis. However, Cleary et al. (2011) used only one type of outcome while in the current dissertation, SRL microanalysis emerged as a superior predictor for several types of achievement outcomes. What is particularly interesting is that although SRL questionnaires tend to capture more global characteristics of SRL, they were not as useful as microanalytic measures in predicting a global domain-level outcome. These results are especially relevant considering that SRL questionnaires remain the most frequently used measure of SRL (Cleary, 2009).

The pattern of predictive validity of the SRL microanalytic composites across the three outcome measures seems to mirror some of the implications discussed for the convergence results. The fact that SRL microanalytic measurement of a strategic approach to solving MPS items predicted the problems that were completed during the interview but not a more comprehensive measure of MPS skill or a more global measure of mathematics skill seems to provide further support to contextual nature of strategy use. On the other hand, the SRL microanalytic Metacognitive Monitoring composite was significantly predictive of all three mathematics outcomes. These results seem to imply that SRL metacognitive monitoring could be a more global aspect of SRL whereas strategy use is a more contextualized process. However, more research is needed to replicate the findings of the current study and continue to study the generalizability of metacognitive monitoring. The fact that the Metacognitive Monitoring composite which was measured in relation to three mathematics problems can generalize to individually predict seven percent of student's general mathematics achievement is impressive. These findings have direct implications to educational settings because standardized tests of academic achievement are common in today's school. High stakes tests are frequently implemented as a means to evaluating students' learning, and in some cases have become the basis for evaluating the effectiveness of educators and schools. The fact that metacognitive monitoring skills were predictive across a range of academic outcomes, is also exciting to the author because a number of SRL intervention programs currently exist that have been shown to develop metacognitive monitoring skills as well as other important SRL processes.

There are a number of reasons why the Metacognitive Monitoring composite may have presented as such a strong predictor of mathematical outcomes. First, the predictive capability of the Metacognitive Monitoring composite may be due in part to the complexity of mathematical problem solving tasks. As noted in chapter two, MPS requires a student to successfully navigate a series of steps such as decoding text, developing a solution plan, setting up an equation, completing computations, and checking work. Failure in just one step is likely to result in an incorrect solution even if all other steps were completed with ease. It is possible that students who metacognitively monitor throughout the MPS task are more apt to identify and correct errors. Prior research supports this hypothesis in that expert problem solvers more frequently engage in a recursive solution process characterized by multiple iterations of planning, solving, evaluating, re-planning, solving, and so forth (Overtoom, 1991; Schoenfeld, 1985).

The metacognitive monitoring measure was examined by determining the calibration between predictors and performance. Prior research examining self-efficacy calibration may also shed some light on the impact of metacognitive monitoring during MPS. Similar to the current study, self-efficacy calibration is assessed by comparing mean efficacy ratings with task performance (Klassen, 2002a). Researcher examining efficacy calibration has noted a particular concern for students with a positive illusion or over-confidence of efficacy beliefs in comparison to actual aptitude (Pintea, 2006; Glaser, Langer, & Weber, 2005; Glasser & Weber, 2003). Students who over-estimate their ability may further hinder their performance by investing an inadequate amount of energy while preparing or performing the task of interest. In the current dissertation, students who over-estimated their performance for the Metacognitive Monitoring items may have also invested insufficient energy toward essential MPS processes such as checking one's work for errors or inconsistencies.

Given the relative strong evidence for the predictive validity of selected aspects of the SRL microanalytic protocol, it appears that SRL microanalysis could be of interest to educational professionals. Moreover, SRL microanalysis entails a multitude of conceptual advantages for academic settings. (1) In comparison to the composite scores generated by SRL questionnaires, SRL microanalysis appears to be a stronger predictor of future achievement. (2) Compared to SRL questionnaires, the data produced from SRL microanalysis may better inform educators of instructional practices because students' responses to microanalytic questions can be compared qualitatively and quantitatively to responses that are indicative of task mastery and thus pinpoint specific deficits to target with instruction; (3) Instructors can use SRL microanalysis as a formative measure, to track intervention progress, and because of the real-time nature of the measurement, teachers can both measure and instruct students concurrently. For example, research has begun to examine how teachers and tutors can use SRL microanalytic data in a formative way to modify the nature of professional development training programs or tutoring sessions (Cleary & Platten, 2013; Peters & Burton, 2013); (4) There is also some data that teachers prefer assessment data generated with microanalysis than data produced from more traditional questionnaires because it is more useful for intervention planning and working with students who struggle in school (Cleary & Zimmerman, 2006); (5) SRL microanalysis also fits exceptionally well with the emergent model of service delivery in schools which bases instructional practices on the presence or lack of remediation in student functioning in response to academic or behavioral intervention or accommodations (Bergan, 1977; Deno, 1985;

Reschley, 2008) This model is more commonly known as the “response to intervention model” and requires contextualized measurement tools to detect aforementioned remediation. If practitioners are to address self-regulatory aspects in schools that are functioning from this model, the development and validation of highly contextualized measures such as SRL microanalysis is necessary. Microanalysis is exceptionally well fit for this model since by design it is context specific, more sensitive to very fine changes in SRL and thus is optimal for tracking intervention progress (Cleary, 2011; Cleary et al., 2008; Cleary & Zimmerman, 2004).

Limitations of this Study

There are some limitations in the current dissertation. These include a relatively small sample size, missing prior achievement data, a lack of observational data, and a lack of data regarding many SRL processes within the three-phase model of SRL.

Although this study did possess adequate statistical power to conduct the desired statistical analyses, the sample size was relatively small in comparison to many other psychometric studies. The limited sample size was primarily a function of the time and resource constraints associated with a qualitative interview measurements such as administering individualized interviews and coding data. For this reason, the generalizability of the findings should be interpreted with caution. Related to the small sample size is the fact that a sizeable portion of the already modest sample size needed to be removed from the final analyses due to missing prior achievement data. Considering the statistical power necessary for the hierarchical multiple regressions conducted in the current study, the loss of any data is unfortunate.

The absence of observational data is a second limitation that should be noted for the current study. Direct observations of students’ actual use of SRL strategies would have enabled the author to identify how well SRL microanalysis, SRL questionnaires, and SRL teacher ratings relate to students’ use of strategies. This data would have been particularly valuable when interpreting the convergence and divergence of the SLR measures. The author posited several potential explanations for the lack of convergence of measures but since the current study did not included observational data, interpretation was limited.

Another limitation of this study is that the author did not collect data for self-efficacy or satisfaction. When measuring SRL with a contextually-sensitive measure, such as SRL microanalysis, the extent to which students report strategically planning or using strategies during performance could vary as a function of students' perception of the their ability to complete that particular task. For this reason, some high-achieving students who perceived the MPS items during the SRL microanalytic interview to be easy may not have identified the need to self-regulate because the task appeared routine. This possibility limits the true understanding of the relationship between some SRL microanalytic processes and achievement. Collecting self-efficacy data could have enabled the author to control for these situations. In addition, collecting data such as satisfaction or interest could have allowed the research to determine if participants cared about the research task.

Future Research

It seems that this study unearthed more questions than answers. For that reason, the author will identify a number of future areas for research that may be of importance. First of all, the author is interested in refining the SRL microanalytic protocol that was developed for the current dissertation. A number of SRL processes and motivational believes were not addressed by the current study and it is possible that other SRL could be powerful predictors of achievement or informative of educational practices. In addition to adding new measurement aspects, the author believes that it could be important to examine some of the items that were problematic. For example, the goal-setting item, attributions items, and adaptive inferences items displayed cross loading in the factor analyses. Prior SRL microanalytic research has often supported the utility of these items in that reflection and goal-setting processes have frequently been linked to outcomes. Additional research comparing SRL measurement formats is needed to better understand how, when, and why these measures may or may not relate. Specifically, research should examine the relationship between SRL microanalysis, SRL questionnaires, and SRL teacher ratings while including direct observational data to identify which measures are most related to actual behavior.

