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Differences in Self-Regulatory Processes among Students Studying Science: A Microanalytic Investigation

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Abstract

Differences in self-regulatory processes of fifty-one high school juniors who were high, average, or low achieving students in science were studied using a microanalytic methodology. It was hypothesized that high science achievers would engage in more subprocesses of Zimmerman's cyclical phase model of self-regulated learning (SRL), spend more time studying, and display higher test performance scores than average or low achieving science students. Gender differences in self-regulation and learning of science were also studied. Students were individually given a science passage to read, study, and be tested upon. A microanalytic methodology was developed to assess students' thoughts, feelings, and behavior about science learning during forethought, performance, and self-reflection phases. Trend analyses revealed twelve positive linear relations between students' level of achievement and their level of self-regulation, study time, and science performance. The size of each of these linear effects was large. It was concluded that students who are high achievers in science learning tend to use more of the subprocesses in Zimmerman's three phase model than those who are average and low achievers regardless of gender. Significant study time differences were also found with the high and average achievers spending more time studying than the low achievers.

Keyword: Differences in self-regulatory processes, self-regulation, high and low achievers

There is considerable national concern about the quality of science learning in the United States. The U.S. participates in two international assessments that measure science skills: the TIMSS (Trends in International Mathematics and Science Study) and the PISA (Program for International Student Assessment) and the results of both tests reveal that American students are falling substantially behind their international peers. In addition to these poor results in science, there is evidence that American girls' are at particular risk in terms of their science achievement and choice of careers in science (Baldi, Jin, Green, & Herget, 2007). The present study seeks to discover sources of students' success in science by comparing students who are considered high achievers in science with classmates who are average and low achievers. There is evidence that students' success in science in computer learning contexts is related positively to their development of self-regulatory methods of learning (Greene, Moos, Azevedo, & Winters, 2006). The present research addresses science learning during traditional text-based

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studying and uses a microanalytic methodology involving fine-grained measures of specific self-regulatory processes and sources of motivation. This methodology has proven very useful in research on expertise in sports (Kitsantas & Zimmerman, 2002), but it has not, to our knowledge, been used in research on science to date.

Academic Self-Regulation

Academic self-regulation has been defined by Zimmerman (1998) as one's "self-generated thoughts, feelings, and actions for attaining academic goals" (p.73). According to social cognitive perspective (Zimmerman, 2002), there are three phases of self-regulation which students engage in when performing an academic task. The forethought phase is the first phase in which there are two major categories: task analysis and self-motivational beliefs. The forethought phase involves self-initiative and self-direction on the part of the learner. This phase is pivotal in the self-regulation cycle because it is here that the student will plan his or her course of action, be it a study schedule, what course he or she will take, or the path he or she will take in a career. The performance phase consists of two main categories: self-control and self-observation. In this phase the student is performing a task towards reaching his or her goal. Here the student is employing the various strategies outlined in the forethought phase and is monitoring progress towards the goal. This phase is mentally and physically active for the highly self-efficacious student in that while the student is performing the behavior, the student is self-regulating as he or she monitors and adjusts his or her strategy while working to achieve goals. In the third phase, self-reflection, the student uses self-judgment and self-reacts. The results of the third phase are assumed to feed into the forethought phase for future behavior resulting in the cyclical feedback loop. There is evidence to support the various subprocesses and the cyclical nature of this three phase model with regard to athletic tasks (Kitsantas & Zimmerman, 2002; Cleary & Zimmerman, 2001). There is some research on students' self-regulated learning of science. Greene, Moos, Azevedo, and Winters (2006) examined the self-regulatory learning processes with hypermedia and compared gifted students from grade-level students. Their findings suggest that students who were gifted used more sophisticated strategies in learning as compared to the grade-level students.

Research on the amount of time students spend during the performance phase (studying and preparing for an academic task) and its relationship to achievement has been limited to date (Nonis and Hudson, 2010). If students spend more time studying and are using more self-regulatory processes, there would be a positive relation between the time spent and achievement.

Gender and Science Learning

There is much concern about the presence of gender differences when learning science (Hanson, 1996). For example, significant gender differences in science achievement were found among eighth grade students in America, and the international average was higher for boys than for girls (Eccles, 1989). However, rather than being due to genetic variables, gender differences in achievement may be due to exposure to role models, to family expectations, and to cultural values --

all of which can convey lower achievement standards for girls (Bandura, 1997). For example, gender-role stereotypes are often displayed on television (Signorielli, 1990) and in storybooks (Jacklin & Mischel, 1973). Females typically occupy lower level positions or household jobs whereas males occupy more professional types of jobs. Family and cultural experiences have been closely tied to girls' lack of pursuit of STEM (science, technology, engineering, mathematics) related professions (Hackett & Betz, 1981). For example, parents often believe that math is a male dominant field and may underestimate their daughter's ability to achieve in math or may not consider encouraging her to pursue a math related career. The issue of what variables may explain science achievement differences between boys and girls will be investigated from an academic self-regulation perspective in the present study.

Research Questions

One research question that will be addressed is: Are there performance and gender differences on two science achievement measures for students grouped according to three achievement levels who are in the 11th grade? The second research question concerns whether or not there are differences in students' use of the self-regulatory processes among students with different levels of achievement as they study and prepare for science learning tests? In addition, to test the relationship among the subprocesses within the three phases, an additional research question asks whether or not there are correlational relations among the various subprocesses of the three phases of self-regulation. The fourth research question asks whether or not there are differences in the amount of study time used by students in different achievement groupings.

The present study attempted to address the research questions using a microanalytic methodology. This approach involves asking specific questions targeted at addressing specific psychological processes at key times during the act of learning (Kitsantas & Zimmerman, 2002). In a microanalysis, the participant is performing a task and is asked open or closed-ended questions which are context-specific and provide online qualitative and quantitative data. The questions are short and asked at very specific times during the performance in order to minimize any threats to validity. A microanalytic methodology differs from the think-aloud methodology in that during the latter, the participant verbalizes their thoughts without any direction while engaging in a task.

Method

Participants

The participants in this study were fifty-one 11th grade students from three middle class, suburban parochial high schools. The ethnicities of the students were 9.8% Asian or Pacific Islander, 19.6% African American, 19.6% Hispanic, and 51% White. Individual and parental consents were obtained from the students and their parents or legal guardians.

