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The Effects of Self-Regulation Strategies on Middle School Students' Calibration Accuracy and Achievement

ABSTRACT. *This study investigated the impact that self-regulation strategies have on metacognitive judgements (calibration) and mathematics achievement of typical and advanced achieving 7th grade mathematics students over a period of seven weeks. Self-regulation strategies, four square graphic organizers and vocabulary games were implemented with the treatment condition while online games were implemented with the control condition. The results revealed that participants in the treatment condition were more accurate in their calibrations than participants in the control condition, more specifically for postdiction accuracy. Although the participants in the treatment condition scored higher on their achievement tests than the participants in the control condition, there were no significant differences between the conditions.*

Purpose

The purpose of this study was to investigate the impact that self-regulation strategies have on metacognition and mathematics achievement of middle school students. Since students do not inherently self-regulate (Finn & Metcalfe, 2014), and self-regulation is even more difficult in mathematics (Winne & Muis, 2011), it is imperative that mathematics students are taught self-regulation strategies to monitor and evaluate their own performance during the learning process. Further, academic vocabulary in mathematics plays a critical role in advancing students' understanding of mathematical concepts and metacognitions. Therefore, this study was developed to understand how self-regulation strategies and vocabulary games affect 7th grade mathematics students' calibration accuracy and achievement.

Perspectives and Theoretical Framework

This study was guided by Zimmerman and Campillo's (2003) three-phase self-regulation model. They proposed a three-phase cyclical self-regulation learning process that involves forethought, performance, and self-reflection (see Appendix). The forethought phase is the process that "sets the stage for action," (Schunk, 2012, p.411). It precedes learning or performance and incorporates goal setting, strategic planning, task analysis, and self-motivation. The performance phase is the process of performing the task at hand. It involves self-control and metacognitive monitoring. The self-reflection phase is one's response to their efforts on the task and encompasses self-evaluation and adaptation.

Vocabulary strategies to enhance learning can be used to assist students in assessing their understanding and learning of academic vocabulary. The four square is one such strategy and can be situated in a self-regulated learning (SRL) framework. Four squares require students to engage in multiple cognitive strategies (write in your own words, visual representations) and assess their understanding of the academic term. Marzano (2010) suggested that students rate their understanding of the terms (self-reflection), and as they refine their vocabulary squares (performance), their understanding of the term will continue to develop.

Another strategy positioned in the SRL framework are educational games. Educational games increase student motivation and correspond to SRL because they are captivating, offer a different venue for learning, have built in goals (forethought), incorporate cognitive strategies (performance), and provide immediate feedback (self-reflection). The rapid feedback offered through educational games can help students to better regulate their progress (Wells & Narkon, 2011). Moreover, many educational games increase student discourse (performance) by requiring students to explain, justify, and communicate their responses (Groth & Butler, 2016; Oldfield, 1991; Riccomini, Smith, Hughes, & Fries, 2015). Many educational games allow students to work collaboratively and competitively (performance) as well as build on each other's ideas to promote learning, understanding, and mastery of important content (Bragg, 2012; Oldfield, 1991; Wells & Narkon, 2011).

Students also need to be able to self-regulate their learning of mathematical vocabulary and concepts. Calibration is one method which students can use to monitor their knowledge and vocabulary learning. Calibration involves students making predictions about their performance (e.g. predict test score), actually performing the task at hand (e.g. taking the test), and making a postdiction about their performance (e.g. postdict test score). It is evident that calibration is found in all three phases of SRL.

No empirical research has been conducted that explored the effects of *combined* SRL strategies in the form of four squares, games, and calibration in mathematics classrooms. Researchers and educators need to provide evidence of connecting these domains to effectively help students improve their self-regulation and learning quality in mathematics. Students' self-regulation and calibration accuracy vary across domains, and students are not very well calibrated in mathematics (Winne & Muis, 2011). Therefore, using four squares and educational games to assist students to be more knowledgeable of their learning process are likely to improve student calibration accuracy and achievement in mathematics.