Similar to the current study, additional research is needed to address how SRL microanalysis relates to both task specific and global outcomes in additional academic settings. The current study displayed some support that SRL microanalysis can predict a variety of academic outcomes and that metacognitive monitoring may be particularly useful when predicting more global achievement from highly specific performance situations. Additional research should replicate the findings of the current dissertation and examine the predictive validity of additional SRL processes across a continuum of achievement situations.

The application of SRL microanalytic data to inform teacher's instructional practices is another area of future research need. As noted previously, the data produced from SRL microanalysis could be extremely useful to educational professionals, yet there is a limited amount of research that has actually examined the use of SRL microanalysis to support instructional and intervention activities (Cleary & Platten, 2013; Cleary et al., 2008; Peters & Burton, 2013). It may be especially useful to develop and validate SRL intervention programs that utilize SRL microanalytic questions to guide classroom instructors to best serve the motivational and regulatory needs of their students.

Since SRL microanalysis can potentially be used to identify changes in student functioning during a particular task, the use of SRL microanalysis could be beneficial to pinpoint specific components of instructional lessons or SRL intervention programs that most adequately produce the intended and desired changes in student's SRL. For this reason, examining new and currently existing SRL intervention programs from a component analysis perspective with SRL microanalytic measures could be a fruitful research venture.

Conclusion

The results from the current dissertation provide initial empirical evidence that SRL microanalytic measurement can predict achievement across a range of mathematical tasks such as MPS and standardized test performance. In particular, SRL microanalysis emerged as a superior predictor when compared to more commonly used questionnaire measures across narrowly defined MPS tasks and global mathematics achievement. This study also suggests that SRL microanalytic measurement of strategy use may not be expected to relate to more globalized measures of SRL such as questionnaires or teacher ratings. Finally, this study provides some initial, albeit limited, support for the divergent validity of SRL microanalysis.

Appendix A: SRL Microanalytic Protocol

Cover Page

Examiner Name________________________________

Student Name:________________________________

Date:____

Student ID #:_________________________________

Teacher Name:________________________________

Audio File Name / number:______________________

Was this protocol recorded verbatim?____

Verbatim:

- **Question 1____________________ (Time:____________)**
- **Question 2____________________ (Time:____________)**
- **Question 3____________________ (Time:____________)**
- **Question 4____________________ (Time:____________)**
- **Question 5____________________ (Time:____________)**
- **Question 6____________________ (Time:____________)**

I. Microanalytic Interview

MATHEMATICAL PROBLEM SOLVING TASK

General Overview of Study:

a. **Review Informed Consent & Participant Rights**

- Students and parents have already completed informed consent.
- Overview following participant rights and answer any questions s/he may have.
  - Voluntary participation
  - Right to not answer any questions or stop at any time
  - Confidentiality (& exceptions)
  - Won't affect grades
  - Audio recording

Say, **"Before we start, I want you to take a moment to review the informed consent document. If you have any questions or concerns, please don't hesitate to ask."**

Once the participant has read the document: Ask, **"Do you have any questions for me?**

b. **Introduction of Task:**

Say, **"Today we will be doing several math problems. While you work through the problems, I will stop you from time to time to ask you a few questions. I will read the questions to you, and all I need you to do is tell me what you think. There are no right or wrong answers to these interviews questions."**

Say, **"Before we begin to solve the problems, I will tell you the rules. You have as much time as you want to do these problems. How well you do on these problems will not affect your grade in math, but I want you to try your best." Sound good? / Okay? At any point, if there are any words that you do not understand or if you are unsure of a question meaning, please let me know and I can help you.**

☐ **Tear out and present the "math problems preview" (next page)**

Math Problems Preview

First Math Problem

A restaurant has 10 square tables that can each seat four people with one on each side. A large group of customers would like to sit together so they push the 10 tables into one row of tables. How many people can be seated at the new long table?

Second Math Problem

A frog fell down an old abandoned well. The well was 10 feet deep and the sides were slick and hard to climb. It was 8 a.m. when the frog started climbing up. Each hour he climbed up 3 feet before sliding back down 1 foot. At this rate at what time did the frog finally climb out of the well?

Third Math Problem

A caterpillar lives at the southwest corner of a garden that is 12 feet by 10 feet. A sidewalk that is 2 feet wide surrounds the garden. Each day he takes a walk following the same route. He walks around the perimeter of the garden, crosses the sidewalk, then walks the outside perimeter of the sidewalk, and finally walks back across the sidewalk (at the same place he originally crossed the sidewalk) to his home. How many feet does he travel during his walk each day?

Fourth Math Problem

A party sub was cut into 12 equal sections. Only 3 sections remain, but 5 people would each like to equally split the remaining sub amongst each other. What fraction of the original sub should each person receive?

Microanalytic Protocol:

Section A: ***FORETHOUGHT PHASE***

Interview Question #1:
Directions:

1. ☐ Say, **"Please take a look at this set of math problems. Do not start to do any math, but just read the problems and once you understand what the problems are asking, let me know."**
2. ☐ NOTE: If examinee begins describing the procedures that they will use:

   Say, "For right now, you don't have to tell me how to do the problems just yet. I just want you to read through the problems to get an idea of what they are asking for.

   ☐ Just after the participant reads the problems, but before s/he begins to solve the questions, Say: **"In a moment, I will have you begin solving these math problems, but first, I want you to answer a couple of questions**."

Say, **"Do you have a goal in mind as you prepare to practice these math problems? If so, what is it?"** Record answer here: ____

____

____

____

Interview Question #2:
Directions:

1. ☐ Immediately after the student responds to interview question #1, administer interview question #2.

Say, "Do you have any plans for how to successfully complete these math problems?"
(Record response verbatim) ____

____

____

____

☐ **Tear out and present "First math item."**

First Math Problem

A restaurant has 10 square tables that can each seat four people with one on each side. A large group of customers would like to sit together so they push the 10 tables into one row of tables. How many people can be seated at the new long table?

Answer: ____________

<u>Section B: ***PERFORMANCE PHASE***</u>

<u>Directions:</u>

1. ☐ Say: **Okay, now I want you to complete the problems. You can use the space here** (point to the blank space below the problem) **to do any math operations. If you need extra space to work, let me know because I have extra work paper. Please do not erase your work. If you decide to try a new approach to solving the problem, just cross out the old work like this** (show proper crossing out).

2. ☐ Provide the math items one at a time.

3. ☐ Administered the first math item.

<u>Interview Question #3a:</u>

<u>Directions:</u>

1. ☐ Administered interview question #3a immediately after the examinee finishes the first math item.

Say, **"Tell me all of the things that you did to solve this problem** (point @ item #1)**."**

Record response verbatim____

____

____

____

If an answer is provided, prompt: **"is there anything else that you did?"**

____

____

____

If an answer is provided, prompt: **"is there anything else that you did?"**

____

____

____

If multiple answers are given, Say: **"You said a few things that you did to solve the problem. What is the most important thing you did?"**____

____

Second Math Problem

A frog fell down an old abandoned well. The well was 10 feet deep and the sides were slick and hard to climb. It was 8 a.m. when the frog started climbing up. Each hour he climbed up 3 feet before sliding back down 1 foot. At this rate at what time did the frog finally climb out of the well?

Answer:___________________

Third Math Problem

A Caterpillar lives at the southwest corner of a garden that is 12 feet by 10 feet. A sidewalk that is 2 feet wide surrounds the garden. Each day he takes a walk following the same route. He walks around the perimeter of the garden, crosses the sidewalk, then walks the outside perimeter of the sidewalk, and finally walks back across the sidewalk (at the same place he originally crossed the sidewalk) to his home. How many feet does he travel during his walk each day?