The students were grouped as: High science achievers (students who were in advanced level biology courses in 10th grade and who earned a final grade average of 90 or higher. To qualify to be admitted to these advanced courses, the students had to display consistently high levels of achievement in science based on prior academic performance in science only); Average science achievers were students who earned what the school deemed to be the school's "average" final term grades of 84-87" in 10th grade regular (nonadvanced) course in biology; and Low science achievers were students who either failed 10th grade biology or scored the minimum passing grade for that school (ranging from 65-75). The sample consisted of 17 students in each science achievement level with 17 boys and 34 girls. Both genders were represented in each achievement level.

Task and Materials

Students were given a reading passage on the topic of tornadoes. The passage was three pages, double spaced with a formula embedded in the text and a table to refer to at the end. The passage was taken from a textbook on natural disasters (Coch, 1995) and briefly describes how a tornado is formed, the types of damage it can cause, and how to protect oneself. In the body of the text a formula of how to calculate the speed of a tornado is described and a table indicating the intensity of a tornado based on the calculated wind speed. In addition to the science reading passage, an audio-tape recorder was used to record each microanalytic session. Pens, pencils, magic-markers, highlighters, blank index cards, and lined paper were on the desk and available for the student to use. Each room contained a large clock which was directly in front of the student's desk.

Measures

Prior knowledge. Prior to beginning the microanalysis, a measure of prior knowledge was obtained to determine if there were differences between students in different schools and by achievement level and by gender. Students were asked "What do you know about tornados?" The investigator recorded all responses made by the student. This open-ended format was to avoid cueing students about the purpose of the reading passage. Scoring involved counting the number of correct facts and the Pearson Product Correlation revealed an inter-rater coefficient was $r = .77$, $p < .01$ indicating substantial inter-rater reliability.

Acquired tornado knowledge test. This scale involves 10 short-answer questions that required both recall and explanation of scientific knowledge about tornadoes. Questions were primarily short answer. For example: "Define tornados."*…and…* "List four ways in which tornados cause damage." Questions and correct responses were drawn directly from each paragraph of the passage and the Pearson Product Correlation revealed an inter-rater coefficient of $r = .75$, $p < .01$ suggesting there was a substantial amount of inter-rater agreement. A principal component factor analysis indicated that there was one main factor which accounted for 37% of the variance and was labeled *tornado knowledge*. Two test items loaded negatively on a second factor that involved problem solving using the

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Fujita Scale. This second factor explained 11.30% of the variance and was labeled *tornado problem solving*. Although these two items also loaded on the first factor (.54 and .66 respectively), the two factors are independent and were therefore, included as part of the 10 question test format. The negative tornado problem solving loadings imply that a lack of math skill could adversely affect scores on these two items.

Tornado conceptual model test. This test question required students to form a conceptual model of the three stages of tornado development. Students were asked: "Tornados develop from thunderstorms in three phases. Please draw a diagram and briefly describe what is happening in each of the three phases." There was no diagram in the passage, therefore students had to be able to form an abstract image of each stage as they read and studied the passage. The correct diagram and description responses were taken directly from the textbook and the Pearson Product Correlation revealed an inter-rater reliability coefficient of $r = .72$, $p < .01$. This measure was included in the principal component factor analysis, and it loaded the highest on the main factor (.82) indicating it was a factorially valid measure of tornado knowledge. The Pearson Product Correlation between the Tornado Knowledge Test score and the Conceptual Model Test was $r = .70$, $p < .01$.

Microanalytic Processes Measure of Self-Regulated Learning

These scales involved online measures of the various subprocesses within Zimmerman's three phase model. Students' scores on these scales have shown high levels of reliability and predictive validity in prior research using an athletic task (Kitsantas & Zimmerman, 2002). In the present study, students were asked questions as they read and studied the tornado passage and then immediately upon completion of the test. Each microanalytic question was aimed at measuring the various subprocesses in Zimmerman's three phase model of self-regulation as outlined below.

Microanalysis of Phase 1: Forethought Phase Measures

Self-motivational beliefs. Three of the subprocesses were assessed: *Self-efficacy for learning, intrinsic interest, and outcome expectations*. For each of these measures students were asked two questions, one referring to the topic at-hand of tornados, and a second item referring to the field of science in general. These questions were scored on a Likert Scale; for example, for the self-efficacy for learning measure students were asked: "How confident do you feel in your capability to learn and remember all of the material on tornados for this passage?" Responses ranged from 10 (not sure at all) to 100 (very sure). Students were asked to point to the appropriate response.

Task analysis. For the g*oal setting* measure, students were asked a question about the grade goal they had for the test with response choices ranging from 10% to 100%. For the s*trategic planning* measure, students were asked "Do you have any particular plans for how to read this passage and take the test?" A list of possible responses was available for the investigator to check off with space available for additional answers to be noted. Scoring involved counting the number of strategies listed by the students. Inter-rater reliability was $r = .83$, $p < .01$ indicating substantial inter-rater agreement.

Microanalysis of Phase 2: Performance

This phase consisted of three parts: 1. while reading, 2. while studying, and 3. post science assessment. In addition, a *study time* measure was recorded at the point in which the student began to read the passage and at the point in which the student indicated he or she was ready to take the test.

Self-control. Two *task strategies* measures were assessed: one during *reading* and the second during *studying*. For each measure students were asked a question to determine their task strategy use. For example, the *task strategy question for reading* asked "I noticed while you are reading that you are (highlighting, rereading, underlining, etc.); could you explain to me what you are doing and why?" A list of possible responses was available for the investigator to check with space available for additional answers to be noted. Scoring involved counting the number of strategies listed by the students. Inter-rater reliability was $r = .76$, $p < .01$ indicating substantial agreement. Regarding the *task strategy question for studying,* students were asked "Can you explain to me how you are preparing for the test, what exactly are you doing?" A list of possible responses were available for the investigator to check with space available for additional answers to be noted and scoring involved counting the number of strategies listed by the students. Inter-rater reliability was $r = .92$, $p < .01$ indicating substantial inter-rater reliability.

Once the student indicated she or he was ready to take the test, the student was asked to read through all of the test questions without responding. At this point, the *self-efficacy for performance* question was asked to assess the students' self-confidence about his/her capability to earn a perfect score on the test. (This measure is considered a Phase 1 measure for test-taking.) This question was also scored on a Likert Scale ranging from 10 (not sure at all) to 100 (very sure) and students were instructed to point to the appropriate response. The student was then instructed to take the test.