Method

A total of 84 7^{th} grade students took part in this study (see appendix). A pretest/posttest quasi-experimental design (Gall, Gall, & Borg, 2003) was employed to compare the effectiveness of the intervention versus more traditional instruction on participants' achievement and calibration accuracy in the geometry based 'shapes and figures' mathematics unit. The first independent variable was the treatment condition, either the four square with team game or the traditional approach that involved individual online games. The second independent variable was the participants' prior level of mathematics achievement determined by the preassigned mathematics classes, as either typical or advanced achieving mathematics students. The two dependent variables were participants' mathematics achievement scores (number correct on the post-test) and participants' calibration accuracy scores.

Measures

The mathematical achievement test was a combination of multiple choice and open-ended items covering content and vocabulary (see Appendix) from the textbook. The researcher created the assessment instrument by revising questions and problems from the shapes and figures unit found in the 7th grade mathematics textbook. The pretest and posttest were identical and consisted of 11 content problems taken from the shapes and figures unit. Mathematics achievement, was determined by the number of problems correct on the pre and posttests.

The first and last page of the pre and posttests contained an open-ended calibration item. Participants were asked to make predictions and postdictions of how many problems they think they got correct on both the pretest and posttest. The participants' prediction calibration accuracy was computed by calculating the absolute value of the difference between their prediction scores on the tests and their actual scores on the tests. Calibration bias was calculated by calculating the difference between participants' predictions and their actual scores. The same computations were calculated to determine participants' posttest calibration accuracy and bias.

Procedure

Prior to the intervention students completed a pretest. The intervention was implemented by the researcher for a span of 70 minutes, with two 7th grade mathematics classes, on six different days, over a period of seven weeks. Intervention involved the participants completing their mathematics four squares while playing an academic vocabulary game called “Say What?” As the math vocabulary words were displayed through gameplay, the researcher provided pronounced each term and explained and demonstrated the meaning of each term. Participants completed their four squares generating their own meanings, visual representations, and understanding of the terms.

The cooperating teacher provided traditional instruction with two other 7th grade mathematics classes, on the same days for the same duration as the intervention classes. Traditional instruction involved the participants using iPads to complete 20-25 online multiple-choice mathematics vocabulary questions though the ‘quizizz’ website. When the participants completed their ‘quizizz’ questions, they could play mathematics games on their iPads for the reminder of the period. Participants were provided with the posttest.

Analysis and Results

Three analyses of covariance (ANCOVAs) were conducted to determine whether condition and prior mathematics achievement affected students’ posttest predictions, postdictions, and mathematics achievement. The results revealed there were no significant differences in terms of prediction accuracy by condition (control or treatment) nor prior achievement level (typical or advanced). There was, however, a statistically significant difference in terms of postdiction accuracy by condition but not by prior achievement level (see Appendix). This means that participants in the treatment condition were more accurate in their postdictions than participants in the control condition (see Appendix). There were no significant interactions between condition or prior achievement level on the mathematics performance test in terms of prediction or postdiction accuracy. Not surprisingly, the results also revealed that advanced achievers scored significantly higher on their achievement test than typical achievers.

Although the treatment condition scored higher than the control condition there were no significant differences among the treatment and control conditions for mathematics achievement. There was no significant interaction between condition and prior achievement level on mathematics achievement.

Significance

Students that were exposed to the SRL strategies were more accurate in their calibrations, specifically for postdiction accuracy, than students that were exposed to traditional instruction. The four squares required students to assess their understanding of the academic terms. Marzano (2010) and Kinsella (2005) propose, when students rate their understanding of the terms they are thinking about their learning of the vocabulary. It is possible that the students' knowledge of the vocabulary terms used on the test were reinforced using the four squares, guided students' metacognitions (Schmitt, 1997), and allowed them to make more accurate calibrations of their performance.

The investigation of self-regulated learning strategies to enhance metacognitive judgments and ultimately achievement is a critical area of study. The improvement of students' self-regulation strategies may be particularly challenging in mathematics (Winne & Muis, 2011). In the present study, self-regulation strategies were found to significantly improve students' calibration accuracy at the postdiction phase. The intervention seemed to have engaged students in multiple cognitive strategies to better understand mathematics vocabulary and advance their metacognitions. The study is also important because it was conducted in the more ecologically valid context of real world classrooms. Educational researchers have continued to call for more classroom research on the effectiveness of self-regulated learning strategies (Hacker, Bol, & Bahbahani, 2008; Paris & Paris, 2001; Zimmerman, 2008). Future research might isolate the effect that games versus vocabulary strategies have on students' metacognitions and achievement.

