Authors: Michele J. Mann and Christopher Golubski The University of Texas at Austin

Abstract

Using the Motivated Strategies for Learning Questionnaire (MSLQ), scores were evaluated at the beginning and end of the semester in an entry-level biology course for biology majors comparing if the students had taken the Advanced Placement (AP) Biology test. The students that scored a 2 or 4 on the AP Biology test had a statistically significant less of a decrease in MSLQ pre and post test scores than the students that did not take the AP Biology test. There was a trend upward in MSLQ for increasing AP scores in general. Students that took AP test in biology, calculus and/or chemistry had a higher GPA and better performance in the first term biology course for majors. The higher the students scored on the AP tests the higher their self-efficacy and their overall MSLQ scores. Knowing which students will potentially have MSLQ scores that will decrease significantly during a semester helps professors identify students needing more encouragement and support. Students that are capable and interested in a biology emphasis should have access to the degree.

Introduction

The United States relies on the advances in technology and science for the wellbeing of its economy and its citizens (Espinosa, 2011) it is essential that students that are interested and capable of a degree in science, technology, engineering and mathematics (STEM) have access to the field. Sixty percent of the students that start in a STEM degree in college change majors before matriculation (Presidents' Advisory Council on Science and Technology, 2012). Chemers, Hu and Garcia (2001) found that successful students or perceived successful students are more likely to remain in their major. With all of the prerequisites for STEM courses and the hierarchical nature of STEM courses students are not likely to switch into a STEM degree after they start college, which makes it important that the students who matriculate in STEM majors graduate with the degree.

We are building on what was previously reported (Mann & Golubski, 2013) at the conference in 2013 that students self-efficacy decreased during their first majors biology college course. This is the second year of a four-year study of biology majors. The first year we looked at self-efficacy ratings at the beginning and at the end of the semester of their first biology course for majors (fall of their first year). We have continued to track the first cohort and also have a second cohort (freshmen, fall 2013). This year we looked at the effects on self-efficacy and self-advocacy scores grouped by students that took the Advanced Placement (AP) Biology Test and passed and those students that either didn't take the test or didn't score a passing score on the test.

Conceptual Framework

The conceptual framework for this study is a combination of Bandura's Social Cognitive Theory (1986) and Flavell's Metacognition Theory (1979). This paper uses Bandura's social cognitive theory (1986) to examine first-year biology majors' self-efficacy during their first biology course. Social cognitive theory views people as self-reflecting, self-organizing, self-regulating, and proactive, not just reacting to environmental forces or driven by inner impulses (Bandura, 1986). Self-efficacy is when an individual thinks they are capable of performing tasks necessary to achieve their goals (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996). Self-efficacy has been linked to academic success, students' decisions, effort students' put into tasks,

and student stress (Chemers et al., 2001; Pajares & Schunk, 2001; Solberg & Viliarreal, 1997; Vuong, Brown-Welty, & Tracz, 2010).

Self-Regulated Learning refers to students knowing how they are doing in a class and advocating for themselves. This could be joining a study group or asking the professor questions when they don't understand something. Pintrich (1999) found a strong relationship between motivation and self-advocacy in learning. Pintrich further explained that self-regulated learning must include cognitive and metacognitive strategies, which control and regulate their learning. Flavell (1979) explains that metacognition consists of both metacognitive knowledge and metacognitive experiences or regulation. Metacognitive knowledge refers to acquired knowledge about cognitive processes, knowledge that can be used to control cognitive processes. Flavell divides metacognitive knowledge into three categories: knowledge of person variables, task variables and strategy variables. Students have to become aware of their progress to be able to make any changes in their learning (Bransford, Brown, & Cocking, 1999; P. Pintrich, 2004).