Self-observation. Four metacognitive monitoring measures were obtained. The first set of measures consisted of asking students a metacognitive monitoring question about *each test item on the Tornado Knowledge Test*. For example, students were asked "How confident do you feel about your answer to question 1…?" Responses were scored on a Likert Scale ranging from 10 (not sure at all) to 100 (very sure). The second metacognitive monitoring measure addressed the *score on the Tornado Knowledge Test*. Students were asked: "What score do you think you got on the test? Their responses involved a Likert Scale ranging from 10% to 100%. The third metacognitive monitoring measure was on the *Conceptual Model Test question*. Students were asked "How confident do you feel about your answer to the question on drawing and labeling the three phases of tornado development;

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each drawing and each description was worth one point out of six?" Student answers were scored on a Likert Scale ranging from 0 (not sure at all) to 100 (very sure). The final metacognitive monitoring measure concerned the *score on the Conceptual Model test.* Student responses were on a Likert Scale ranging from 1/6 to 6/6. For each of the metacognitive monitoring measures, students were asked to point to the appropriate response.

Microanalysis of Phase 3: Self-Reflection

Self-judgment. Upon grading the Conceptual Model Test the investigator showed the Conceptual Model Test grade to the students and asked them how well they believed they learned about the three phases of tornado development to obtain the *self-evaluation* measure. Responses were based on a Likert Scale ranging from 10 (poorly) to 100 (very well) and students were asked to point to the appropriate response. To assess their *causal attributions* regarding their performance, students were asked one of two questions: "Why do you think you didn't do better on this particular test question on tornado development? Please explain." Or for students who answered this question 100% correctly, "Why do you think you did so well on this particular test question on tornado development? Please explain." All responses were recorded by the investigator according to the following categories: don't know/not sure, ability (for example, "I can't draw"), effort (for example, "I didn't study hard enough"), and strategy (for example, "I did not draw a diagram when I was studying). The inter-rater reliability was $r = .81$, $p < .01$ indicating substantial inter-rater agreement.

Self-reaction. To obtain the *satisfaction* measure, students were asked "How satisfied are you with your score on this particular test item?" Responses were based on a Likert Scale ranging from 1 (very dissatisfied) to 7 (very satisfied) to which students were asked to point to the appropriate response. In addition, students were asked ""Is there anything you would do differently on this particular test question on tornado development if you were given another chance to study the material on tornados? Please explain." to assess the *adaptive/defensive* measure. The responses were coded according to the following categories: no, I would not do anything differently, ability (for example: "I can't do any better"), effort: (for example: "I would try harder next time"), and strategy (for example: "I would have visualized the three phases"). Students who earned a perfect score on the Conceptual Model Test and responded by indicating they would not do anything differently, were coded as strategic. Both inter-rater reliability and chi-square analyses were conducted. The inter-rater reliability was $r = .93$, $p < .01$. Table 1 presents a summary of the microanalytic measures assessed as they addressed Zimmerman's three phases of self-regulation and their subprocesses.

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Table 1
Summary of Microanalytic Measures Addressing Zimmerman's Three Phases of Academic Self-Regulation and their Subprocesses

Phase	Microanalytic Measures Obtained
Phase 1: Forethought (Pre-reading)	- self-efficacy (learning and performance) - outcome expectations - intrinsic values/interest - goal setting - strategic planning
Phase 2: Performance: Part I (While reading)	- task strategy
Phase 2: Performance: Part II (While studying)	- task strategy - metacognitive monitoring
Phase 2: Performance: Part III (Upon completion of the test)	- metacognitive monitoring
Phase 3: Self-Reflection (Post assessments)	- self-evaluation - self-satisfaction - causal attribution - adaptive/defensive responses

Procedure

Students were tested individually by the investigator, and the duration of the session varied based on the student but lasted no longer than 60 minutes. The session began with the student being asked to reread the consent form, which described the purpose of the study -- namely, (a) that they would be reading and studying a science passage, (b) that they would be tested on the passage after studying, and (c) that they would be asked questions throughout the protocol. Upon agreeing again to participate, students were asked what they knew about tornados to assess their prior knowledge. After these responses were noted, the study session began *Study session protocol.* As indicated above and in Table 1, students were asked questions throughout each of the three phases of academic self-regulation. During the *forethought phase,* students were given the passage and asked to look it over without reading it. After five minutes, students were asked questions about their self-efficacy, outcome expectations, intrinsic interest, goal setting, and strategic planning. These questions took place prior to the student reading and studying the material in the tornado passage.

During the *performance phase*, students were asked questions on task strategy and metacognitive monitoring. These questions were asked while students were reading the passage and while students were studying for the test. At the time in which students indicated they were done studying, they were given the test and asked to read each question without responding. When they were done, they were asked the self-efficacy for performance measure which is the only forethought measure assessed once students began reading and studying the passage. Upon taking the test but prior to receiving any feedback on their performance, students were also asked metacognitive monitoring questions about their responses to each question. This measure was used to determine how accurately their beliefs about their performance on the test questions matched the grade earned on each test question.

The *self-reflection phase* questions of self-evaluation, self-satisfaction, causal attribution, and adaptive/defensive measures were asked upon receiving feedback on only the Conceptual Model Test which completed the microanalytic measures assessed. The study time measure was taken at the point in which the students began to study the material and ended at the time in which they indicated they were ready to take the test. The duration of the time spent studying was recorded by the investigator.

Results

Person Measures

Prior Knowledge. A single factor analysis of variance tests revealed no significant differences in prior knowledge based on school affiliation. A 3 (achievement levels) X 2 (genders) analysis of variance did not reveal a significant main effect for the three achievement levels on prior knowledge. There was also no main effect for gender or interaction between the three levels of achievement and gender on prior knowledge.

Acquired Tornado Knowledge Test. A 3 (achievement levels) X 2 (genders) analysis of variance revealed a statistically significant main effect for achievement level for performance on the Tornado Knowledge Test, $F(2, 45) = 15.99$, $p < .01$. The effect size is large (partial eta squared .42) suggesting a large portion of the variance is explained by the students' achievement level in science (Cohen, 1988). A trend analysis revealed a significant positive linear increase in tornado knowledge, $F(1, 48) = 37.27$, $p < .01$, based on the students' achievement level. Post hoc comparisons using the Tukey tests indicated significant pairwise differences between all three achievement levels. There was no main effect for gender or interaction between the three levels of achievement and gender on the Tornado Knowledge Test. Table 2 below reflects the means and standard deviations for all achievement measures by achievement level.

