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Using microanalysis to examine how elementary students self-regulate in math: A case study

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Abstract

The purpose of this descriptive study was to examine how high, average, and low achieving elementary students engage in self-regulation in math. Participants were nine elementary students and their teachers from three different public schools who incorporated the International Baccalaureate Curriculum. Using a microanalytic methodology, students were asked a series of forethought, performance, and self-reflection process items about specific math problem solving. It was hypothesized that high achievers would display more self-regulated learning processes than either average or low achieving students. To provide a more detailed picture of self-regulatory functioning among the different math achievers, a case study of fifth grade students from each achievement level is also presented. Students' reports of self-regulation were also compared with teacher ratings. Results also revealed that high achievers surpassed average achievers, who in turn surpassed the low achieving student in self-regulation. The results were discussed in terms of Zimmerman's social cognitive model of self-regulation. Implications, limitations, and future research are presented.

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Keywords: Self-regulation; differences in self-regulatory processes; mathematics; elementary students.

1. Theoretical background

Self-regulated learning has been characterized as a cyclical process whereby individuals proactively engage in their own learning (Zimmerman, 2008). From a social-cognitive perspective, Zimmerman (2000) describes that self-

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regulated learners engage in various processes through three sequential stages: forethought, performance, and self-reflection. The forethought phase is characterized by processes (goal setting, strategic planning, motivational beliefs) that occur before action and impacts how one engages during performance. The performance phase involves processes (self-control, self-observation) that occur during action. These processes help students to concentrate during learning and optimize their efforts because they employ strategies and monitor their own learning progress. Self-reflection processes (self-judgment and self-reaction) occur following action whereby students reflect on their performance and evaluate it relative to their goals. Self-reflection is assumed to influence subsequent forethought phases, thus resulting in a cyclical feedback loop.

1.1. Research on Academic Self-Regulation

Research on academic self-regulation has shown that differences exist between achievement levels. High academic achievers are described as students who set realistic goals, manage time purposefully, make accurate self-monitoring of progress, and perceive a high sense of academic efficacy for learning. In contrast, low academic achievers display low academic goals, low self-efficacy beliefs in learning and self-regulated learning, and inaccurate assessment of their performances (Kitsantas, 2002; Zimmerman, 2002). For example, Zimmerman and Martinez-Pons (1990) studied self-regulation strategies and self-efficacy beliefs of fifth, eighth, and eleventh grade students in different performance groups. The findings showed those students high in academic achievement display greater, more adaptive use of self-regulation strategies and self-efficacy beliefs than low achieving students. In a more recent study, Kitsantas (2002) examined the effect of self-regulatory processes on test preparation and performance in college students. The results of this study showed that high test scorers exhibited more self-regulatory processes while studying for an exam, taking a test, and after receiving their test results than would low test scorers. More recently, DiBenedetto and Zimmerman (2010) examined students' self-regulation with 11th graders in science. Their findings showed that high achieving students used more subprocesses (i.e. strategic planning, metacognitive monitoring, self-evaluative standards) than those who are average and low achievers. Science learning was also significantly correlated with key subprocesses in forethought (strategic planning) and self-reflection (self-evaluative standards, self-satisfaction). Although there is some research on younger students' isolated self-regulatory processes (Beghetto & Baxter, 2012), to our knowledge no studies have examined how elementary students self-regulate their learning in math as they prepare to engage in the task, act, and reflect on their performance. Findings may yield important insight to guide future instructional practices aimed at supporting students in self-regulated learning.

1.2 Measurement of Self-regulation: A Microanalytic Perspective

A variety of assessment approaches (e.g. self-report scales, interviews, and think-aloud protocols) has been used to measure self-regulation. Self-report scales are the most common method used; however some researchers have called to attention the use of contextualized measures (e.g. think-aloud methodology, SRL microanalysis) as better assessment of self-regulation (Cleary, Callan, & Zimmerman, 2012; Zimmerman, 2008). To capture self-regulation processes, social-cognitive researchers have established an assessment technique called Self-Regulated Learning (SRL) Microanalysis (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). A microanalysis is a structured interview approach that targets key self-regulation processes (e.g., goal setting, strategic planning, self-monitoring, self-evaluation) embedded in Zimmerman's cyclical model of self-regulation. Because a microanalytic approach is highly contextualized and well-equipped to capture the processes of self-regulation (Cleary, 2011), this approach has been widely used in various fields other than educational psychology. To date, research studies using a microanalytic approach have mostly been investigated on the learning of athletic skills such as free-throw shooting, volleyball serving, and dart-throwing (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 1998, 2002). Finally other researchers have found that a microanalytic approach has greater predictive validity of student learning than other well-established teacher reports of students' self-regulation (DiBenedetto & Zimmerman, 2013).