Literature Review

If students have high self-efficacy they are more likely to view a STEM degree as a challenge to transcend rather than a threat to escape (Pajares & Schunk, 2001). Self-efficacy has two major elements: efficacy expectation, an individual's belief about whether he or she can perform a task and response outcome expectancy, an individual's belief that the action performed will result in a desired outcome (Haney et al., 2011). Students' general adjustment to college and college academic areas and self-efficacy have been examined (Chemers et al., 2001; Haney et al., 2011; Hutchison, Follman, Sumpter, & Bodner, 2006; Lent, Brown, & Larkin, 1984; Multon, Brown, & Lent, 1991; Solberg & Viliarreal, 1997; Vuong et al., 2010) but there has not been a comparison of students self efficacy, self advocacy in a biology course and if they took the Advanced Placement test in biology. The students' beliefs and aspirations, in turn, contribute to their academic achievement both directly and by fostering peer acceptance and reducing depression and problem behavior that can undermine productive engagement in academic pursuits (Bandura et al., 1996, p. 1207). Students can build self-efficacy by having successful experiences, observing a peer's success at a task, and having a credible conversation with someone the student respects (Margolis & Mccabe, 2006). As STEM educators, we need to be aware of these opportunities that can build a student's self-efficacy opportunities such as increasing opportunities for proximal goals, verbally encouraging students to set their own goals, and providing frequent and immediate feedback (Pajares & Schunk, 2001). Student perception of their achievement has more to do with their self-efficacy than their actual grades. In the case of STEM majors, they might actually change majors because they do not perceive that they are successful when they actually have good grades (Bandura et al., 1996).

Self-Regulated Learning is being metacognitive, motivated and behaviorally active in one's own learning (Eccles & Wigfield, 2002; Paul R Pintrich, 2000). Student achievement influences initial engagement however self-efficacy, cognitive and self regulation strategies determined engagement and performance (Paul R Pintrich & De Groot, 1990) The specific questions that were used from the Motivated Strategies for Learning Questionnaire (MSLQ) specifically examines self efficacy, task value, control beliefs, peer learning and help seeking (Paul R Pintrich, 1991)

The Advanced Placement Biology tests is taken by about 200,000 students globally each year ("AP Biology Student Score Distributions Global AP Exams May 2013," 2013). Students typically take the test after the have completed a year long AP Biology Class at their high school.

The course is designed to cover the same material that is in most introduction college biology courses (two semesters). A passing score is a 3 on a 1-5 scale with five being the highest score. Percentages of students passing each year ranges but in 2013 sixty-three percent of the students that took the test got a passing score ("AP Biology Student Score Distributions Global AP Exams May 2013," 2013). Knowing how taking the AP Biology test effects self-efficacy and self-regulated learning can help us build stronger students and improve retention in a biology program.

Research Design

We studied freshmen and sophomore biology majors at a large, competitive, four-year public university in the south. The students are of diverse ethnicities and gender all initially enrolled as biology majors. All the students took the MSLQ at the beginning and end of their first semester. The MSLQ uses a 7 point Likert Scale where 7 is the highest and 1 is the lowest. We specifically examined self efficacy, task value, control beliefs, peer learning and help seeking questions, which have a robust reliability with a Cronbach's alpha scores between .52 (help seeking) to.93 (self-efficacy) (Artino Jr, 2005). We also compared if they took the AP Biology exam and their scores to their pre and post semester scores on the MSLQ survey Our research question is what is the effect of obtaining a passing AP Biology test score on self-efficacy and self-regulated learning in biology majors during their first biology course.

Findings

We completed a one way ANOVA based on the MSLQ data and the AP examination scores for the students participating in the study. The following table gives the summary results for each AP exam and post-MSLQ results:

AP Examination	**F**	**p-value**
Biology	3.016	.015 (**)
Calculus AB	0.346	.884
Calculus BC	0.305	.909
Chemistry	0.989	.430

** Significant at the .10 level

In addition to the one way ANOVA, we ran the Tukey HSD post-hoc tests on the significant results to find the location of the differences. We chose to run the Tukey HSD test because other corrections tend to overcompensate, and the results of the Levene Statistic for homogeneity of variance were not significant. The significant results of the post-hoc tests are as follows:

AP Grade	**Compared to**	**p-value**
0 (did not take)	4	.002
2	4	.094

When analyzing the MSLQ survey results, we also did a one way ANOVA comparing overall GPA and course performance for those students who took one or more AP examinations.