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Appendix

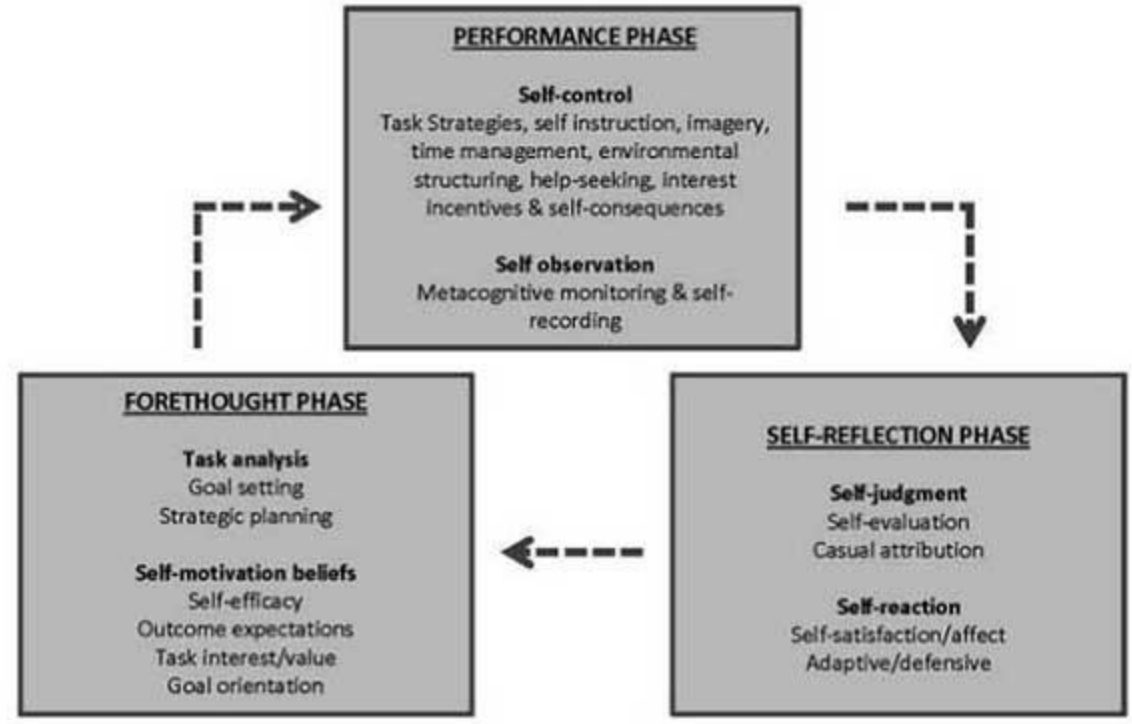


Figure 1. Zimmerman and Campillo's (2003) three cyclical phases of self-regulation.

Table 1
Visual Representation of Treatment Conditions

	Typical Class	Advanced Class
Intervention Condition	Group 1 *N* = 19	Group 3 *N* = 20
Traditional Condition	Group 2 *N* = 23	Group 4 *N* = 22

Table 2.

Example Questions from the Test

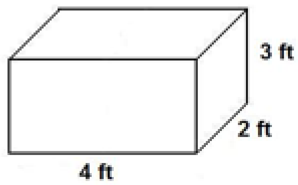
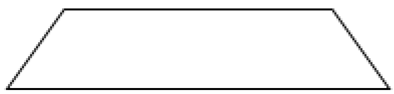
Which property is *not* a characteristic of a rhombus? a. Opposite sides parallel b. 4 right angles c. 4 congruent sides d. Opposite sides congruent
Find the volume *and* surface area of the rectangular prism. 
Classify the quadrilateral using the name that best describe it. 