1.3 Present Study

While a majority of studies have focused on self-regulation with middle school, high school, and college students (e.g., Kitsantas, 2002; Pintrich & De Groot, 1990; Zimmerman & Martinez-Pons, 1990), there remains a lack of studies done on students' academic self-regulation in the elementary years. Little is known about how mid-elementary students self-regulate. Thus, the purpose of the current study is to examine how mid-elementary grade students (grades 3 to 5) self-regulate their learning. In the present study, the microanalytic approach was used to assess students' self-regulation in math. Only a handful of research studies have used this approach to assess self-regulation in academics (Cleary et al., 2012; DiBenedetto & Zimmerman, 2010). It was expected that high achieving students will engage in more subprocesses within the three-phases of self-regulation than both average and low achieving students. Additionally, it is anticipated that students who are high in achievement will be more accurate in their perception of their self-regulation and that teachers' perception of these students are parallel to student ability to self-regulate.

2. Method

2.1. Participants

The sample consisted of nine students in third-, fourth-, and fifth-grade and their teachers ($N = 4$). Participants were from three International Baccalaureate (IB) schools in the Washington DC Metropolitan area. Two to three classrooms from each school were asked to participate. The ages of the students ranged from 8 to10 years ($M = 8.9$), with 5 being female students and 4 being males. The ethnicity of students was: 4 African American, 1 Hispanic, 1 Caucasian, and 1 Asian Pacific Islander. Ethnicities of two students were not reported.

2.2. Materials

The Teacher Rating Scale for Assessing Elementary Student Self-Regulation in Mathematics (Kitsantas, Cohen, & Ware, 2013). This is a 25-item scale that assesses elementary students' self-regulation. Teachers rated self-regulation processes such as goal setting, strategic planning, monitoring, self-reflection, and motivation to learn in mathematics. A sample item was, "Student sets goals before approaching an assignment or difficult math problem." A 5-point Likert scale (1=almost never, 5=almost always) was used to rate how often the learning behavior in mathematics occurred. A "don't know" response was included as one of the options.

The Student Micro-Analytic Interview Protocol (Kitsantas & Miller, 2013). This instrument was developed to measure students' self-regulated learning of an academic mathematics task. This structured interview protocol uses highly contextualized questions while students engage in solving a specific math problem (e.g. fraction problem). Microanalytic items asked direct questions about a specific math problem that was given to students to solve and included 11 items. Sample items of the specific microanalytic questions included these: "How sure are you that you can solve this math problem correctly: (10) Not sure at all to (100) Very sure" (forethought); "Are you checking to see if you are getting the answer you thought you would" (performance); "What is the main reason why you were successful or failed on this math problem" (self-reflection). An inter-rater reliability of 97.6% was reached by the two coders, with disagreements being resolved with discussion.

2.3. Procedure

After collecting informed consent, teachers were asked to select two to three students of different ability levels to participate in the study. After receiving parental consent from students, teachers completed the teacher rating scale for each participating student. Prior to the microanalytic interview, teachers were asked to provide the researcher with a math problem for the student to solve, which was based on what students were currently studying (e.g. comparing fractions, 4 digit subtraction, division, multiplying and dividing fractions). During the student interview, the researcher read-aloud to the student all the items. Afterwards, students were shown the math problem that was provided by the teacher and asked items pertaining to the forethought phase. Next, students were asked to solve the problem, and then asked items from the performance phase. After completing the math problem, students were asked microanalytic items from the self-reflection phase. Each student interview took approximately 20-30 minutes to complete.

3. Results

A descriptive case study approach was used to analyse students' self-regulatory processes in math. Analyses of the microanalytic measurement approach provided qualitative and quantitative data for reporting differences in self-regulatory processes across the three math achievement levels. Examination of the teacher perceptions' of their students' self-regulation were reported using Pearson r correlations.

3.1. Descriptive Statistics

Table 1 provides the means and standard deviations of the teachers' ratings of the three achievement groups. Descriptive results indicate that teachers generally viewed high math performers with higher levels of self-regulation than average and low performers.