AP Examination	**F**	**p-value**
Biology	7.189	< .0001 (**)
Calculus AB	6.238	< .0001 (**)
Calculus BC	4.849	< .0001 (**)
Chemistry	6.004	< .0001 (**)

** Significant at the .10 level

While all four results are significant, we are going to focus on the biology subgroup of this cohort, as we are primarily interested in biology education. Like the analysis of the MSLQ above, we ran the Tukey HSD post-hoc test after the Levene statistic reported that the data was homoscedastic.

AP Grade (Biology)	**Compared to**	**p-value**
0 (did not take)	3	.019
0 (did not take)	4	.001
1	3	.025
1	4	.007
1	5	.026
2	3	.070
2	4	.015
2	5	.090

The following table contains results of a one way ANOVA comparing course grade and grade on the AP Biology tests:

AP Examination	**F**	**p-value**
Biology	12.07	< .0001 (**)
Calculus AB	6.024	< .0001 (**)
Calculus BC	4.589	< .0001 (**)
Chemistry	6.817	< .0001 (**)

** Significant at the .10 level

Again, when executing the post-hoc tests, we will focus on the AP Biology results primarily.

AP Grade (Biology)	**Compared to**	**p-value**
0 (did not take)	3	< .0001
0 (did not take)	4	< .0001
0 (did not take)	5	.066
1	3	.008
1	4	.001
1	5	.020
2	3	.098
2	4	.009
3	1	.008

Discussion

Compared to last year's study, we have a considerably larger sample size; however, some of the results are still somewhat dubious due to low sample size, especially in some of the higher score ranges of the AP examinations. For instance, there is a strongly significant difference in the post-MSLQ surveys for students who scored different on the AP Biology examination; however, after post-hoc testing, we found that the substantially significant difference is between those who did not take the AP Biology exam and those who scored a 4 on it, as well as those who did not take the exam and those who scored a 2 on it.

At first glance, this result might not be intuitive; but we should note that the largest group we had was the group who did not take the exam (n = 79) and the group who scored a 4 (n = 25). When considering that we had to combine survey data with a low response rate with a proportion of students who took the AP Biology examination, we found that some of the data bins had only single digit values, which is problematic for these types of statistical tests.

Even though only these two groups were significant, though, we did find that self-efficacy trends downward at a faster rate for those who did not take the AP Biology examination than for those who did. For example, on the entirety of the MSLQ, students who did not take an AP exam had a cumulative survey result of 129.86, the students who scored a 3 had a result of 137.72, and the students who scored a 4 had a result of 147.84. This indicates that although the results between some of the groups were not statistically significant, we had a considerable increase in self-efficacy and MSLQ survey results among students who did well on the AP examinations. Additionally, we only had a sample size of 3 students who completed the entire MSLQ inventory and earned a 5 on the AP examination, essentially eliminating the value of that category in the analysis. Students that score a 5 on the AP Biology can get credit for this course.

In regard to overall GPA vs. AP Biology scores and course grade vs. AP Biology scores, the results were crystal clear: the AP exam takers did considerably better in both the course and overall GPA compared to students who had no AP examination experience. In addition, the increased scores were not limited only to AP Biology. Students who took the AP Calculus AB, AP Calculus BC, and AP Chemistry examinations had a tendency to do better in their respective biology course as well as in their overall GPA.

Clearly, the AP Biology grade had the greatest effect on their biology course performance. Nonetheless, AP Chemistry results also provided an indication that students would do well in overall GPA and biology course performance. As would be expected, results of the AP Calculus AB and BC examinations did indicate that students would do well, likely for the general experience of taking a college-level course.

Implications

The analysis of AP scores gives us a springboard to consider other related topics, such as finding detailed reasons as to why students benefit from AP courses other than academic rigor. This student population is a heterogeneous population, so results are not simply confined to SES. Examining students based on their academic backgrounds will allow us to find out why certain students are doing better than others and potentially help us attain better outcomes in biology education.