Table 4

Descriptive Statistics for Dependent Variables

	Condition							
	Control				Treatment			
	Typical		Advanced		Typical		Advanced	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Prediction	2.95	2.23	2.25	1.67	2.82	1.61	2.36	1.40
Postdiction	1.90	1.28	2.02	1.32	1.46	1.31	0.97	0.67
Test Scores	4.75	1.91	5.98	1.02	5.39	1.67	6.81	1.31

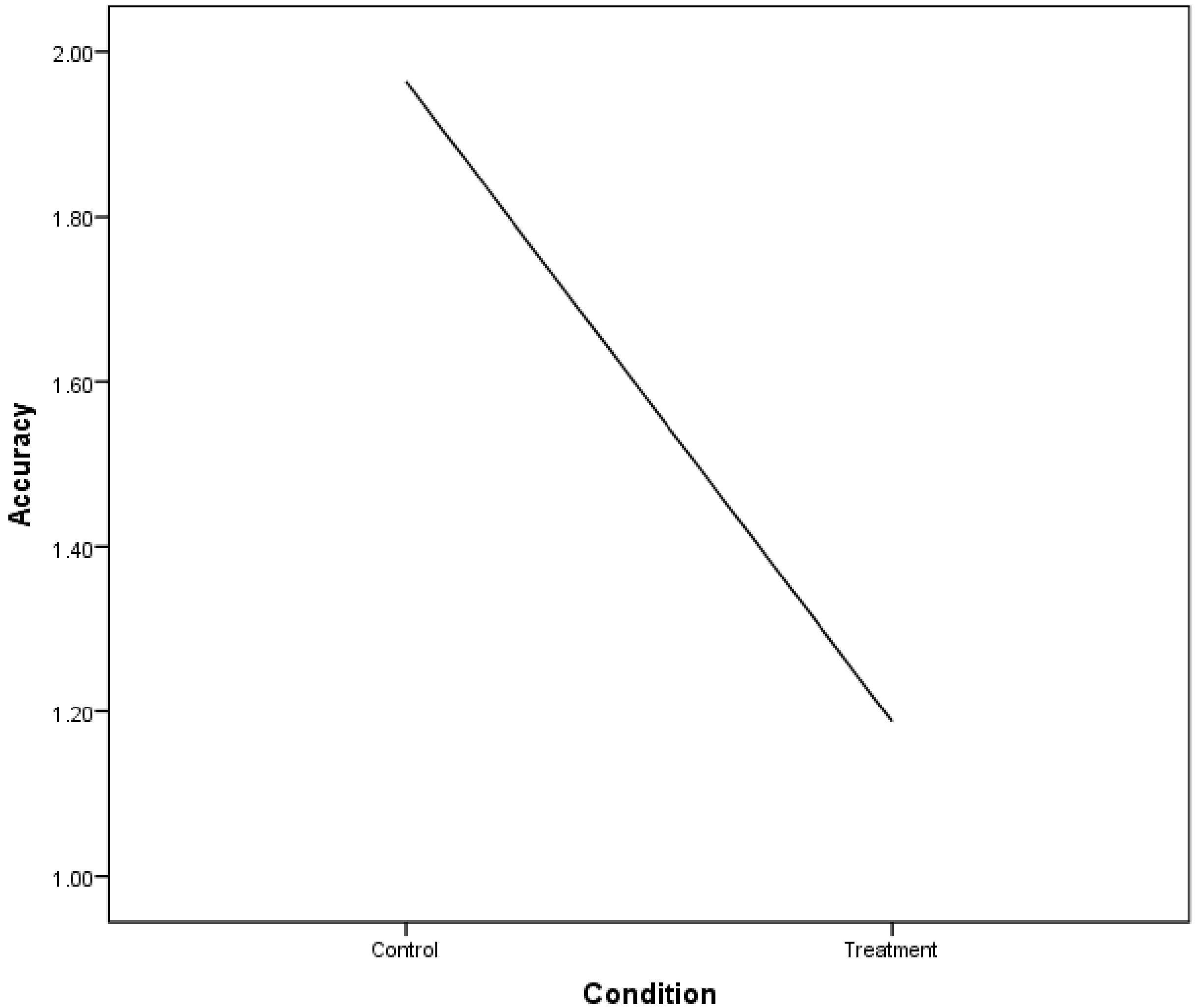


Figure 2. The main effect of condition on participants' postdiction accuracy. Note: Lower scores mean better calibration accuracy.