Table 1. *Means and Standard Deviations of Teacher Ratings of Students' Self-Regulation by Achievement Level*

Student (*N* = 9)	Self-Regulation Phases					
	Forethought		Performance		Self-Reflection	
	M	SD	M	SD	M	SD
High Achievers (*n* = 5)	4.30	.55	4.73	.32	4.15	.42
Average Achievers (*n* = 3)	4.18	.51	4.21	.28	3.67	.33
Low Achievers (*n* = 1)	2.88	-	3.36	-	3.22	-

3.2. Student Self-Regulatory Functioning in Specific Math Problem Solving

Forethought Phase. Regarding *strategic planning*, students were shown a specific math problem and then asked about having a plan to solve it. Six out of nine students reported having a strategic plan to solve the presented math problem. In addition, two students in third grade had no plan and one low achieving student in fifth grade failed to mention a strategic plan (i.e. look back at notes, solve it). For this item, the numbers of strategies mentioned by students were counted, with responses ranging from one (f = 4) to two (f = 2) strategies. Three students reported no strategy. Regarding *self-efficacy beliefs*, all students reported a high level of self-efficacy for solving the math problem. In terms of *outcome expectations*, eight students were very sure that they could solve the problem (M = 97.5, SD = 3.66) and one student in third grade indicated a moderate level (55 out of 100). When asked why they believe they can solve the math problem, seven students responded with a general focus and two students had a specific focus. An example of a specific focus is explaining the steps to solve the problem, while a general focus response would be talking about being confident or good at using strategies. Regarding *task interest*, most students (f = 7) were interested in learning more about similar math problems. A slight pattern emerged showing that older students (f = 3) were more interested in doing similar math problems than compared to younger students (f = 1). When asked about their *goal orientation*, all students mentioned that a mastery goal orientation was more important than a performance goal orientation.

Performance Phase. Regarding plan implementation, seven students indicated using their original plan to solve the math problem and one fifth grade student had mentioned setting a new plan. When asked about whether they were checking their progress, seven students mentioned that they were checking. All seven responses were valid monitoring, with various responses such as these: "I did it in my head, and then I checked to make sure the right name of food [from the problem]" and checking work using a drawing.

Self-Reflection Phase. Regarding *self-evaluation*, students were immediately asked after they finished the math problem whether they achieved their goal to solve the math problem. Seven students responded having achieved their goal to solve the math problem. Interestingly, students varied in responses when asked about how they knew they achieved or did not achieve their goal. Responses included the following: using a correct strategy (e.g. multiplication) (f = 2), effort (e.g. showing work) (f = 1), and making an incorrect calculation (f = 2). Responses that did not fit with these were indicated as other (i.e., mentioning that they did a good job, feeling confident) (f = 4).

Regarding *causal attribution*, seven students responded using strategies as the main reason why they were successful or failed on the math problem. The strategies mentioned varied across students. For example, a strategy that some students reported was checking one's work. In addition to checking, they mention that "I need to show my work, check, put more than one sentence, and explain everything" and "read the question, be careful, do it, then go over it." One student (third grader) from the average group indicated not knowing basic math skills last year thus attributed his outcome to ability. Another student (fifth grader) from the low achieving group attributed learning to effort. Regarding *satisfaction*, eight students were very satisfied with their overall performance on the math problem (M = 98.13, SD = 3.56) and one fourth grade student (average achiever) that received partial credit for solving the math problem reported being moderately satisfied (50 out of 100). Regarding *adaptive/defensive inferences*, students were asked what they needed to do to perform well on the next math problem. Eight students provided adaptive inferences, with seven students indicating strategies and one fifth grade student responding effort. The same third grader who attributed failure to ability responded to this item with do not know.

3.3. A Case Study of High, Average, and Low Achieving Fifth Grade Students

To provide a more detailed scope of the differences in SRL processes among students of different achievement levels, a case study of three fifth grade students from each achievement level was examined. Due to the small sample size of students from each grade levels, a comparison of students across the same grade level from each achievement group were not available with third and fourth graders, thus fifth graders were selected for the case study. The three fifth graders were Kelley, a high achiever, Cindy, an average achiever, and Daniel, a low achiever. These students had the same teacher and were given the same math problem to work on.

Forethought phase SRL processes. In general, a high level of self-efficacy in math was reported by the three fifth grade students in each achievement level. Kelley and Daniel rated being very sure (99 out of 100) about solving the math problem; while Cindy rated a self-efficacy score of 96. The students' *strategic planning* was qualitatively different. When students were shown a math problem, for example, Kelley described two strategies for solving a specific math problem, while Cindy provided one strategy and Daniel provided no strategies. **Performance phase SRL processes.** During students' performance on the specific math problem, differences were found in plan implementation. Kelley and Cindy reported using their initial plan to solve the math problem, while Daniel indicated a new plan (e.g. using strategies) that was different from his original plan (e.g. look back at notes, solve it). The data for *self-monitoring* during the math problem showed that all students were checking their answer. **Self-reflection phase SRL processes.** All students reported using one strategy for identifying when they do not understand math concept. After students finished solving the math problem, slight differences were found in *attribution* and *adaptive/defensive inferences*. For example, Kelley and Cindy both reported adaptive inferences (i.e. strategy), while Daniel reported a less adaptive inference (i.e. effort).