Answer: ______________

2. ☐ Administered second math item
3. ☐ Administered third math item

Interview Question #3b:

Directions:

1. ☐ Immediately after the examinee finishes math item#3, administer question #3b.

Say, **"Tell me all of the things that you did to solve this problem** (point to math item #3)**."**

Record response verbatim____

If an answer is provided, prompt: **"is there anything else that you did?"**

If an answer is provided, prompt: **"is there anything else that you did?"**

If multiple answers are given, Say: **"You said a few things that you did to solve the problem. What is the most important thing you did?"** ____

Interview Question #4:

Directions:

1. ☐ Administer question #4 immediately after the student finishes **ALL** word problems.

Say, **"On a scale from 1 to 7, with 1 being *not sure*, 3 being *somewhat sure*, 5 being pretty sure, and 7 being *very sure*** (show the cue card)**, How sure are you that you solved....**

Question 1: "This problem (point to question 1) **correctly?" _______**

Question 2: "This problem (point to question 2) **correctly?" _______**

Question 3: "This problem (point to question 3) **correctly?" _______**

Section C: ***REFLECTION PHASE***

Directions:

1. ☐ Compare the participant's problem solution answer to the answer key.
2. ☐ Find the first incorrectly solved problem.
3. ☐ If examinee answered all problems correctly, admin fourth math item (page 14).

Say: Now, I want to ask you a question about an individual math problem. Show first math item that was answered incorrectly.

Say, **"You got this item wrong (**point to the math item**)...."**

Interview Question #5:

Say, **"Why do you think you were unable to get the right answer for this problem?**

____

____

____

____

If an answer is provided, prompt: **"Is there any other reason why you were unable to get the right answer for this problem?"**

____

____

____

____

If an answer is provided, prompt: **"Is there any other reason why you were unable to get the right answer for this problem?**

____

____

____

If multiple answers are given, Say: **"You gave a few reasons why you did not solve the problems. What is the main reason?"**____

____

____

<u>Question #6</u>

<u>Directions:</u>

1. ☐ Administer question #6 immediately after administering question #5.

Say, "If you were given another chance to do a similar math problem, what would you need to do to do well?" ______________________________

____

____

If an answer is provided, prompt: **"Is there anything else that you would do?"**

____

____

____

If an answer is provided, prompt: **"Is there anything else that you would do?"**

____

____

____

If multiple answers are given, Say: **"You gave a few things that you would do. What is the most important thing you would do?"** ______________________________

____

____

☐ Say, "**That concludes the interview. Now, I will have you complete a few surveys.**"

Fourth Math Problem

A party sub was cut into 12 equal sections. Only 3 sections remain, but 5 people would each like to equally split the remaining sub amongst each other. What fraction of the original sub should each person receive?

Answer: ___________________

Part A
Self-Esteem Questionnaire

Directions: These questions ask how you feel about yourself. For each question, choose the *one* answer that best describes how **YOU** feel about yourself. There are **NO** right or wrong answers. Just give your **HONEST** opinion. Put a check mark in the appropriate box for each question.

1 Strongly Disagree	2 Disagree	3 Agree	4 Strongly Agree
○	○	○	○

Choose the answer that best describes how YOU feel.	1 Strongly Disagree	2 Disagree	3 Agree	4 Strongly Agree
1. I am as popular with kids my own age as I want to be.	○	○	○	○
2. I am happy with the way I look.	○	○	○	○
3. I am as good as I want to be at making new friends.	○	○	○	○
4. I like my body just the way it is.	○	○	○	○
5. I have as many close friends as I would like to have.	○	○	○	○
6. I feel good about my height and weight.	○	○	○	○
7. I am as well liked by other kids as I want to be.	○	○	○	○
8. I wish I looked a lot different	○	○	○	○
9. I feel good about how well I get along with other kids.	○	○	○	○
10. I wish my friends liked me more than they do.	○	○	○	○
11. I feel good about how much my friends like my ideas.	○	○	○	○
12. I feel OK about how much other kids like doing things with me.	○	○	○	○

Part B
Self-Regulation Strategy Inventory – Self-Report

Directions: The purpose of this section is to see how often you do certain things in **MATH**. For each statement, please fill in **ONE** circle to indicate **HOW OFTEN** you do each of these things when doing homework for **MATH** or studying for **MATH** tests.

To answer these questions, use the following 5-point scale:

1 Almost never	2 Not very often	3 Somewhat often	4 Very often	5 Almost always
○	○	○	○	○

How OFTEN do you do the following things when studying or doing homework for MATH…	1 Almost never	2 Not very often	3 Somewhat often	4 Very often	5 Almost always
1. I make sure no one disturbs me when I study.	○	○	○	○	○
2. I try to study in a quiet place.	○	○	○	○	○
3. I think about the types of questions that might be on a test.	○	○	○	○	○
4. I ask my math teacher about the topics that will be on upcoming tests.	○	○	○	○	○
5. I rely on my math class notes to study.	○	○	○	○	○
6. I study hard even when there are more fun things to do at home.	○	○	○	○	○
7. I quiz myself to see how much I am learning during studying.	○	○	○	○	○
8. I make a schedule to help me organize my study time.	○	○	○	○	○
9. I use binders or folders to organize my math study materials.	○	○	○	○	○
10. I lose important math worksheets or materials.	○	○	○	○	○
11. I avoid going to extra-help sessions in math.	○	○	○	○	○
12. I wait to the last minute to study for math tests.	○	○	○	○	○

13. I try to forget about the topics that I have trouble learning.	○	○	○	○	○
14. I try to see how my notes from math class relates to things I already know.	○	○	○	○	○
15. I try to identify the format of upcoming math tests (e.g., multi-choice, essay, test length)	○	○	○	○	○
16. I try to study in a place that has no distractions (e.g., noise, people talking).	○	○	○	○	○
17. I ask my teacher questions when I do not understand something.	○	○	○	○	○
18. I make pictures or drawings to help me learn math concepts.	○	○	○	○	○
19. I give up or quit when I do not understand something.	○	○	○	○	○
20. I forget to bring home my math materials when I need to study.	○	○	○	○	○
21. I tell myself exactly what I want to accomplish during studying.	○	○	○	○	○
22. I look over my homework assignments if I don't understand something.	○	○	○	○	○
23. I avoid asking questions in class about things I don't understand.	○	○	○	○	○
24. I tell myself to keep trying when I can't learn a topic or idea.	○	○	○	○	○
25. I carefully organize my study materials so I don't lose them.	○	○	○	○	○
26. I let my friends interrupt me when I am studying.	○	○	○	○	○
27. I think about how best to study before I begin studying.	○	○	○	○	○
28. I finish all of my studying before I play video games or with my friends.	○	○	○	○	○

Part C

Learning and Study Strategies Inventory – Test Strategies

Directions: The purpose of this section is to see how well you learn in math. For each statement, please fill in only **ONE** circle to indicate how typical each statement is of you. To answer these questions, use the following 5-point scale:

1 Not AT ALL typical of me	2 NOT VERY typical of me	3 SOMEWHAT typical of me	4 FAIRLY typical of me	5 VERY MUCH typical of me
○	○	○	○	○

How TYPICAL OF YOU are each of the following statements…	1 Not AT ALL typical of me	2 NOT VERY typical of me	3 SOMEWHAT typical of me	4 FAIRLY typical of me	5 VERY MUCH typical of me
1. I do poorly on math tests because I find it hard to plan my work within a short period of time.	○	○	○	○	○
2. I have trouble summarizing what I just heard in math class or read in my math textbook.	○	○	○	○	○
3. When I study for math quizzes or tests, I have trouble figuring out just what to do to learn the material.	○	○	○	○	○
4. I have trouble understanding what a math test question is asking.	○	○	○	○	○
5. When I take a math test I often realize I have studied the wrong material.	○	○	○	○	○
6. I memorize math formulas without understanding them.	○	○	○	○	○
7. I have a hard time changing how I study for different types of math problems.	○	○	○	○	○
8. In taking math tests, I often do not understand what the teacher wants and I lose points because of it.	○	○	○	○	○

Self-Regulation Strategy Inventory – Teacher Rating Scale

Student Name:________________Teacher Name:_________________ Date:__________

We are interested in the types of behaviors that students exhibit in relation to your course. Please fill in the circle next to each question to indicate **HOW OFTEN** this student does each behavior or activity. There is no right or wrong answer. It is important that you answer each statement to the best of your ability. Use the following categories below to answer all questions.