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Table 2
Means and Standard Deviations for SRL Processes and Outcomes by Achievement Level

SRL Processes and Outcomes	High Achievers		Average Achievers		Low Achievers	
	M	SD	M	SD	M	SD
Tornado Knowledge Test	75.74	9.97	61.01	12.70	29.27	14.77
Conceptual Model Test	5.18	.95	3.29	1.83	1.94	1.60
Forethought: Goal setting	88.23	2.90	88.98	2.76	90.19	2.76
Forethought: Strategic planning	2.44	.22	2.31	.21	1.27	.21
Forethought: Self-efficacy for learning about tornados	71.83	2.92	70.11	2.79	72.27	2.79
Forethought: Self-efficacy for learning new topics in science	68.58	3.97	73.98	3.78	79.09	3.78
Forethought: Self-efficacy for performance	72.98	4.00	77.77	3.81	75.61	3.81
Forethought: Outcome expectations: tornados	3.95	.36	4.3	.34	4.55	.34
Forethought: Outcome expectations: science	5.63	.35	5.41	.33	5.79	.33
Forethought: Intrinsic interest: tornados	3.40	.21	3.92	.20	3.26	.20
Forethought: Intrinsic interest: science	3.53	.22	3.99	.21	4.17	.21
Performance: Task-strategy: reading	2.71	.27	1.83	.26	1.61	.26
Performance: Task-strategy: studying	3.48	.34	2.46	.32	1.96	.32
Performance: Metacognitive monitoring: Tornado Knowledge Test	91.82	2.20	88.11	2.11	75.62	2.11
Performance: Metacognitive monitoring: Conceptual Model Test	91.38	4.70	85.68	4.49	65.10	4.49
Performance: Metacognitive Monitoring: Tornado Knowledge Test score	90.60	2.17	83.48	2.07	74.00	2.07
Performance: Metacognitive Monitoring: Conceptual Model Test score	4.98	.32	4.08	.30	3.59	.30
Self-Reflection: Self-evaluative standards	88.38	4.70	72.89	4.48	55.61	4.48
Self-Reflection: Attribution	-	-	-	-	-	-
Self-Reflection: Self-satisfaction	5.97	.35	4.57	.34	3.27	.34
Self-Reflection: Adaptive/defensive	-	-	-	-	-	-

Tornado Conceptual Model Test. The same 3 (achievement levels) X 2 (genders) two-way analysis of variance revealed a statistically significant main effect for achievement level for performance on the Conceptual Model Test, $F(2, 45) = 16.68$, $p < .01$. The effect size for achievement level (partial eta squared) was .43, which is considered large. A trend analysis revealed a significant positive linear trend, $F(1, 48) = 39.20$, $p < .01$, for achievement level regarding achievement on the Conceptual Model Test. Post hoc comparisons using the Tukey tests indicated significant pairwise differences between all three groups. The effect size for gender (partial eta squared) was .10, which is considered moderate. The girls' performance on the conceptual model test ($M = 3.85$) was superior to that of the boys' ($M = 2.71$). There was no interaction between the three achievement levels and gender.

Microanalytic Results

The same two-way analyses of variance were used to assess differences in microanalytic measures for all three phases based on students' science achievement level and gender. For the strategic planning and the task strategies measures, two-way analyses of variance were followed by a trend analyses, and Tukey HSD. In the self-reflection phase, two measures were categorical, and these measures were analyzed using chi-square tests.

Forethought Phase Microanalytic Results for Motivational Beliefs. Each of the two measures for *self-efficacy for learning* measure and the *outcome expectations* were analyzed along with the s*elf-efficacy for performance* measure using two-way analyses of variance. They did not reveal a significant main effect for science achievement level, gender, or interaction between achievement level and gender. The third set of self-motivational beliefs involved students' *intrinsic interest.* The two-way analysis of variance revealed a marginally significant main effect for achievement level on intrinsic interest in learning about tornados, $F(2, 45) = 2.92$, $p = .06$. The effect size for achievement level (partial eta squared) was .12, which is considered moderate; however, the trend analysis did not reveal a significant positive linear trend. Post hoc comparisons using Tukey tests indicated significant pairwise differences between average achievers and the other two groups. The high achievers group did not differ significantly from the low achievers group. There was no main effect for gender or interaction between the three achievement levels and gender on the intrinsic interest in learning about tornados measure.

Regarding the second intrinsic interest measure, *intrinsic interest in learning about new topics in science*, the two-way analysis of variance did not reveal a significant main effect for science achievement level on students' intrinsic interest in learning about new topics in science. There was also no significant main effect for gender or interaction between the three achievement levels and gender.

Forethought Phase Microanalytic Results for Task Analysis. Regarding *goal-setting,* the two-way analysis of variance did not reveal a significant main effect of science achievement level and goal-setting. There was also no main effect for gender or interaction between the three achievement levels and gender for this measure.

Regarding the *strategic planning* subprocess, the two-way analysis of variance revealed a statistically significant main effect for science achievement level on strategic planning, $F(2, 45) = 8.76$, $p < .01$. The effect size for achievement level (partial eta squared) was .28, which is considered large. A trend analysis revealed a significant positive linear trend for achievement level, $F(1, 48) = 10.24$, $p < .01$, on strategic planning. Post hoc comparisons using Tukey tests indicated significant pairwise differences with high achievers and average achievers differing from the low achievers group. There was no main effect for gender or interaction between the three achievement levels and gender on the strategic planning measure.

Performance Phase Microanalytic Results for Self-Control. Two observational measures of task strategies were obtained: while reading and while studying. The two-way analysis of variance revealed a statistically significant main effect for achievement level on strategy use during *reading*, $F(2, 45) = 4.80$, $p < .01$. The effect size for the high achievement level (partial eta squared) .18, is considered large. A trend analysis revealed a significant positive linear trend for achievement level, $F(1, 48) = 7.57$ $p < .01$, on students' task-strategy for reading. Post hoc comparisons using Tukey tests indicated significant pairwise differences between the high achievers and the low achievers while the average achievers did not differ significantly from either high achievers or low achievers. There was no main effect for gender or interaction between the three achievement levels and the students' task-strategy for reading measure.

The two-way analysis of variance revealed a statistically significant main effect for achievement level on strategy use during *studying*, $F(2, 45) = 5.44$, $p = .01$. The effect size for achievement level (partial eta squared) .20, is considered large. A trend analysis revealed a significant positive linear trend for achievement level, $F(1, 48) = 15.56$ $p = .01$. Post hoc comparisons using Tukey tests indicated significant pairwise differences between the high achievers and the low achievers while the average achievers did not differ significantly from either the high achievers or the low achievers. There was no main effect for gender or interaction between the three achievement levels and the students' task-strategy for studying measure.

