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Within the Pipeline: Self-regulated Learning and Academic Achievement among College Students in Science Courses

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Abstract

The present study examined the associations between self-regulated learning and science achievement and whether the academic self-regulation variables described, such as self-efficacy, delay of gratification, and help seeking, predict science achievement in courses deemed necessary for a major in science. It was hypothesized that students who do not use academic self-regulation in the science courses, would perform poorly, and thus leak out of the pipeline rather than proceed further down the funnel. The results of this study provide support for the expected association between self-regulated learning and academic achievement among college students in science courses. These findings suggest that students' self-regulation of learning, self-efficacy beliefs, academic delay gratification, and final course grade are related.

Within the Pipeline: Self-regulated Learning and Academic Achievement among College Students in Science Courses

Researchers have used the analogy of a *pipeline* to create an image of students moving through a funnel, which ends in a STEM (Science, Technology, Engineering, Mathematics) career (Hanson, 1996). As young children, boys and girls are required to take science in school, but as they progress through the educational system, they are often provided with the choice of whether or not to take science courses. This is especially evident in high school where many students begin to leak out of the pipeline. Research suggests that this is particularly true for females who seem less engaged or interested in taking high school science courses (Schmidt & Smith, 2010; Larson, 1996) An interesting question therefore, is what accounts for those women to persist in taking science courses in college and could this persistence be explained by self-regulatory variables?

Self-regulation of learning refers to one's self-generated thoughts, feelings, and actions towards attaining one's goals (Zimmerman, 1998). Self-regulation involves *self-efficacy*, which is defined as an individual's belief in his/her capability to reach specific goals (Bandura, 1997). This study sought to examine whether or not students' science self-efficacy and self-regulation were related to their science achievement and whether or not there were differences across gender.

Students are constantly faced with choices related to their studies. One such choice may be whether to complete the work that needs to be done or to postpone the school related activity for something "fun." Thus, another research question is whether there is a relationship between *academic delay of gratification* in the science courses at-hand and the students' grades in these courses.

Self-regulated learners engage in *adaptive help seeking*, which is a strategic self-regulatory way in which learners obtain information from formal and informal sources to attain knowledge (Karabenick, 1998). Do students who seek help perform better than those who do not in their science courses?

In sum, we investigated whether students who do not use self-regulation in their science courses, would be more likely to be candidates to leak out of the pipeline rather than proceed further down the funnel towards a STEM career.

2. Perspective(s) or Theoretical Framework

The perspective of this study is within the social cognitive theory framework (Bandura, 1986). Zimmerman (2002) has developed the theoretical framework that explains the various processes students engage in to learn. However, there is little research on the relationship between self-regulation of college students and science achievement. The self-regulatory variables in the present study include learning strategies, self-efficacy, academic delay of gratification, and help seeking.

According to Zimmerman (1998), the self-regulated learner will consider various dimensions of learning such as where the studying will take place, what the actual studying will consist of, and self-monitoring strategies. Self-efficacy is also an essential variable in Zimmerman's (2002) model of the self-regulated learner and is considered a motivational variable. Bandura (1997) suggests that students who are self-efficacious will set higher goals for themselves, and will continue to persist even when confronted with challenges. Self-efficacy is related to a myriad of motivational, cognitive, and behavioral learning constructs, which in turn are related to academic achievement (DiBenedetto & Bembenuity, 2011, DiBenedetto & Zimmerman, 2010; Zimmerman, 1998)

Academic delay of gratification requires the learner to be cognitively aware of his or her performance and this awareness along with the student's motivation, guide the decision. Bembenuity and Karabenick (1998) have defined the decision to put off immediately available opportunities to satisfy impulses over pursuing chosen important academic goals as academic delay of gratification. Research suggests academic delay of gratification is linked to academic achievement (Bembenuity, 2009a).

According to Zimmerman (2002) as students advance through the years, outside support diminishes and students are left to succeed or fail based on various self-regulatory processes. Research has demonstrated that in younger children, girls are more likely than boys to seek help (Eccles & Blumenfeld, 1985), but more research is needed about the help seeking activities of college science students.