3.4. Reports of teachers' ratings of their students' self-regulation

Students' reports of self-regulated learning were compared with teachers' reports of their students' engagement in self-regulation. Results indicate that high achieving students were rated more highly by their teachers in various SRL processes within each self-regulatory phase as compared to average and low performers. Particularly, high achieving students surpassed average achievers, who in turn surpassed low achievers in setting goals, utilizing strategies, monitoring of one's own learning, seeking help, using higher level thinking, and motivation. In spite of the small sample size there was a significant positive correlation between math problem solving and teacher reported task analysis, $r = .79$, $p < .05$, and math interest, $r = .79$, $p < .05$. A similar pattern of results emerged for math problem solving and strategy use, $r = .74$, $p < .05$, and strategy implementation, $r = .75$, $p < .05$. A stronger relationship was found between math problem solving and self-evaluations, $r = .89$, $p < .001$. Thus, students who reflected on their performance and evaluated it were more likely to solve the math problem correctly.

4. Discussion

Using a microanalytic approach, the present study showed that mid-elementary math students report using various processes of self-regulation within Zimmerman's three-phase model of self-regulation. Findings showed that high achievers engage in more strategic thinking before, during, and after math problem solving than average and low achievers. These results are fairly consistent with previous research on science learning in high school students (DiBenedetto & Zimmerman, 2010) and test preparation in college students (Kitsantas, 2002). In addition, findings supported earlier studies using a microanalysis with high school and college athletes (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). Furthermore, a case study of fifth graders was conducted to provide more insights about the differences in self-regulation among different achievers. Finally, comparison of teachers' and students' reports of self-regulation showed that high achievers differed from average and low achievers.

4.1. Patterns in Self-Regulatory Functioning in Specific Math Problem Solving Using Microanalysis

Forethought phase. Overall, nearly all students reported a high level of motivational beliefs within the subprocesses of *self-motivational beliefs* (i.e. self-efficacy, outcome expectation, and goal orientation). A possible reason why students reported similar levels of motivational beliefs is that primary school children tend to overestimate their competence (Bandura, 1986, 1997). Consequently, this finding suggests that children may exhibit inflated performance expectations because they underestimate the task demands. As children mature though, they gradually gain familiarity with the task demands and knowledge about their capabilities. Therefore, they become more realistic of their capabilities over time (Bandura, 1997). Regarding *outcome expectations*, however, one student (third grade) reported a contradicting response, first mentioning a high level of self-efficacy to solve the math problem, and then reporting being somewhat (55 out of 100) certain that he can solve it correctly. In addition, this student previously indicated a low level of self-efficacy in math and mentioned struggling with the current math unit (i.e. 4 digit number subtraction). In previous reports, this student (average achiever) indicated setting no goals, using general techniques, no monitoring of math progress, and maladaptive self-reflections. Overall, this student struggled to solve the math problem and reported low engagement of self-regulation processes.

In addition, most students focused on general reasons for why they can solve the math problem, with similar responses saying that "I've done it before, it takes strategy" and "I've done problems like this in my class and I've gotten them right". Interestingly, students who mentioned having done this type of problem before and being good at using strategies were the ones who received partial credit for solving the math problem. In contrast, students who mentioned a specific focus such as steps for solving the problem were the ones who solved the problem successfully. This suggests that strategic thinkers are specifically focused on a strategic plan, and in turn will tend to use correct strategies to solve math problems.

Regarding *strategic planning*, findings showed that most students had at least one strategy in mind for solving the math problem. Students who provided detailed descriptions of strategies of their plan tended to get the correct solution. This suggests that regulated students not only know when and how to use learning strategies, but can elaborate on their strategies. Elaboration, a key process of metacognitive strategies, is essential to learning as it enables students to acquire and master academic content (Alderman, 2008).

Performance phase. Regarding plan implementation, many students indicated using their initial plan to solve the math problem. Regarding *self-monitoring*, most students indicated checking their work. Self-monitoring is an important process of self-regulation because it informs the learner of his or her progress and helps the learner modify strategies as they engage in tasks (Zimmerman, 2000).

Self-reflection. After finishing the math problem, students who solved the problem correctly (high performers) used good judgments to evaluate their performance. Students (average performers) who received partial credit also attributed their performance to strategy. In contrast, the low achiever attributed his performance to effort and solved the problem incorrectly. In addition, students' degree of strategic thinking was varied among the type of achiever, with high reports of strategic thinking among high achievers. These findings are consistent with previous research showing that high performers make better judgments of their performance than lower performers (DiBenedetto & Zimmerman, 2010).