Performance Phase Microanalytic Results for Self-Observation. As indicated above, four *metacognitive monitoring measures* were obtained: two on the Tornado Knowledge Test and two on the Tornado Conceptual Model Test. Regarding the *metacognitive monitoring measure of each test item on the Tornado Knowledge Test,* a mean was calculated for each student and was analyzed using the two-way analysis of variance. It revealed a statistically significant main effect for achievement level on metacognitive monitoring, $F(2, 45) = 15.80$, $p < .01$. The effect size for achievement level (partial eta squared) .41, is considered large. A trend analysis revealed a significant positive linear trend for achievement level, $F(1, 48) = 34.90$, $p < .01$, on students' metacognitive monitoring of test questions. Post hoc comparisons using Tukey tests indicated significant pairwise differences between the low achievers and both the high achievers and the average achievers; however the difference between high achievers and average achievers was only marginally significant ($p < .20$). There was no main effect for gender or interaction between the three achievement levels and the students' metacognitive monitoring of test questions.

Regarding the *metacognitive monitoring measure for the score on the Tornado Knowledge Test* the two-way analysis of variance revealed a statistically significant main effect for achievement level, $F(2, 45) = 15.53$, $p < .01$. The effect size for achievement level (partial eta squared) was .41, which is considered large. A trend analysis revealed a significant positive linear trend, $F(1, 48) = 36.09$, $p < .01$, for achievement level on metacognitive monitoring of test score. Post hoc comparisons using the Tukey tests indicated significant pairwise differences between all three groups. There was no main effect for gender or interaction between the three achievement levels and metacognitive monitoring of Tornado Knowledge Test score.

Regarding the *metacognitive monitoring measure for the Conceptual Model Test,* the two-way analysis of variance revealed a statistically significant main effect for achievement level on metacognitive monitoring of the Conceptual Model Test, $F(2, 45) = 9.24$, $p < .01$. The effect size for achievement level (partial eta squared) was .29, which is considered large. A trend analysis revealed a significant positive linear trend, $F(1, 48) = 19.94$, $p < .01$, for achievement level on metacognitive monitoring. Post hoc comparisons using the Tukey tests indicated significant pairwise differences between all three groups. There was no main effect for gender or interaction between the three achievement levels and gender on metacognitive monitoring of Tornado Conceptual Model Test.

Regarding the *metacognitive monitoring measure for the Tornado Conceptual Model Test score*, the two-way analysis of variance revealed a statistically significant main effect for achievement level on metacognitive monitoring of Conceptual Model Test score, $F(2, 45) = 5.23$, $p < .01$. The effect size for achievement level (partial eta squared) was.19, which is considered large. A trend analysis revealed a significant positive linear trend, $F(1, 48) = 9.91$, $p < .01$, for achievement level on metacognitive monitoring of the Tornado Conceptual Model Test score. Post hoc comparisons using the Tukey tests indicated significant pairwise differences between high achievers and average achievers and low achievers. The average achievers, however, did not significantly differ from the low achievers. There was no main effect for gender or interaction between the three achievement levels and gender regarding metacognitive monitoring of the Tornado Conceptual Model Test score.

Self-Reflection Phase Microanalytic Results for Self-Judgment. Each measure assessed in the self-reflection phase was based on the Conceptual Model Test. With regard to *self-evaluation,* a two-way analysis of variance revealed a statistically significant main effect for achievement level and gender on self-evaluation, $F(2, 45) = 12.77$, $p < .01$. The effect size for achievement level (partial eta squared) .36 is considered large. A trend analysis revealed a significant positive linear trend for achievement, $F(1, 48) = 31.51$, $p < .01$. Post hoc comparisons using Tukey tests indicated significant pairwise differences between all three levels. There was no main effect for gender or interaction between the three achievement levels and self-evaluation.

A chi-square analysis was conducted for the *causal attribution* measure, and it revealed significant differences across achievement level, $\chi^2(6) = 13.12$, $p < .04$, $\varphi = .51$ on the attribution measure. Table 3 below indicates the frequency of responses based on achievement level and attribution response. A secondary chi-square was conducted to determine if there were differences between the achievement level of students who indicated either ability or strategy on their attribution measure. This chi-square analysis revealed a stronger significant difference between achievement level and attribution to ability or strategy, $\chi^2(2) = 9.90$, $p < .01$, $\varphi = .56$. No significant differences across gender were found.

Table 3
Attribution Frequency Results for the Self-Reflection Phase

Attribution: Why do you think you didn't do better on this particular question on tornado development?	Attribution	Achievement Level Count High Achievers	Average Achievers	Low Achievers	Total
	Do not know	0	2	1	3
	Ability	3	6	9	18
	Effort	5	6	6	17
	Strategy/perfect score	9	3	1	13
	Total	17	17	17	51

Self-Reflection Phase Microanalytic Results for Self-Reaction. With regard to the subprocess of *self-satisfaction*, a two-way analysis of variance revealed a statistically significant main effect for achievement level and self-evaluation, $F(2, 45) = 15.37$, $p < .01$. The effect size for achievement level (partial eta squared) was .41, which is considered large. A trend analysis revealed a positive linear trend, $F(1, 48) = 31.37$, $p = .01$, across achievement level on self-evaluation. Post hoc comparisons using Tukey tests indicated significant pairwise differences between all three levels. Although there was no interaction between the three achievement levels and self-satisfaction, there was an effect for gender, $F(2, 45) = 8.36$, $p < .01$; the mean for females was 5.17 and males 4.03 and respective standard deviations were .23 and .32.

The second subprocess in self-reaction category is the subprocess of *adaptive* or *defensive inferences*. The chi-square analysis revealed significant differences across achievement level, $\chi^2(6) = 15.21$, $p < .02$, $\varphi = .49$ on the adaptive/defensive measure. Table 4 below indicates the frequency of responses based on achievement level and adaptation response. Based on the frequency of responses, a secondary chi-square analysis was conducted to determine if there were differences between the achievement level of students who indicated either effort or strategy on their adaptive/defensive measure. This analysis revealed a stronger significant difference between achievement level and adaptive/defensive response based on effort or strategy use, $\chi^2(2) = 11.63$, $p < .01$, $\varphi = .44$. Chi-square tests revealed no significant differences across gender. Table 5 presents a summary of the differences found or not found in the subprocesses across achievement level.