Objectives of the Study

Four objectives guided the current study:

1. Examine the association between students' self-regulation, self-efficacy beliefs, and willingness to delay gratification, gender differences, and academic performance.
2. Examine whether the effects of self-regulation, self-efficacy beliefs, and willingness to delay gratification on students' academic performance are moderated by gender.
3. Examine whether gender, self-regulation, self-efficacy beliefs, and delay of gratification separately account for unique variance in the students' performance, even after controlling for the effect of each other.
4. Examine whether there is any gender differences in the frequencies of help seeking resources college students employ in science courses.

Methods

Participants

Fifty-seven undergraduate college students (24 males; 33 females) enrolled in two biology courses in an urban college in New York participated in the study. Their areas of concentration include biology, chemistry, and others for whom the courses were required. Students were Caucasians, Asian Americans, African Americans, Hispanics, and others (see Table 1). The courses include various topics such as the chemistry of life, cellular organization, and animal anatomy. These courses are typically taken by students who are

considering future study in biology. The administration of the instruments took part during regular classroom instruction.

Instruments

Self-efficacy. Using a 4-item scale, students rated their beliefs about their capability to perform in the science courses ($M = 6.38$, $SD = .66$; $\alpha = .75$) (see Appendix).

Self-regulation of learning. Self-regulation was measured with an 11-item scale assessing students' degree of keeping records, estimation, goal-setting, self-rewarding, self-monitoring, selecting strategies, and environmental control ($M = 5.56$, $SD = .93$; $\alpha = .87$).

Help Seeking Resources of. Resources help seeking resources were measured with an item asking the students to mark all of their possible help seeking resources listed in the question, such as getting a tutor, use library resources, forming a study group.

Academic Delay of gratification. This an 8-item scale which examined students' delay of gratification in relation to the science courses in which they were currently enrolled ($M = 3.44$, $SD = .41$; $\alpha = .59$). The students rated their preference for an attractive and immediately available option versus a delayed alternative.

Final Exam Grades. The final course grades had values ranging from 0 (F) to 12 (A+); $M = 7.86$; $SD = 3.34$).

Results

Objective One

Table 2 displays the correlations between students' self-regulation, self-efficacy, delay of gratification, gender, and final course grades. Final course grade was significantly related to delay of gratification ($r = .30$) and self-regulation ($r = .28$). Delay of gratification was related to self-regulation and gender. Self-efficacy was highly correlated with self-regulation ($r = .63$).

Objective Two

We examined whether the effects of self-regulation, self-efficacy, and delay of gratification on students' academic performance were moderated by gender. We first conducted independent t -test analyses, which show that female students reported higher delay of gratification ($t = 2.32$, $p < .05$, $\eta_p^2 = .09$) and self-regulation ($t = 2.64$, $p < .05$, $\eta_p^2 = .11$) than male students (see Table 1). An ANCOVA was conducted to assess the main effects and interactions between gender and the other variables.

This model revealed only a significant main effect for self-efficacy, $F = 4.66$, $p = .036$, $\eta_p^2 = .087$; with larger effect for females. There were no significant main effects or interaction for the other variables. This model accounted for 18% of the variance. To reduce error, the model was run again without the non-significant interaction terms, gender, and self-regulation (which was highly correlated with self-efficacy).

The final model (see Table 3), revealed a marginal significant main effect on delay of gratification and self-efficacy. This model accounted for 15% of the variance. The standardized beta for delay of gratification ($\beta = 2.06, p = .051, \eta_p^2 = .069$) and for self-efficacy ($\beta = 1.18, p = .071, \eta_p^2 = .059$) indicate that students' willingness to delay gratification and self-efficacy beliefs influence their final course grade.