Please fill in <u>only one</u> circle completely for <u>each</u> question like this: ○ ● ○ ○

1	2	3	4	5
Almost never	Not very often	Somewhat often	Very often	Almost always

HOW OFTEN?	**1 Almost never**	**2 Not very often**	**3 Some what often**	**4 Very often**	**5 Almost always**
1. The student asks about topics that might appear on upcoming tests	○	○	○	○	○
2. The student keeps his or her class materials very organized	○	○	○	○	○
3. The student asks insightful questions in class	○	○	○	○	○
4. The student asks questions about errors he or she makes on tests or assignments	○	○	○	○	○
5. The student attends extra help sessions	○	○	○	○	○
6. The student asks questions in class when he or she does not understand something	○	○	○	○	○
7. The student keeps himself or herself motivated even when they struggle to learn something	○	○	○	○	○
8. The student monitors how well he or she learns class material	○	○	○	○	○
9. The student asks about the format of upcoming tests (short-answer, multiple choice)	○	○	○	○	○
10. The student pushes himself or herself to understand all the details of the topics presented in class	○	○	○	○	○
11. The student is enthusiastic about learning	○	○	○	○	○
12. The student makes excellent use of class time	○	○	○	○	○
13. The student is prepared for class	○	○	○	○	○

Appendix B: SRL Microanalysis Coding Rubric

SRL Microanalysis Coding Rubric

Mathematical Problem Solving Edition

Developed By: Gregory Callan and Timothy Cleary, PhD

Goal-Setting

Process Goals:

Definition: Statement indicates a focus on the execution of procedures or the processes involved in solving the math problem.

1. **Process Specific:**
   Definitions: Statements that focus on the process of solving the problem and also identify the use of a specific math strategy, tactic, or mathematical procedure as the primary focus of the problem solving session.

   - "I'll probably draw a picture to understand how to do these problems"
   - "I want to make sure that I identify the important information first, Etc…
   - "I will do addition to find the perimeter."
     - Must say the procedure and how it will be used or for which problem it will be used.
   - "I will figure out what the problem is asking me"
   - "I will make sure that I really understand the problems"
   - "I will read the problem"
   - "I will highlight key information"
   - "I will make sure to draw a picture"
   - "I will write out an equation before I solve the problem"
   - "I will check to make sure that I did everything correctly when I am finished"
   - "I'll make an estimate of the correct answer before I do the computations"

2. **Process General:**
   Definition: Statements indicating a focus on a process in general but does not identify any particular procedures. **DO NOT** code **Process General** goals if the examinee has also indicated a **Process Specific** goal.

   - "Do it the right way"
   - "I want to choose the correct math for these problems."
   - "I want to do them fast"
   - "I will TRY my best"
   - "I will work hard"
   - "I'll give it my best"
   - "I'll think the problem through"
   - "try different methods"
   - "I need to understand the problem"

Outcome Goals:

Definition: Statement indicates a focus on achievement or an outcome during the problem solving session.

3. **Outcome Specific Goals**
   Definition: Statements that identify a clear and measureable outcome as the focus of problem solving practice session.

   - "I want to get 5 out of 5 of these problems correct"
   - "I want to get 3 out of 5; 2 out of 5; etc… of these problems correct"
   - "I want to get all of these problems correct"
   - "I want to get them ALL right"
4. **Outcome General Goals**
   Definition: Statement identifies an outcome that is unclear, not quantifiable, or not directly measurable as the focus of problem solving practice session.

   - "I will DO my best"
   - "I want get them DONE fast"
   - "I want to do my best on these problems"
   - "
   - "I want to get better at doing math."
   - "Get them right"
   - "I want to get a lot/some of them right"
5. **Other Goal**
   Definition: Statements that indicate a goal that does not fit into any of the other coding categories.

   - Goals that are not reflected in the coding scheme and not incongruent with the task.
6. **Non-Task Goal**
   Definition: Statements that indicate a goal that is so incongruent with the current task of the MPS practice session that the goal reflects an inadequate understanding of the task.

   - "To get into college"
   - "To get a better math grade"
7. **No Goal**
   Definition: Statement indicates that the student does not have a goal for the problem solving practice session.

   - "no"
   - "I don't know"
   - "not really"
   - "I don't really have a goal"
   - Shakes head
   - Does not respond

The Math Problem Solving Strategy

General Coding Guidelines

NOTE: Use these general coding guidelines while coding responses for SRL Microanalytic items that include the Math Problem Solving Strategy category.

1. Math Problem Solving Strategy (Total possible points= 15)

a) Step 1 – Identify Key Information (Max points for category = 4)

Definition: Statements that describe tactics to identify the most pertinent information in the problem. Includes four categories: (1) Reading & Re-reading, (2) Search, (3) Highlight, Underline, or List, and (4) Identify the Problem.

Coding Notes:

"Identifying Key Information" **DOES NOT** include overt uses of the tactics themselves**.**

- **(1) Read & Re-read (1)**
  Definition: Statements that describe reading or re-reading the math item.
    - "I will read the problem"
    - "I will look over the problem"
    - "I will read it over a couple times"
    - "If I don't get it, I'll have to read it again".
- **(2) Highlight, Underline, List, or Search (1)**
  Definition: Statements that describe actions to isolate or identify the most pertinent information.
    - "I will underline/highlight the important information"
    - "I will write out the main information"
    - "I will eliminate information that is un-important"
    - "I will write out the positive and negative signs"
    - "I will search the problem for important information"
    - "I will look for key words"
    - "I will look for clues"
    - "I will search for the most important information/clues/hints"
    - "I'll make sure that I pay attention to each key word"
    - "I will look for the most important information"

  Non-Examples

    - Statements that describe the labeling of drawings or diagrams.
        - I wrote the length of each side down on the diagram that I drew (Code as translating - drawing).
    - Statements that describe pertinent information but does not specify the action of identifying that information.
        - "It says that there are 10 tables and that 4 people can sit at each one." (Do not code)

  - Statements identifying key information within the problem.
    - "well it says that there are 10 tables and 4 people can sit at each table"

- **(3) Identify the Problem/Question (1)**
  Definition: Statements that identify the necessity of identifying what the problem is asking them to do or what the problem requires.

  - **Directly references Problem Identification (1)**
    - "I need to understand/figure out what I am supposed to do"
    - "I need to figure out what the problem is asking me"

  Non-Examples

  - Statements that **Actually** Identify the Problem Type / Question
    - "This is a perimeter problem."
    - "This problem is asking me to add up all of the sides to find out how far the caterpillar walked."

b) Step 2 – Translate (Max points for category = 3)

Definition: Statements that describe the modification of the problem solving content changing the wording, formulating the problem into a visualization, or connecting the current problem content to a previous learning experience**. Translate** includes 3 categories: **(1)** Paraphrase, Re-state, **Or** Create an Analogous Problem, **(2)** Visualization, and **(3)** Elaboration.