Table 4
Adaptive/Defensive Frequency Results for the Self-Reflection Phase

Adaptive/defensive: Is there anything you would do differently if given another chance to study the material on tornado development?	Adaptive/defensive	Achievement Level Count High Achievers	Average Achievers	Low Achievers	Total
	No, I would not do anything differently	0	1	2	3
	Ability	1	0	1	2
	Effort	1	10	7	18
	Strategy/perfect score	15	6	7	28
	Total	17	17	17	51

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Table 5
Summary of Differences found across Science Achievement Levels in Zimmerman's Three Phase Model of Academic Self-Regulation

Academic Self-Regulation Subprocesses	High Achievers	Average Achievers	Low Achievers
Forethought: Goal setting	-	-	-
Forethought: Strategic planning	Significantly differed from low achievers	Significantly differed from low achievers	Significantly differed from high achievers and average achievers
Forethought: Self-efficacy for learning about tornados	No significant differences	No significant differences	No significant differences
Forethought: Self-efficacy for learning new topics in science	No significant differences	No significant differences	No significant differences
Forethought: Self-efficacy for performance	No significant differences	No significant differences	No significant differences
Forethought: Outcome expectations: tornados	No significant differences	No significant differences	No significant differences
Forethought: Outcome expectations: science	No significant differences	No significant differences	No significant differences
Forethought: Intrinsic interest: tornados	Marginally differed from average achievers	Marginally differed from high achievers and low achievers	Marginally differed from average achievers
Forethought: Intrinsic interest: science	No significant differences -	No significant differences -	No significant differences -
Performance: Task-strategy: reading	Significantly differed from low achievers	No significant differences -	Significantly differed from high achievers
Performance: Task-strategy: studying	Significantly differed from low achievers	No significant differences -	Significantly differed from high achievers
Performance: Metacognitive monitoring: Tornado Knowledge Test	Significantly differed from low achievers; marginally differed from average achievers	Significantly differed from low achievers; marginally differed from high achievers	Significantly differed from high achieversand average achievers
Performance: Metacognitive monitoring: Conceptual Model Test	Significantly differed from average achievers and low achievers	Significantly differed from high achievers and low achievers	Significantly differed from high achievers and low achievers
Performance: Metacognitive Monitoring: Tornado Knowledge Test score	Significantly differed from average achievers and low achievers	Significantly differed from high achievers and low achievers	Significantly differed from high achievers and average achievers
Performance: Metacognitive Monitoring: Conceptual Model Test score	Significantly differed from average achievers and low achievers	Significantly differed from high achievers	Significantly differed from high achievers
Self-Reflection: Self-evaluative standards	Significantly differed from average achievers and low achievers	Significantly differed from high achievers and low achievers	Significantly differed from high achievers and low achievers
Self-Reflection: Attribution	Chi-square: Significant differences across levels	Chi-square: Significant differences across levels	Chi-square: Significant differences across levels
Self-Reflection: Self-satisfaction	Significantly differed from average achievers and low achievers	Significantly differed from high achievers and low achievers	Significantly differed from high achievers and average achievers
Self-Reflection: Adaptive/defensive	Chi-square: Significant differences across levels	Chi-square: Significant differences across levels	Chi-square: Significant differences across levels

Correlation Analyses

Zimmerman's model of academic self-regulation suggests there relationships exist among measures within and across the three phases: forethought, performance, and self-reflective. To test this, correlations were calculated among the subprocesses, and significant correlations were found among some variables as indicated in Table 6 below.

Table 6
***Correlations between Self-Regulatory Phase Processes and Science Learning* Outcomes**

Forethought: Goal setting	Performance: Task-strategy: reading	Performance: Task-strategy: studying	Performance: Metacognitive monitoring: TKT Responses	Performance: Metacognitive monitoring: CMT Response	Performance: Metacognitive monitoring: TKT Score	Performance: Metacognitive monitoring: CMT Score
Forethought: Goal setting	-.04	-.21	-.08	.01	.01	-.16
Forethought: Strategic planning	.079	.31*	.35*	.28*	.30*	.21
Forethought: Self-efficacy for learning about tornados	-.01	-.16	-.06	-.11	.10	-.06
Forethought: Self-efficacy for learning new topics in science	-.25	-.24	-.13	-.05	-.03	-.03
Forethought: Self-efficacy for performance	-.08	.05	.13	.21	.11	-.03
Forethought: Outcome expectations: tornados	-.27	-.12	-.08	-.06	-.12	-.14
Forethought: Outcome expectations: science	-.09	.00	-.06	.03	-.08	.03
Forethought: Intrinsic interest: tornados	.09	-.08	.08	-.06	.03	-.30*
Forethought: Intrinsic interest: science	-.09	-.14	-.01	.02	-.01	-.21
Self-Reflection: Self-evaluative standards	.36**	.28*	.66**	.77**	.62**	.58**
Self-Reflection: Attribution	.24	.34*	.26	.16	.24	.13
Self-Reflection: Self-satisfaction	.30*	.29*	.52**	.61**	.49**	.59**
Self-Reflection: Adaptive/ defensive	.17	.19	.08	.01	.25	.08

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

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Supplementary Calibration Bias Analyses

The Forethought Phase motivational measures were not predictive of tornado learning outcomes, which failed to support expectations. These motivational measures were given before the students had an opportunity to learn from personal feedback about tornados, and it was possible that some students overestimated their motivation, especially if they lacked expert
ise in science. To test this emergent hypothesis, a calibration analysis was conducted; it was designed to assess students' bias in reporting their self-efficacy scores. This analysis was only possible with self-efficacy measures of motivation in the present study because they involved test item-specific judgments. Bias scores measure over - or under - confidence regarding knowing the answer to a test item.

Two measures of self-efficacy bias were obtained to determine whether students over– or underestimated their competence in science. The first measure was *self-efficacy for learning and remembering the material in the tornado passage bias.* This measure was calculated by subtracting students' score on the Acquired Tornado Knowledge Test from their self-efficacy for learning and remembering the material in the tornado passage score. The means and standard deviations for these measures of self-efficacy bias are presented in Table 7. A two-way analysis of variance revealed a statistically significant main effect for achievement level on self-efficacy for learning bias, $F(2, 45) = 9.25$, $p < .01$. The effect size for achievement level (partial eta squared) was .30 and is considered large. A trend analysis revealed a significant negative linear trend for achievement level, $F(1, 48) = 26.28$, $p < .01$, on self-efficacy for learning bias. Post hoc comparisons using the Tukey tests indicated significant pairwise differences between high achievers and the other two levels. There was no main effect for gender or interaction between the three achievement levels and gender on the self-efficacy for learning bias measure.