Objective Three

To test whether gender, self-regulation, self-efficacy, and delay of gratification separately account for unique variance in the students' final course grade even after controlling for the effect of each other, a regression analysis was conducted (all variables were entered around the mean; see Tables 4 and 5). To avoid multicollinearity between the predictors, the interaction terms were not included in the model. In the initial model delay of gratification, self-efficacy, self-regulation, and gender were entered in three steps predicting final course grade. The results revealed that gender ($\beta = .04, p = .755$) and self-regulation ($\beta = .10, p = .575$) did not predict final course grade. The model accounted for 15% of the variance. Thus, gender and self-regulation were dropped from the model.

In the final model, self-efficacy was entered in Step 1. Self-efficacy ($\beta = .28, p = .030$) was a significant predictor of final course grade, accounting for 8% of the variance. In Step 2, delay of gratification was added. Self-efficacy ($\beta = .23, p = .071$) and delay of gratification ($\beta = .25, p = .051$) were marginal predictors of final course grade, accounting for 14% of the variance. No severe violation of the constant variation assumption was detected as indicated by the Variance Inflation Factor (VIF) = 1.04, Tolerance = .99, and the Condition Index < 1.23.

Objective Four

To examine gender differences in the frequencies of help seeking resources college students employ in science courses, a series of Chi-square analyses were conducted. Although none of the analyses happened to be significant at the .05 traditional level, the patterns of findings are within themselves revealing (see Table 6). Female students consistently seek help more frequently than male students in all of the help seeking resources (with the exception of forming study groups).

With regard to seeking help from the instructors, females reported attending office hours (69%) and e-mailing (65%) the instructors more frequently than male students. Seeking help from the instructor by e-mail was significantly related to self-regulation ($r = .55, p = .000$), delay of gratification, ($r = .29, p = .031$), and self-efficacy ($r = .29, p = .029$). Females read extra material (60%) and used a study guide (58%), the internet (57%), and the library (63%) more frequently than did male students. Use of the library resources was significantly related to self-regulation ($r = .31, p = .021$). The amount of different help seeking sources used by the students was related to self-regulation ($r = .40, p = .002$).

Discussion and Educational Implications

This study provides support for the expected association between self-regulated learning and academic achievement among college students enrolled in science courses. These findings suggest that students' self-regulation of learning, self-efficacy beliefs, academic delay gratification, and final course grade are related. These findings support Zimmerman's (1998) contention that self-generated thoughts, feelings, and actions towards attaining one's academic goals are associated with high academic achievement.

Self-regulation is particularly important for females in these college level science classes. Women who engage in delay of gratification and have high confidence are more likely to succeed in these major related science courses, thus are unlikely to "leak out" of the pipeline due to poor achievement. These findings support Bandura's (1997) work on self-efficacy. Students who believed in their capability to reach specific academic goals were those who received higher course grades. They prefer to put off immediately available opportunities to satisfy impulses over pursuing chosen important academic goals; they delayed gratification (Bembenutty, 2009).

The results suggest (although not statistically significant) that there is a pattern of gender differences in the frequency of help seeking activities that these college students employ in science courses. This is consistent with previous research indicating that as young children, girls are more likely than boys to seek help (Eccles & Blumenfeld, 1985). As DiBenedetto and Zimmerman (2010) found on research with high school girls and science learning, self-regulated learning is closely associated with academic success in science.

These findings have important implications for educators in that perhaps teaching self-regulated processes and working with students' self-efficacy for science learning may increase the number of females who remain in the pipeline to pursue STEM careers.

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APPENDIX A

Academic Delay of Gratification Scale (Sample Items) (Bembenutty & Karabenick, 1998)

1. Which of the following would you choose to do?

- A. Go to a favorite concert, play, or sporting event and study less for this science class even though it may mean getting a lower score on an exam you will take tomorrow, OR
B. Stay home and study to increase your chances on getting a higher grade.

Choose One

Definitely choose A Probably choose A Probably choose B Definitely choose B

2. Which of the following would you choose to do?

- A. Study a little every day for an exam in this science class and spend less time with your friends, OR your friends, OR
B. Spend more time with your friends and cram just before the test.