Coding Notes:

"Translate" **DOES NOT** include overt uses of the tactics themselves**.**

- **(1) Paraphrase, Re-state, or Create an Analogous Problem (1)**
  Definition: Statements that describe actions such as re-writing, paraphrasing, or creation of analogous problems.

    - "I will make a simpler problem that is similar to this one"
    - "I will re-write the problem in my own words"
    - "I will summarize what the problem is asking me to do."

  Non-Examples:

  - Statements that actually paraphrase, re-state, or summarize the problem.

- **(2) Visualization (1)**
  Definition: Statements describing the use of pictures of mental images to aid problem comprehension or solution.

- “I’ll draw a picture”
- “I’ll make a diagram
- “I’ll picture the path that the caterpillar travels in my head”
- “I’ll visualize the problem”

Note: Statements that describe labeling graphics are coded as an instance of “visualization.” Maximum of one instance of visualization per interviewee.

- **(3) Elaboration: (1)**

Definition: Statements that describe the use of elaboration tactics wherein students connect the current task demands to prior learning experiences.

- “I’ll think about past problems that I’ve done”
- “I’ll remember what the teacher taught us to solve the problem”

Non-Examples

- Statements that indicate engagement in reflection
  - “This is similar to a problem I’ve done before.”
  - “I’ve done some like this before”
  - “Our teacher taught us a procedure for these types of problems”

c) Step 3 – Hypothesize / Estimate / Predict the Answer **(Max pts = 1)**

Definition: Statements that describe the creation of a hypothesis about a potential answer to the math problems.

- “I will make a ball park guess of the right answer”
- “I’ll estimate what I think the answer should come out to”
- I will guess and check

d) Step 4 – Equation Development and Computation **(Max pts = 3)**

Definition: Statements that explicitly reference the need to **(1)** develop an equation to solve the problem and **(2)** complete computations **OR** **(3)** statements that propose, select, or describe the completion of mathematical procedures or computations necessary to solve the problem.

- (1) Equation Development Intention (1)
  - “I need to make an equation to solve this problem”
  - “Before I do the math, I will write out the equation”

- (2) Computation Intention (1)
  - “Next I will need to solve the equation”
  - “Then I will compute the procedures that I selected”

- Procedures Selection or Computation Completion (1)
  - “I’ll do some addition for problem #4 to find the perimeter.”

- "I will add up 10, 10, 12, and 12 to find the perimeter of the garden."
- "Well, since 10, 10, 12, and 12 is 44. I know that the perimeter of the garden is 44 and then _____"
- "I added up the sides to find the perimeter"
- "I added 10 + 10 + 12 + 12 and then I multiplied it by two"

Non-Examples

- Statements that only list procedures or computations without identifying how or where they will be used.

e) Step 5 – Check (Max points = 4)

Definition: Statements that describe **(1)** the intention to monitor the understanding of the problem, **(2)** procedures to verify the accuracy or appropriateness of one's work, or **(3)** to compare their solution to an estimated answer.

- **(1) Check / Monitor Understanding (2)**
  Definition: Statements that describe tactics to check / monitor the understanding of the problem. These statements may describe **(A)** the intention to use specific strategies to monitor understanding (e.g., self-questioning) or **(B)** may make direct references to monitoring understanding.

  - **(A) Self-Questioning (1)**
    Definition: Examinee indicates that they will ask themselves questions about the current task demands.

    - "I will ask myself questions about the problem as I do it"
    - "I will prompt myself to make sure that I am doing the right things"

  - **(B) Direct References Checking Understanding (1)**
    Definition: Statements that describe the intention to check understanding

    - "I will make sure that I am understanding the problem"

Non-Examples of "Checking / Monitoring Understanding

- Indicators of Monitoring of Understanding
  Definition: Statements which are only possible if one has monitored their understanding. For example, in order to identify one's current understanding (e.g., I don't really get this one) it is necessary that they engaged in monitoring behaviors.

  - "I got confused by this one…."
  - "I'm not really understanding this one yet…"

  - "I get this one"

- **(2) Check Performance (1)**
  Definition: Statements that describe the checking of operations for accuracy and appropriateness

  - "I'll check if I selected the right operations"
  - "I will check my work"
  - "I'll make sure that I did the computations right"
  - "I'll double check my work"
  - "I'll make sure I didn't make any errors"
- **(3) Compare Solution and Estimate (1)**
  Definition: Statements that describe checking the solution to determine if it makes sense.

  - "I will compare the answer I got with my estimate"
  - "I will see if the answer makes sense"

Strategic Planning

Coding Guidelines

1. Math Problem Solving Strategy (Total possible points= 15)

Follow the MPS general coding guidelines listed above.

**********************NON-MPS Coding Categories (4) ************************

2. Other (1)

Definition: Statements that identify a specific behavior or strategy that is not found or better coded as another category. Could include other SRL strategies such as self-control.

- "I will make sure that I don't rush" **or** "I'll take my time"
- "I will take a deep breath before starting the problems to calm my nerves"
- "I will visualize myself succeeding on these problems"
- "I will tell myself to keep trying even if the problems are really hard"
- "I will keep reminding myself that I need to: (describes specific math procedures)"

Notes: **Other** responses are **NOT** coded if examinee provides an answer that can be coded into one of the other identified categories. RECORD the response that is being identified as "OTHER" in the coding spread sheet for later examination.

- Examples are likely to be low incidence statements"

3. Non-Task Plans

Definition: Statements that indicate a goal that is so incongruent with the current task of the MPS practice session that the goal reflects an inadequate understanding of the task.

- "I would probably ask my teacher for help"
- "I will probably look in my notes to figure out how to do these problems"
- "I would probably use a calculator."

4. Don't Know or No plan (1)

Definition: Statements that indicate that the examinee does not know how to approach the problems or what they will do to solve the problems.

Notes: Statements are **NOT CODED AS DK** if the statement is followed or preceded by a different code-able response.

- "I have no idea"
- "don't know"
- shakes head / provides no response
- "I'm not sure"

Strategy Use

Coding Guidelines

1. Math Problem Solving Strategy (Total possible points= 15)

Follow the MPS general coding guidelines listed above.

********************** **NON-MPS Coding Categories (3)** ************************

2. Other (1)

Definition: Statements that identify a specific behavior or strategy that is not found or better Coded as another category.

Note: **Other** responses are **NOT** coded if the examinee provides an answer that can be coded into one of the other identified categories. RECORD the response that is being identified as "OTHER" in the coding spread sheet for later examination.

- Examples are likely to be low incidence responses

3. Non-Task Strategies

Definition: Statements that indicate a goal that is so incongruent with the current task of the MPS practice session that the strategy reflects an inadequate understanding of the task.

4. Don't Know or No Strategy (1)

Definition: Statements that indicate that the examinee did not use a strategy or cannot explain how they solved the problem.

Note: These statements are **NOT CODED** AS DK/NO if the statement is followed or preceded by a different code-able response.

- "I don't know"
- "not sure"
- "No response provided"

Attributions

Coding guidelines

1. Math Problem Solving Strategy (Total possible points= 15)

Follow the general coding criteria listed above.

2. Other (1)

Definition: Statements that identify a specific behavior or strategy that is not found or better labeled as another category.

Note: **Other** responses are **NOT** coded if the examinee provides an answer that can be coded into one of the other identified categories. RECORD the response that is being identified as "OTHER" in the coding spread sheet for later examination.

- Examples are likely to be low incidence responses

3. Non- Task Related (1)

Definition: Statement highlights the use of a strategy or procedure that is not appropriate or consistent with the current task.

- "I didn't ask my teacher for help"

4. Don't Know or No plan (1)

Definition: Statements that indicate that the examinee does not know why I got the wrong answer.