Table 7
Means and SDs for Self-Efficacy Calibration Measures for each Science Achievement Group

Bias Measures	High Achievers		Average Achievers		Low Achievers	
	M	*SD*	*M*	*SD*	*M*	*SD*
Self-efficacy for learning bias	-2.96	4.5	10.31	4.29	23.76	4.30
Self-efficacy for performance bias	-1.81	5.58	17.96	5.34	27.12	5.34

The second measure of self-efficacy bias obtained was *self-efficacy for performance bias.* This measure was obtained by subtracting students' score on the *Tornado Knowledge Test* from their self-efficacy for performance score. A two-way analysis of variance revealed a statistically significant main effect for achievement level and self-efficacy for performance bias, $F(2, 45) = 7.29$, $p < .01$. The effect size for achievement level (partial eta squared) was .23 and is considered large. A trend analysis revealed a significant negative linear trend for achievement level, $F(1, 48) = 17.99$, $p < .01$, on self-efficacy for performance bias. Post hoc comparisons using the Tukey tests indicated significant pairwise differences between high achievers and the other two levels, with the high achievers displaying less bias. The average achievers did not differ from the low achievers. There was no main effect for gender and interaction between achievement level and gender on the self-efficacy for performance bias measure.

These results reveal that on both measures of self-efficacy (i.e., for learning and for performance), low achievers overestimated their competence in science the most, the average achievers showed lower levels of overestimation, and the high achievers showed a slight underestimate of self-efficacy. In future research using designs that involve multiple feedback cycles, it will be interesting to see whether forethought measures will become less biased by students who are lower in achievement in science.

Study Time

Students' *study time* was assessed to determine if there were differences due to achievement level or gender. The time gap between when students began to read and the time in which students indicated they were ready to take the test were recorded. The difference between the two was termed a study time measure. The two-way analysis of variance revealed a statistically significant main effect for achievement level on the study time measure, $F(2, 45) = 4.35$, $p < .02$. The effect size for achievement level (partial eta squared) .16, is considered large. A trend analysis revealed a significant linear increase, $F(1, 48) = 6.57$, $p < .01$, for achievement level. Post hoc comparisons using the Tukey tests indicated significant pairwise differences between high achievers and low achievers, and marginal differences between average achievers and low achievers. There was no main effect for gender or interaction between achievement level and gender for the study time measure. Pearson correlational analyses revealed that the length of students' study time correlated positively with the number of self-regulated learning processes they used, such as task strategies for reading ($r = .47$, $p < .01$), for studying ($r = .32$, $p < .05$) and for the level of self-evaluative standards ($r = .30$, $p < .05$).

Discussion

Differences in Performance

With regard to performance, significant differences were found among the three achievement levels, with the high achievers performing better than the average achievers, who performed better than the low achievers on both the Tornado Knowledge Test and the Conceptual Model Test. The latter test is particularly important because it involved having to form an image of the three-phases of tornado development from the reading. This finding is similar to that of Greene and Azevedo (2007) who found that students who were more self-regulatory were better able to abstract a model of the blood circulatory system than those who were less self-regulatory.

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Differences in the Three Phases of Academic Self-Regulation

Forethought phase. With regard to the forethought phase task analysis measure of strategic planning, both the high achievers and average achievers differed significantly from the students in the low achievers group. This finding indicates that students who are low achievers have fewer strategies in their repertoire as they prepare to study an academic task.

One possible reason for the lack of differences in pre-existing motivational beliefs regarding tornados is that low achievers may not be able to judge their self-efficacy or outcome expectations accurately. The calibration results regarding students' self-efficacy beliefs provide some support for this hypothesis. Unfortunately, time constraints prevented the tracking of these measures during additional cyclical efforts to learn. Once the students have an opportunity to try to learn information about tornados, their self-efficacy beliefs about their competence and their outcome expectations can be expected to increase in their predictive power. They may also form a more reliable sense of intrinsic interest in the topic of tornados as well.

Performance phase. The results from measures of performance phase processes were generally supportive of Zimmerman's theory than forethought phase measures. With regard to self-control strategies, high achievers differed significantly from the low achievers in their use of the self-regulatory strategies during reading and studying. These findings reveal that students who are high achievers used more self-regulatory strategies while reading a science passage and while studying for a science test when compared to students who are low achievers.

Regarding metacognitive monitoring, high achieving science students were significantly higher in the quality of their monitoring on all four microanalytic self-control measures than average achievers and low achievers. This indicates that students who are High achievers are more aware of their self-regulatory behavior and academic performance than students in the other two groups.

Self-reflection phase. Significant differences were found regarding self-evaluative standards, attributions, self-satisfaction, and adaptive/defensive responses among the three science achievement groups. Interestingly, females were significantly different in their satisfaction levels suggesting that there may be differences in academic grades that satisfy males versus females. Overall, students who are high achievers held higher SRL standards, attributed their performance to self-regulatory strategies more frequently, are more satisfied with their performance measures, and are more adaptive when compared to students in the other two achievement levels.

Gender Differences in Self-Regulated Learning

A marginally significant gender difference was found on the Conceptual Model Test: Girls abstracted a model of volcanoes from their reading and studying better than boys. In addition, significant gender differences were found on the microanalytic measure of self-satisfaction indicating that females were more satisfied with their science knowledge than males. These two gender results were contrary to conventional expectations in that the girls' performance in science surpassed the boys. There is evidence that the two unexpected findings were related ($r = .59$). It is possible that the girls' higher level of conceptual learning may have led them to feel more self-satisfied with their results. These results were unexpected based on the literature on gender stereotyping. There were no gender differences on any of the other microanalytic measures or the Tornado Knowledge Test. The lack of gender differences across most of the phases of self-reflection phase measures suggests that self-regulatory competence, rather than gender, is the cause of academic achievement.

Correlations among Processes Assessed during the Three Phases of Self-Regulation

Strategic planning in the forethought phase was significantly correlated with several of the measures in the performance phase suggesting that there may be a causal relation between students who plan in advance of studying for an academic task and their actual studying and performance on the task. This implies that it is important for students to think in advance of studying. This hypothesis should be explored in future research.

Several measures in the performance phase also correlated significantly with measures from the self-reflection phase. The correlations between these two task strategies and the self-reflective measures suggests that the number of strategies described is related to the ways in which students evaluate their performance, what they attribute their performance to be, and how satisfied they are with their performance. Implications of these findings are that it is important for educators to help students who are engaging in academic tasks to set appropriate standards and to examine the degree of satisfaction they may experience regarding various grades.