Choose One

Definitely choose A Probably choose A Probably choose B Definitely choose B

APPENDIX B
Self-Regulation of Learning Scale (Sample Items)
(Bembenutty, 2009b)

	Never						Always
1. How often do you keep track of how well you are doing in this science class?	1	2	3	4	5	6	7
2. How often do you set specific goals to guide your efforts in preparation for this science?	1	2	3	4	5	6	7

APPENDIX C
Self-Efficacy Scale (Sample Items)
(Bembenutty, 2009b)

	Strongly disagree						Strongly agree
1. I am sure that I can learn all the material for this science class.	1	2	3	4	5	6	7
2. I am sure that I will pass this science class.	1	2	3	4	5	6	7

Table 1
Mean Scores and Standard Deviations for Measures of Self-regulation, Motivation, and Final Course Grade as a Function of Gender

		Academic Delay of Gratification	Self-regulation	Self-efficacy	Final Course Grade
Male	<i>M</i>	3.19	5.19	6.29	7.37
	<i>SD</i>	.29	.89	.66	3.69
Female	<i>M</i>	3.44	5.82	6.44	8.21
	<i>SD</i>	.46	.88	.67	3.06
Total	<i>M</i>	3.34	5.56	6.38	7.85
	<i>SD</i>	.41	.93	.66	3.34
<i>t</i>		2.32	2.64	.86	.93
<i>p</i>		.024	.011	.391	.355
η_p^2		.09	.11	.03	.02

Note. ^a Males are coded 0, females are coded 1.

Table 2
Correlation Matrix of the Measures of Self-regulation, Motivation, and Final Course Grade

Variable	1	2	3	4	5
1. Academic Delay of Gratification	-----				
2. Self-regulation	.41**	-----			
3. Self-efficacy	.20	.63**	-----		
4. Gender	.29*	.33*	.11	-----	
5. Final Course Grade	.30*	.21	.28*	.12	-----
<i>M</i>	3.34	5.56	6.38	-----	7.85
<i>SD</i>	.41	.93	.66	-----	3.34
α	.59	.87	.75	-----	-----

Note. * $p < .05$. ** $p < .01$. ^a Males are coded 0, females are coded 1.

Table 3
General Lineal Analysis of Final Course Grade with Self-efficacy and Academic Delay of Gratification as Covariate

Parameter	<i>B</i>	<i>SE</i>	<i>t</i>	<i>P</i>	95% Confidence Interval		η_p^2
					Lower Bound	Upper Bound	
Academic Delay of Gratification	2.06	1.03	2.00	.051	-.005	4.126	.069
Self-efficacy	1.18	.64	1.84	.071	-.105	2.468	.059

Table 4
Hierarchical Regression Analysis Predicting Final Course Grade with Self-efficacy and Academic Delay of Gratification

Step	<i>R</i>	<i>R</i> ²	ΔR^2	<i>R</i> ² Change	<i>F</i> Change	ANOVA <i>F</i>
1	.28	.08	.06	.08	4.98*	4.98*
2	.38	.14	.11	.06	4.00**	4.63*

Note. * $p < .05$.

Table 5
Regression Analysis Predicting Final Course Grade with Self-efficacy and Academic Delay of Gratification

Step	Variable	<i>B</i>	<i>SE B</i>	β	<i>t</i>	<i>p</i>
1	Self-efficacy	1.41	.64	.28	2.23	.030
2	Self-efficacy	1.18	.64	.23	1.84	.071
	Academic Delay of Gratification	2.06	1.03	.25	2.00	.051

Table 6
Help Seeking Resources among Males and Females Students in Science Courses

Sources of Help Seeking	Males				Females			
	Yes		No		Yes		No	
	N	%	n	%	N	%	N	%
Tutor	8	31	16	52	18	69	15	48
Library	11	37	13	48	19	63	14	52
Study Group	11	44	13	40	14	42	19	59
E-mail Professor	14	35	10	59	26	65	7	41
Study Partner	16	48	8	36	19	54	14	67
Internet	21	43	3	38	28	57	5	15
Study Guide	13	42	11	42	18	58	15	58
Extra Reading	20	40	4	57	30	60	3	43
Office Hours	8	31	16	52	18	69	15	48
Others	0	0	24	44	3	100	30	57