Note: These statements are **NOT CODED** AS DK/NO if the statement is followed or preceded by a different code-able response.

- "I have no idea"
- "don't know"
- "shakes head" **OR** "provides no response"
- "I'm not sure"

Adaptive Inferences

Coding Guidelines

1. Math Problem Solving Strategy (Total possible points= 15)

Follow the MPS general coding guidelines listed above.

2. Other (1)

Definition: Statements that identify a specific behavior or strategy that is not found or better labeled as another category.

Note: **Other** responses are **NOT** coded if the examinee provides an answer that can be coded into one of the other identified categories. RECORD the response that is being identified as "OTHER" in the coding spread sheet for later examination.

- Examples are likely to be low incidence responses

3. Non- Task Related (1)

Definition: Statement highlights the intention to use a specific strategy or procedure that is not appropriate or consistent with the current task.

- "I would probably ask my teacher for help"
- "I will probably look in my notes to figure out how to do these problems"
- "I would probably use a calculator."

4. Don't Know or No plan (1)

Definition: Statements that indicate that the examinee does not know how to approach the problems or what they will do to solve the problems.

Note: These statements are **NOT CODED** AS DK/NO if the statement is followed or preceded by a different code-able response.

- "I have no idea"
- "don't know"
- "shakes head"
- "provides no response"
- "I'm not sure

Appendix C: SRL Microanalytic Scoring Template

Microanalysis Scoring Template							
Goal Setting Microanalytic Item Scoring							
Scoring	Plus 3	Plus 2	Plus 2	Plus 1	No score	Minus 1 pt	Minus 2pts
CRITERIA	Process Specific	Process General	Outcome Specific	Outcome General	Other goal	Minus1 point for **'non-task'** goals that are inconsistent **<u>ONLY if</u>** no other goal type is code-able.	Minus 2 points for **'IDK'** goals or **'No'** **<u>ONLY if</u>** no other goal type was provided
Strategic Planning Microanalytic Item Scoring							
Scoring	Plus points for MPS strategy components (max 11 pts)					Minus 1pt	Minus 2pts
CRITERIA	<u>Identify Key information</u> (Max= 2pts) 1. Highlight, underline, list, search 2. Identify the question	<u>Translate</u> (Max= 3pts) 1. Paraphrase 2. Visualize 3. Elaborate	<u>Hypothesize / Estimate</u> (Max= 1pt)	<u>Equation Develop (Max= 1pt)</u>	<u>Check (Max= 4pts)</u> 1. Check understanding a. Self-Question b. Direct references 2. Check performance 3. Compare solution & estimate	Minus 1 point for plans that indicated plans that are inconsistent **<u>ONLY if</u>** no other plan is code-able.	Minus 2 points for **'IDK'** or **'No'** plan **<u>ONLY if</u>** no other plan type was provided.
Strategy Use Microanalytic Item Scoring							
Scoring	Plus points for MPS strategy components (max 11 pts)					Minus 1pt	Minus 2pts
CRITERIA	<u>Identify Key information</u> (Max= 2pts) 1. Highlight, underli	<u>Translate</u> (Max= 3pts) 1. Paraphrase 2. Visualize 3. Elabor	<u>Hypothesize / Estimate</u> (Max= 1pt)	<u>Equation Develop (Max= 1pt)</u>	<u>Check (Max= 4pts)</u> 1. Check understanding a. Self-Question b. Direct references 2. Check	Minus 1 point for plans that indicated plans that are inconsistent **<u>ONLY if</u>** no other	Minus 2 points for **'IDK'** or **'No'** plan **<u>ONLY if</u>** no other plan type was provided.

	ne, list, search 2. Identify the question	ate			performance 3. Compare solution & estimate	plan is code-able.	
Causal Attributions Microanalytic Item Scoring							
Scoring	Plus points for MPS strategy components (max 11 pts)					Minus 1pt	Minus 2pts
CRITERIA	<u>Identify Key information</u> (Max= 2pts) 1. Highlight, underline, list, search 2. Identify the question	<u>Translate</u> (Max= 3pts) 1. Paraphrase 2. Visualize 3. Elaborate	<u>Hypothesize / Estimate</u> (Max= 1pt)	<u>Equation Develop (Max= 1pt)</u>	<u>Check (Max= 4pts)</u> 1. Check understanding a. Self-Question b. Direct references 2. Check performance 3. Compare solution & estimate	Minus 1 point for plans that indicated plans that are inconsistent <u>**ONLY if**</u> no other plan is code-able.	Minus 2 points for **'IDK'** or **'No'** plan <u>**ONLY if**</u> no other plan type was provided.
Adaptive Inferences Microanalytic Item Scoring							
Scoring	Plus points for MPS strategy components (max 11 pts)					Minus 1pt	Minus 2pts
CRITERIA	<u>Identify Key information</u> (Max= 2pts) 1. Highlight, underline, list, search 2. Identify the question	<u>Translate</u> (Max= 3pts) 1. Paraphrase 2. Visualize 3. Elaborate	<u>Hypothesize / Estimate</u> (Max= 1pt)	<u>Equation Develop (Max= 1pt)</u>	<u>Check (Max= 4pts)</u> 1. Check understanding a. Self-Question b. Direct references 2. Check performance 3. Compare solution & estimate	Minus 1 point for plans that indicated plans that are inconsistent <u>**ONLY if**</u> no other plan is code-able.	Minus 2 points for **'IDK'** or **'No'** plan <u>**ONLY if**</u> no other plan type was provided.

Appendix D: Posttest MPS Items

POST-TEST MATH PROBLEM #1

Chairs are to be set up in a meeting room so that each row has 1 more chair than the previous row (this way none of the chairs will be directly behind another). If there are 5 chairs in the first row, how many chairs will be in the sixth row?

POST-TEST MATH PROBLEM #2

Adam and Spencer live in an apartment building. From the first floor to the second floor there are 22 steps. Adam lives on the second floor. How many steps would Adam climb to get to Spencer's apartment, which is on the eighth floor? Assume that there are the same number of steps between all floors.

POST-TEST MATH PROBLEM #3

Sixteen softball teams are participating in a single-elimination tournament (a team is done after their first loss). That is, only the winners of each game go on to play the next game. How many games will the first place team have played?

POST-TEST MATH PROLEM #4

In a certain restaurant a whole pie has been sliced into 8 equal wedges. Only 2 slices of the pie remain. Three people would each like an equal portion from the remaining slices of pie. What fraction of the original pie should each person receive?

POST-TEST MATH PROBLEM #5

A road crew is building a 9-mile road along the side of a mountain. Each day they complete 4 miles of the road, but each night rockslides destroy 1 mile of the road. At this rate, how many days will it take the crew to complete the road?

POST-TEST MATH PROBLEM #6

Madeline has 10 chips each with a number written on it from 1 to 10 (only one per number). She places each of the chips in a bag, mixes them up, and then draws one chip out of the bag. What is the probability that Madeline will draw a chip with an even number? Report answer in simplest form.

POST-TEST MATH PROBLEM #7

Zach, Bob, Sam, and Tony each play a different sport (baseball, basketball, football, and hockey). At lunch they sat around a square table.

- The baseball player sat on Bob's left
- Zach and Sam sat across from each other
- The football player sat across from Tony.
- Zach sat to the right of the basketball player.

Who plays hockey?

POST-TEST MATH PROBLEM #8

Tony has 2 quarters and 2 dimes. Marta has 1 quarter, 2 dimes, and 1 nickel. Which of the coins from Tony's bank would he need to give Marta so that they each have the same amount of money?

POST-TEST MATH PROBLEM #9

A club needs to sell 625 tickets. If it has already sold 184 tickets to adults and 80 tickets to children, how many more does it need to sell?