The metacognitive monitoring measures correlated significantly with the self-evaluation measure suggesting that based on their achievement level, students are differentially aware of their performance level on the tornado learning task. This has interesting implications for students in that it suggests that the standards students set for themselves are in synch with their reactions regarding their performance on academic tasks. Correlations between performance measures, such as metacognitive monitoring, and students self-satisfaction were also statistically significant, suggesting that students who monitor their performance more closely experience greater satisfaction. This finding provides support for Zimmerman's model by indicating that the subprocesses in the performance phase are directly linked to subprocesses in the self-reflection phase.

Calibration Bias Analyses

The calibration analyses indicate that students who are high achievers tend to judge their capability to perform a task quite accurately while students who are low achievers tend to overestimate it. These achievement level differences in calibration on performance phase measures indicate that the students were differentially monitoring their effectiveness. An adverse effect of overestimation of one's competence during science learning is that low achieving students may not study sufficiently to do well on the exam. By contrast, high achieving science students may have studied more because of their more accurate estimates of the effectiveness of their studying.

Study Time

One interesting finding was the significant differences found across science achievement level with regard to study time. High achievers and average achievers spent significantly more time preparing for the exam (mean score of 35 minutes for high achievers and average achievers groups) when compared to low achievers mean score of 22 minutes). One possible implication from this finding is that the amount of time that students use to prepare for examinations, may in fact be the result of their greater use of self-regulatory strategies while studying, which ultimately affects their achievement. There is some support for this interpretation in the significant correlations between the length of students' study time and their level of self-evaluative standards and with their number of task strategies for reading and studying (Plant, Ericsson, Hill, & Ansberg, 2004).

Recommendations for Further Research

One limitation of the current study is that it did not provide the students with a second or third follow-up academic task which would test whether students' self-reflective processes provided the necessary feedback to change the forethought processes. Feedback is an important element in academic self-regulation, and the present investigation did not test for this beyond the third phase of the first cycle, thus information about full impact of the feedback loop was not examined.

Another limitation of the study in terms of students' forethought phase motivation is that the task was not taxing motivationally. The students were aware that the tornado task would not affect their academic grades, and that their scores would remain anonymous. A recommendation for further research is to test Zimmerman's three phase model using an academic task in an authentic classroom setting. If the researcher could collaborate with the teachers to use an academic task that is part of the students' records, the students may be more engaged and more challenged. This may result in differences across achievement levels in the forethought phase processes, which were expected but not found in the present investigation.

Conclusion

This study revealed that high achievers in science displayed extensive use of phase-specific self-regulatory processes when learning a new topic in science. By contrast, average and low achievers exhibited significantly fewer self-regulatory processes when studying a new topic in science. However, the issue of the causal role of self-regulatory processes must be addressed in future training research. A microanalytic methodology had not been used with academic learning tasks in previous research but had been used to assess students' acquisition of skill in sports. Science is a more abstract learning task, and this may have led to over-estimates of personal skill and to less studying by average and low self-regulators. The present research indicates that self-reflection processes, such as self-evaluation and self-satisfaction reactions, were related significantly to not only students' acquisition of tornado knowledge but also to their formation of an abstract conceptual model of tornados. As an online measure of self-regulation, microanalysis enables researchers or teachers to identify specific processes that can undermine a students' progress in science. The diagnostic potential for this methodology should be more evident in multi-trial studies of scientific learning. Clearly, the present study represents a significant milestone in the application of microanalysis to new domains of learning.

References

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Upper Saddle River, NJ: Prentice Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York, NY: W.H. Freeman and Company.

Baldi, S., Jin, Y., Green, P., & Herget, D. (2007). Highlights from PISA 2006: Performance of U.S. 15 year old students in science and mathematics literacy in an international context. *National Center for Education Statistics.* 74 pp.

Cleary, T. J., & Zimmerman, B. J. (2001). Self-regulation differences during athletic practice by experts, non-experts, and novices. *Journal of Applied Sport Psychology, 13,* 185-206.

Coch, N. K. (1995). *Geohazards, natural and human.* Englewood Cliffs, NJ: Princeton-Hall, Inc.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Eccles, J. S. (1989). Bringing young women to math and science. In M. Crawford & M. Gentry (Eds.), *Gender and thought* (pp.36-58). New York, NY: Springer-Verlag.

Greene, J. A., & Azevedo, R. (2007). Adolescents' use of self-regulatory processes and their relation to qualitative mental model shifts while using hypermedia. *Journal of Educational Computing Research, 36*(2), 125-148.

Greene, J. A., Moos, D. C., Azevedo, R., & Winters, F. I. (2006). Exploring differences between gifted and grade-level students' use of self-regulatory learning processes with hypermedia. *Computers & Education, 50*(3), 1069-1083.

Hackett, G., & Betz, N. E. (1981). A self-efficacy approach to career development of women. *Journal of Vocational Behavior, 18*, 326-339.

Hanson, S. L. (1996). *Lost talent: Women in the sciences*. Philadelphia, PA: Temple University Press.

Jacklin, C. N., & Mischel, H. N. (1973). As the twig is bent: Sex role stereotyping in early readers. *The School Psychology Digest, 2,* 30-38.

Kitsantas, A., & Zimmerman, B. J. (2002). Comparing self-regulatory processes among novice, non-expert, and expert volleyball players: A microanalytic study. *Journal of Applied Sport Psychology, 14,* 91-105.
Noris, S., Hudson, G. (2010). Performance of college students: Impact of study-time and study habits. *Journal of Education for Business, 85*(4), 229-238.
Pant, E. A., Ericsson, K. A., Hill, L., & Asberg, K. (2004). Why study time does not predict grade point average across college students: Implications of deliberate practice for academic performance. *Contemporary Educational Psychology, 30*(1), 96-116.
Signorielli, N. (1990). Children, television, and gender roles: Messages and impact. *Journal of Adolescent Health Care, 11*, 50-58.
Zimmerman, B. J. (1998). Academic studying and the development of personal skill: A self-regulatory perspective. *Educational Psychologist, 33,* 73-86.
Zimmerman, B. J. (2002). Achieving self-regulation: The trial and triumph of adolescence. In F. Pajares & T. Urdan (Eds.), *Academic motivation of adolescents* (vol.2, pp.1-27). Greenwich, CT: Information Age.

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