4.2. A Case Study of High, Average, and Low Achieving Fifth Grade Students

The case study of three fifth graders in each achievement group showed qualitative differences in self-regulatory processes, thus validating the microanalytic approach. Kelley, the high achiever, reported an accurate perception of her math competency, used a variety of strategies, and made adaptive evaluations of her performance. Low self-regulators such as Cindy and Daniel formulated inaccurate perceptions of their ability, made fewer strategic plans, were less metacognitively aware of his or her performance, and made lower self-evaluative standards. A high level of self-efficacy was exhibited by all three students for the math problem. Realistically, Cindy and Daniel overestimated their level of competency in solving the math problem because they have yet to master the skills needed in performance. Regarding *strategic planning*, Kelley provided more accounts of strategies to solve the math problem, followed by Cindy and then Daniel. Furthermore, Kelley provided a plan that was more specific and descriptive. Cindy simply mentioned the strategy (i.e. "Just multiply it") and Daniel did not seem to know what strategies to use.

Regarding plan implementation, Kelley and Cindy both indicated a valid plan with strategies, while Daniel did not indicate a valid plan (no strategy). Regarding *self-monitoring*, all three students indicated checking their work for mistakes. Regarding self-reflection processes, Kelley exhibited more strategic strategy use than Cindy and Daniel. In addition, Kelley generally has a good understanding of the strategies to use and can tell when a wrong strategy is used. In contrast, Cindy and Daniel indicate seeking help most of the tine when they don't understand math concepts. During self-evaluation, Kelley mentioned being confident (self-efficacy) and reflected on her goal. For Cindy, checking for mistakes to the math problem was her main focus in her evaluation; however she did not specify the steps used to check her answer. For Daniel, his evaluation was focused on the strategy (i.e. multiplication). Unlike Kelley and Cindy who both indicated strategies that were aligned to the process of learning, Daniel's evaluation was rather a poor judgment because he was concerned with the strategy itself and not his performance. Regarding *causal attribution*, Kelley and Cindy both attributed their learning to learning strategies. In contrast, Danny attributed his outcome to effort (i.e. "I took my time, rethink, and see if I got this answer correct or not."). Regarding *adaptive/defensive inferences*, Kelley and Cindy both indicated adaptive inferences (i.e., strategies), while Danny exhibited a defensive inference (i.e., effort). In addition, their outcomes on the math problem reflected their math ability, with Kelley solving the math problem correctly, Cindy receiving partial credit, and Daniel unable to solve the problem correctly.

4.3. Teacher-Student Agreement

Finally, using quantitative data, evidence showed teacher-student agreement in reports of self-regulation among different level achievers, with high achieving students exhibiting more SRL processes than average and low achieving students. These findings supported Zimmerman's self-regulation model and previous research showing that a microanalytic measurement is well-equipped for capturing students' self-regulation in an academic domain (DiBenedetto & Zimmerman, 2013).

5. Implications and Conclusions

Despite the limitations of the present study (e.g., just one low achieving student and the targeted academic context), the findings of the current investigation have important implications for teachers. The use of SRL microanalysis in academic domain allows teachers to gather context-specific information about how students' forethought, performance, and self-reflection are interconnected (Zimmerman, 2000). For example, students who set process-oriented goals demonstrate not only greater motivation to persist in tasks, but also more strategic strategy use, and adaptive reflections of their performance. In contrast, students who set outcome-oriented goals exhibit less motivation, demonstrate fewer strategies, and make more maladaptive reflections of their performance (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). Teachers, thus, should emphasize their students to set process goals rather than outcome goals because it is crucial to the development of self-regulation in learning.

In addition, teachers should provide guidance for when and how to use strategies (Pressley & Woloshyn, 1995). For example, teachers can advise students to set goals before doing math homework and to think about strategies beforehand (strategic planning). In preparing students for doing math homework and studying for math tests, teachers should help students to develop a repertoire of self-regulated strategies. Furthermore, teachers should instruct students to set new goals after getting back a math test. This form of self-reflection is important because it allows students to evaluate their performance. Particularly, teachers should educate students on making adaptive evaluations of performance that are based on the process of learning rather than on outcomes. Focusing on the process not only helps students to enhance math skills, but also increase self-efficacy and intrinsic interest, and performance (Kitsantas & Zimmerman, 1998). Overall, collectively, these findings provide valuable knowledge to help teachers instil self-regulated learning.

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