POST-TEST MATH PROBLEM #10

At the school carnival, Carmen sold 3 times as many hot dogs as Shawn. The two of them sold 152 hot dogs altogether. How many hot dogs did Carmen sell?

POST-TEST MATH PROBLEM #13

Kirstin wants to buy a flute that costs $240. She has already saved $20 for the last 3 weeks. How many more weeks does Kirstin need to save money if she continues to save $20 each week?

POST-TEST MATH PROBLEM #14

There were 90 employees in a company last year. This year the number of employees increased by 10 percent. How many employees are in the company this year?

POST-TEST MATH PROBLEM #15

Bob and Mike put up a rope to mark the start line for the sack race. The rope was 10 meters long. They put a post at each end of the rope and at every 2 meters. How many posts did they use?

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Zimmerman, B.J., & Martinez-Pons, M. (1988). Construct validation of a strategy model of student self-regulated learning. *Journal of Educational Psychology, 80*, 284-290. doi:10.1037//0022-0663.80.3.284

Zimmerman, B., & Schunk, D. (Eds.) (2011). *Handbook of self-regulation of learning and performance*. New York: Routledge.

GREGORY L. CALLAN

EDUCATION

Ph.D. **University of Wisconsin-Milwaukee** **08/2014**
Major: Educational Psychology - School Psychology
Minor: Clinical Psychology

M.S. **University of Wisconsin-Milwaukee** **08/2009**
Major: Educational Psychology - School Psychology

B.A. **Saint Norbert College**, (DePere, WI) **05/2008**
Major: Psychology; Minor: sociology

PROFESSIONAL & RESEARCH INTERESTS

My primary professional and research interests include: self-regulation and motivation (academic and emotional), child and adolescent mental health, multicultural practice in school psychology, and neuropsychological assessment. I have a particular interest in developing self-regulation assessments tools and self-regulation intervention programs to address student academic and behavioral difficulties.

HONORS & AWARDS (ordered by date)

- Graduate Student Research Award (2014): American Educational Research Association – Studying and Self-Regulated Learning: "*The validity of a SRL microanalytic protocol for mathematical problem solving*"
- UWM School of Education Scholarship (2013 – 2014)
- Society for the Study of School Psychology Dissertation Award (2012 – 2013)
- Doctoral Dissertator Fellowship, University of Wisconsin-Milwaukee (2012-2013)
- UWM Student Activity Center Large Grant (Spring, 2012)
- Ed Psych Nominee: UWM Distinguished Graduate Student Fellowship (Finalist, 2012)
- Ed Psych Nominee: UWM Distinguished Graduate Student Fellowship (Finalist, 2011)
- UWM Student Activity Center Large Grant (Fall, 2011)
- UWM Graduate Student Travel Award (2011, 2012)

TEACHING EXPERIENCE

Ed-Psy: 330 - Introduction to Learning & Development 08/2011 – 08/ 2012
Department of Educational Psychology UW-Milwaukee
Associate Lecturer:

Developed and administered the curriculum, weekly lectures, assignments, and assessments. Evaluated all assigned work and tests. Taught classroom section in traditional in-class format and web-based learning format.

Theories of Personality in Psychology 08/2008 – 12/2008

Department of Clinical Psychology UW-Milwaukee

Teaching Assistant:

Created and led weekly discussion sessions. Developed weekly quizzes and unit exams. Responsible for grading exams and makeup examinations. Intermediary between students and lead instructor.

PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS (ordered by date)

- Cleary, T. J., **Callan, G. L.,** and Zimmerman, B. J. (2012). Assessing Self-Regulation as a Cyclical, Context Specific Phenomenon: Overview and Analysis of SRL Microanalytic Protocols. *Education Research International, vol. 2012,* doi:10.1155/2012/428639.
- Cleary, T. J., & **Callan, G. L.** (2014). Student self-regulated learning in an urban high school: Predictive validity and relations between teacher ratings and student self-reports. *Journal of Psychoeducational Assessment*, 32(4), 295-305. doi:10.1177/0734282913507653

PROFESSIONAL PRESENTATIONS (ordered by date)

- **Callan, G. L.,** & Cleary, T. J. (2014, April). *The validity of a SRL microanalytic protocol for mathematical problem solving.* Paper presented at the annual meeting of the American Education Research Association (2014, April, Philadelphia, PA.
- Cleary, T. J., & **Callan,** G. (2014, April). *Using self-regulated learning (SRL) microanalysis to examine relations among cyclical-phase SRL processes.* In M. K. DiBenedetto, Research evidence on the dynamic and cyclical nature of self-regulated learning. Symposium conducted at the annual meeting of the American Education Research Association, Philadelphia, PA.
- **Callan, G.L.,** Cleary, T.J., Reynolds, C.E., Looser, J., Schumaker, C., Rollo, K. (2014, February). *Self-Regulated Learning Microanalysis for Math Problem Solving.* Presented at the annual convention of The National School Psychologist Association, Washington D.C.
- **Callan, G.L.**, Cleary, T., Reynolds, C., & Looser, J. (2013, May). *Measuring self-regulated learning (SRL) during mathematical problem solving with SRL microanalysis.* Presented at the annual University of Wisconsin-Milwaukee Doctoral Student Research Session, Milwaukee, WI.
- Bocanegra. J., **Callan, G. L.,** Newell, M. (2012, August). *Analysis of multicultural competency within School Psychology Quarterly journals from 1992—2008.* Presented at the annual convention of the American Psychological Association.
- **Callan, G. L.,** & Cleary, T. *A teacher rating scale to examine student self-regulation in math contexts.* Paper presented at the annual meeting of the American Educational Research Association, (2012, April) Vancouver, British Columbia, Canada.
- Avdeev, I., Berg, C., **Callan, G. L.,** Lovell, M., Posnanski, T., & Piechowski, M. (2012, March). *RET site: Milwaukee regional energy education initiative.* Presented at the National Science Foundation Engineering Education Programs Awardees Conference, Washington, D.C.
- **Callan, G., L.,** & Cleary, T. (2012, February). *Differential Effects of Self-Regulation Across Achievement Levels and Gender.* Presented at the annual meeting of the National Association of School Psychologists, Philadelphia, PA.
- Hernandez, M., Bocanegra, B., VanGrinsven, L., & **Callan, G. L**. (2012, February). *Examining the state of diversity research.* Presented at the annual meeting of the National Association of School Psychologists, Philadelphia, PA.

- Hernandez, M., Van Grinsven, L., **Callan, G**., and Stoiber K. (2011, August) *Predictors of Drop-Out Risk in African-American Youth.* Presented at the American Psychological Association Annual conference, Washington D.C.
- Van Grinsven, L., Hernandez, M., **Callan, G.,** & Stoiber, K. (2011, August). *The Impact of Small Learning Communities on Dropout Risk in Urban Youth.* Presented at the American Psychological Association Annual conference, Washington D.C.
- Cleary, T., **Callan, G.,** & Peterson, J. (2011, April). *Using Self-Regulated Learning (SRL) Microanalysis in an Academic Context: Conceptual and Empirical Advantages.* Presented at the annual meeting of the American Educational Research Association, New Orleans, LA.
- Bocanegra, J., Petersen, J., **Callan, G.**, and Gubi, A. (2010, May). *Preliminary findings: An overview of racial/ethnic minority research in school psychology.* Presented at the University of Wisconsin-Milwaukee Multi-Cultural Research Forum, Milwaukee, WI.
- **Callan, G. L.,** Adams, T., Peterson, J., & Cleary, T. J., (2010, March). *Psychometric features of the self-regulation microanalytic Assessment Interview.* Poster session presented at the annual University of Wisconsin-Milwaukee School of Education research convention, Milwaukee, WI.
- Cleary, T., **Callan, G.,** Adams, T., & Peterson, J. (2010, March). *Best practices in implementing self-regulation interventions in school settings.* Paper session presented at the annual meeting of the National Association of School Psychologists, Chicago, IL
- Cleary, T., Adams, T., Peterson, J., **Callan, G.** (2010, March). *Development and validation of a microanalytic self-regulation interview.* Poster session presented at the annual meeting of the National Association of School Psychologists, Chicago, IL.