We will continue to follow these students to monitor their progress, as well as acquire additional data on first semester freshmen with new cohorts as they enter the university. We will continue to monitor the students' attitudes toward biology, their grades and their progress towards a degree. This data will likely give us insight as to why the attrition rate for biology majors is considerably higher than majors in the humanities.

References

. AP Biology Student Score Distributions Global AP Exams May 2013. (2013) (pp. 1). Advanced Placement Central: College Board.

Artino Jr, A. R. (2005). Review of the Motivated Strategies for Learning Questionnaire. *Online Submission*.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (1996). Multifaceted Impact of Self-Efficacy Beliefs on Academic Functioning. *Child Development, 67*(3), 1206-1222. doi: 10.2307/1131888

Bransford, J., Brown, A. L., & Cocking, R. R. (1999). *How people learn : brain, mind, experience, and school*. Washington, D.C.: National Academy Press.

Chemers, M. M., Hu, L.-t., & Garcia, B. F. (2001). Academic self-efficacy and first year college student performance and adjustment. *Journal of Educational Psychology, 93*(1), 55-64. doi: 10.1037/0022-0663.93.1.55

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual review of psychology, 53*(1), 109-132.

Espinosa, L. L. (2011). Pipelines and pathways: Women of color in undergraduate STEM majors and the college experiences that contribute to persistence. *Harvard Educational Review, 81*(2), 209-241.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist, 34*(10), 906-911. doi: 10.1037/0003-066x.34.10.906

Haney, J. J., Midden, W. R., Nurnberger-Haag, J. A., Partin, M. L., Scheuermann, A., Underwood, E. M., & Worch, E. A. (2011). Yes I can: the contributions of motivation and attitudes on course performance among biology nonmajors. *Journal of College Science Teaching, 40*(6), 86.

Hutchison, M. A., Follman, D. K., Sumpter, M., & Bodner, G. M. (2006). Factors Influencing the Self‐Efficacy Beliefs of First‐Year Engineering Students. *Journal of Engineering Education, 95*(1), 39-47.

Lent, R. W., Brown, S. D., & Larkin, K. C. (1984). Relation of self-efficacy expectations to academic achievement and persistence. *Journal of Counseling Psychology, 31*(3), 356.

Mann, M. J., & Golubski, C. (2013). *Self-efficacy and First Year Biology Majors*. Paper presented at the 2013 NABT Biology Education Research Symposium, Atlanta, Georgia. http://www.nabt.org/websites/institution/File/docs/Four%20Year%20Section/2013%20Proceedings/SELF-EFFICACY%20AND%20FIRST%20YEAR%20BIOLOGY%20MAJORS.pdf

Margolis, H., & Mccabe, P. P. (2006). Improving Self-Efficacy and Motivation: What to Do, What to Say. *Intervention in School and Clinic, 41*(4), 218-227. doi: 10.1177/10534512060410040401

Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of Counseling Psychology, 38*(1), 30-38. doi: 10.1037/0022-0167.38.1.30

Pajares, F., & Schunk, D. H. (2001). Self-beliefs and school success: Self-efficacy, self-concept and school achievement In R. Riding & S. Rayner (Eds.), *Perception* (pp. 239-266). London: Ablex Publishing.

Pintrich, P. (2004). A Conceptual Framework for Assessing Motivation and Self-Regulated Learning in College Students. *Educational Psychology Review, 16*(4), 385-407. doi: 10.1007/s10648-004-0006-x

Pintrich, P. R. (1991). A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ).

Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research, 31*(6), 459-470. doi: http://dx.doi.org/10.1016/S0883-0355(99)00015-4

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*(1), 33.

Presidents' Advisory Council on Science and Technology. (2012). Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics (pp. 1-130).

Solberg, V. S., & Viliarreal, P. (1997). Examination of self-efficacy, social support, and stress as predictors of psychological and physical distress among Hispanic college students. *Hispanic Journal of Behavioral Sciences, 19*(2), 182-201.

Vuong, M., Brown-Welty, S., & Tracz, S. (2010). The effects of self-efficacy on academic success of first-generation college sophomore students. *Journal of College Student Development, 51*(1), 50-64.