IN PROGRESS PUBLICATIONS & PRESENTATIONS

- Cleary, T. J., **Callan, G. L.,** Peterson, J., & Adams, T. Validity of self-regulated learning (SRL) microanalysis in an academic context. Manuscript submitted for publication.
- **Callan, G. L., & Cleary, T. J.** An examination of the cyclical model of SRL and a comparison of self-regulated learning (SRL) microanalysis, trace observations, and self-report questionnaires. Manuscript in preparation.
- **Callan, G. L., & Cleary, T. J.** A multi-dimensional approach to self-regulated learning measurement: Examining the unique contributions of microanalysis, teacher ratings, and trace observations

RESEARCH PROJECTS (ordered by date)

Dissertation: *Self-Regulated Learning (SRL) Microanalysis for Mathematical Problem Solving: A comparison of a SRL Event Measure, Questionnaires, and a Teacher Rating Scale.*

Dissertation Chair: Timothy Cleary, Ph.D. – Rutgers University
Defense date: December, 2013
Synopsis: This study is an initial validation study of a *Self-Regulated Learning (SRL) microanalysis* protocol developed to measure self-regulated learning during mathematical problem solving. SRL microanalysis is a highly contextualized, structured interview measurement tool that provides real-time datum regarding student cognitive and metacognitive SRL processes while engaged with a task. This study is the first application of SRL microanalytic measurement methodology to mathematics. The objectives of this study include the exploration of the concurrent, divergent, and predictive validity of SRL microanalysis relative to traditional SRL measures.

Research Experience for Teachers (RET) 12/2011 – 08/2012
Supervisor: Illya Avdeev, Ph.D. UW-Milwaukee
Role: Project Administrator

- Developed project **research design, data collection plan, and analysis plan**
- **Organized and supervised summer research internships** of high school STEM educators
- Managed ongoing research agenda
- Recruited & selected teacher participants
- Developed and **managed project website**

Evaluation of Self-Regulation Intervention 08/2010 – 08/2011
Supervisor: Tim Cleary, Ph.D. UW-Milwaukee
Role: Co-interventionist and co-researcher

- **Co-designed and implemented** school based self-regulation intervention
  - Created intervention **session scripts & multi-media resources**; developed intervention posters; **consulted** with classroom teacher, collected, analyzed, and communicated continuous assessment findings to educators and researchers.
- **Supervised** junior graduate student employees
- Collected, managed, & analyzed data

Project Emerge 08/2009 –08/2010
Supervisor: Karen Stoiber, PhD UW-Milwaukee
Role: Progress monitoring coordinator, data manager, curriculum generation

- Coordinated assessments (pretest, mid-point assessments, & posttest)
- Created reading curriculum materials (e.g., learning aids, classroom lessons)
- Administered student performance assessments (3 to 5 year olds)
- Managed datasets and analyzed data

CLINICAL TRAINING & EXPERIENCE

Virginia Beach City Public Schools: Doctoral Internship 07/2013 – 06/2014
APPIC & APA Accredited Virginia Beach, VA
Supervisors: Clifford Hatt, Ph.D. & Deborah Edwards, Psy. D.
Doctoral Intern in Professional Psychology

- Intervened with academic, behavioral, and mental health difficulties
  - Led Individual and group therapy with school populations
  - Led classroom and small group SRL interventions
- Specialized assessment of Autism Spectrum Disorders (proficient in ADOS-2)
- Pre-school assessment @ Pre-school Assessment Center (PAC)
- Assessment for special education and gifted service eligibility
  - **Experience: 2080 hours**

Aurora Psychiatric Hospital: Child & Adolescent Day Treatment 06/2011 – 03/2012
Supervisor: Munther Barakat Psy.D Waukesha, WI
Practicum Student

- Led & co-facilitated **group, individual, & family therapy sessions**
  - Adapted and administered weekly **CBT lessons**
  - Trained clients in use of biofeedback **(Em-Wave)** & relaxation techniques
- Worked on **multidisciplinary team** (psychologists, psychiatrist, nurse, social workers, school liaison)
- Completed **psychological assessments** & **intake interviews**
- **Experience: 16 hours per week**

<u>Medical College of Wisconsin: Pediatric Neuropsychology</u> 08/2010 - 06/2011
<u>Supervisor</u>: Jennifer Koop, Ph.D. Waukesha, WI
<u>Practicum Student</u>

- Administered & scored neuropsychological, cognitive, academic, behavioral, social-emotional, & personality assessments
- Composed formal reports of assessment results & behavioral observations
- Provided feedback to clients and client guardians
- Interviewed clients and guardians
- **<u>Experience</u>: 8 hours per week**

<u>Milwaukee Public School District</u> 09/ 2009 - 06/2010
<u>Supervisors:</u> Jennifer Schiefer, Eds *&* Michael Crossot, Eds Milwaukee, WI
<u>Practicum Student:</u>

- Evaluated students for special education services
  - Administered, scored, and interpreted psycho-educational assessment
  - Led meetings for special education service eligibility
- Provided Individual and Group intervention services
  - **Mental Health or behavioral:** CBT, EM-Wave biofeedback, person centered, & counsel
  - **Academic Intervention:** Discrete academic skills (e.g., reading, math) & self-regulation
  - **Life Skills:** Team building lessons, life-skills curriculums, self-advocacy training, self-regulation
- **Consulted** with teachers, parents, and school staff
- Participated on crisis management team
- **<u>Experience</u>: 16 hours per week**

SUPERVISION EXPERIENCE

Practicum Student Supervisor

- Site based supervisor of first year practicum student (psychological assessment/academic intervention)
  - Virginia Beach City Public Schools (Spring & Summer, 2014)
- Supervised four junior school psychology practicum students in school-based intervention (2010)

Research Assistant Supervisor

- Provided supervision and training to four graduate student research assistants for Self-Regulated Learning (SRL) research project.
  - Trained and supervised students in SRL assessment procedures
  - Supervised data management and analysis

LEADERSHIP

- AERA – Studying and Self-Regulated Learning (SSRL) Graduate Study Board (2014-2015), **committee member**
- UWM School of Education: Dean Colbeck's Student Advisory Board (2012-2013), **committee member**
- UWM School Psychology Ph.D. Student Representative (2012-2013), **student representative**
- UWM School Psychology Faculty Search and Screen Committee, **Student committee member**

(2012)

- UWM School Psychology Research Club **(Student coordinator**, 2012)
- UWM School Psychology Student Association **(SPSA),** (2008-2012; **Vice President:** 2011-2012)
- UWM Multicultural Graduate Student Alliance (**MGSA**; **Co-President:** 2009-2011)
- UWM Multicultural Connections for School Psychologists (**MCSP**; **Co-President:** 2009-2011)

PROFESSIONAL AFFILIATIONS

- American Psychological Association **(APA),** Graduate Student Affiliate, (2009 - present)
- National Association of School Psychologists **(NASP),** Student Affiliate, (2009 – present)
- American Educational Research Association **(AERA),** Graduate Student Affiliate, (2010 – present)

REFERENCES

Timothy Cleary, Ph.D.
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Milwaukee, WI 53201-0413

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University of Wisconsin-Milwaukee
Milwaukee, WI 53201-0413

************************Additional references available upon request*************************